

Association of Researchers in Construction Management

THIRTIETH ANNUAL CONFERENCE

2014

September 1-3

Portsmouth

Volume 1

Association of Researchers in Construction Management (ARCOM)
Proceedings of the 30th Annual Conference

Edited by Ani Raiden and Emmanuel Aboagye-Nimo

First published 2014

ISBN: 978-0-9552390-8-3 (2 vols)

Published by
ARCOM, Association of Researchers in Construction Management
c/o School of Construction Management and Engineering
University of Reading
PO Box 219
Reading
RG6 6AW, UK

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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 the 30th annual Association of Researchers in Construction Management (ARCOM) conference; an occasion to celebrate construction management research.

ARCOM has developed into a popular and professional research association; our conference is attracting ever increasing number of research students, lecturers, prolific researchers and practitioners internationally. This year our delegates come from 28 countries with diverse range of backgrounds, interests and expertise.

In these proceedings we present the rich variety of contributions to the conference. Project management, building information modelling and sustainability continue to draw a large number of submissions. Health and safety and wellbeing, and construction management education and learning also feature as important themes in the conference together with procurement and information management. Policy research emerges as a new area of interest. In addition to our construction management papers, ARCOM is pleased to host the CIB W113 Law and Dispute Resolution Working Commission as a specialist stream of the conference this year.

We present to you 146 papers that were accepted for publication. This is the result of an intense three-stage review process through which we have been able to maintain high quality standards. Our initial call led to an astonishing 457 abstracts and 235 full papers being submitted. The Scientific Committee have worked very hard to select the final papers for presentation. If your paper is included in these proceedings then you should feel very proud of your achievement!

In addition to the research papers we welcome to the conference Tim Broyd (University College London) and Libby Schweber (University of Reading), our keynote speakers, and Martin Löwstedt (Chalmers University of Technology) who will deliver the Langford Lecture. Tim Broyd and Libby Schweber will join Christine Räisänen (Chalmers University of Technology), Mark Addis (Birmingham City University) and Stuart Green (University of Reading) as panellists on our debate: 'Do we need to have a method in order for us to be or become a community of construction management researchers?' The 30th ARCOM conference is a timely opportunity for an academic debate; time for reflection on the nature of research in construction management and discussion whether a method is central to our development as a community of researchers.

Putting together the academic programme for the conference is a collective effort, and we thank the ARCOM committee and wider Scientific Committee for their voluntary contribution to making the conference such a success year after year. Paul Chan, Andrew Dainty, Chris Harty, Scott Fernie and Simon Smith in particular have been instrumental in supporting us throughout the planning and managing of the conference over the past eight months.

We wish you an enjoyable and inspiring three days in Portsmouth; enjoy the diversity of research presented at the conference and proceedings and make the most of the many networking events. We hope that you will engage in critical reflection and discussions during the conference and afterwards through our web resources and workshops, and thus support our ongoing aim to further the advancement of knowledge in all aspects of management in construction.

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SUSTAINABLE CONSTRUCTION: EXPLORING THE CAPABILITIES OF NIGERIAN CONSTRUCTION FIRMS

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As the built environment accounts for much of the world's emissions, resource consumption and waste, concerns remain as to how sustainable the sector is. Understanding how such concerns can be better managed is complex, with a range of competing agendas and institutional forces at play. This is especially the case in Nigeria where there are often differing priorities, weak regulations and institutions to deal with this challenge. Construction firms are in competition with each other in a market that is growing in size and sophistication yearly. The business case for sustainability has been argued severally in literature. However, the capability of construction firms with respect to sustainability in Nigeria has not been studied. This paper presents the preliminary findings of an exploratory multi-case study carried out to understand the firm's views on sustainability as a source of competitive advantage. A 'mega-international firm' and a 'lower medium-sized indigenous firm' were selected for this purpose. Qualitative interviews were conducted with top-level management of both firms, with key themes from the sustainable construction and dynamic capabilities literature informing the case study protocol. The interviews were transcribed and analysed with the use of NVivo software. The findings suggest that the multinational firm is better grounded in sustainability knowledge. Although the level of awareness and demand for sustainable construction is generally very poor, few international clients are beginning to stimulate interest in sustainable buildings. This has triggered both firms to build their capabilities in that regard, albeit in an unhurried manner. Both firms agree on the potentials of market-driven sustainability in the long term. Nonetheless, more drastic actions are required to accelerate the sustainable construction agenda in Nigeria.

Keywords: competitiveness, developing countries, dynamic capabilities, sustainable construction.

INTRODUCTION

The sustainable construction (SC) agenda requires far reaching changes to the design, construction and operations of buildings. The Agenda 21 for sustainable construction document laid down an early marker for the construction sector at national to local levels (CIB, 1999). Many other strategies for dealing with the requirements of SC have evolved over the years. In developing countries, the increasing relevance of the building sector justifies the need for greater attention towards sustainable buildings (Berardi, 2013). However, questions arise as to if and how the SC agenda can be pursued in developing countries, particularly by those on the African continent.

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Many of the challenges of construction in developing countries have been documented by several researchers (Ofori, 2000, Reffat, 2004, Wells, 2007, Ofori, 1984). These challenges negatively impact on the abilities of these countries to learn from past examples of developed countries while addressing problems of rapid urbanisation and inadequate housing and infrastructure (du Plessis, 2007). As attention gradually shifts to the African continent as the next possible region for rapid economic growth and development, conscious efforts have to be made to ensure that this projected development is 'sustainable' (Luciana, 2007). The construction sector is likely to be the focal point of this development as the continent rises to meet its deficiencies in housing and infrastructure. However, there is little or no evidence that the construction sector in these countries are in a position to take on these challenges head-on.

Nigeria exemplifies an interesting context to study how these developments are taking shape and what improvements can be recommended. The country has recently been adjudged to be the largest African economy by GDP, and has attracted the largest Foreign Direct Investment (FDI) on the continent in the past few years (National Bureau of Statistics, 2014). It has an active and vibrant construction sector catering for the needs of its diverse 170million people. This paper discusses the on-going role construction firms are playing in advancing the sustainability agenda.

LITERATURE REVIEW

Sustainable Construction

SC is the construction sector's response to the sustainable development agenda which came to global focus through the publication of 'Our Common Future' (World Commission on Environment and Development., 1987). The report emphasized three fundamental components of sustainable development: environmental protection, social equity and economic growth. For these three dimensions to be captured in the built environment, SC should address the concerns of water usage, energy consumption, biodiversity, waste, construction materials and quality (Kibert, 2013). The literature on SC and appropriate strategies and technologies that deal with these concerns is growing. Environmental assessment tools such as LEED, BREEAM and Greenstar (Cole, 2005, Ding, 2008) have been developed, in addition to many 'off-the-shelf' sustainable technologies that could readily be incorporated into buildings (Pinkse and Dommissie, 2009). Ethical sourcing (Glass *et al.*, 2011) of construction materials is encouraged, while the business case for corporate sustainability has been discussed severally (Dyllick and Hockerts, 2002, Salzmann *et al.*, 2005)

The pursuit of SC is not without its challenges. The level of awareness is usually a critical factor in the early stages of diffusion (Herremans and Reid, 2002, Zainul Abidin, 2010). The concept has various definitions which are vague and subjected to a variety of interpretations making it difficult to comprehend (Murray and Cotgrave, 2007, Berardi, 2013). It calls for new sources of knowledge and technology which may be costly to implement in the short run (Häkkinen and Belloni, 2011, Serpell *et al.*, 2013). It also requires input from individual stakeholders to ensure a holistic approach in changing the way the construction sector carries out its activities.

Corporate sustainability

The corporate sustainability literature explores the integration of sustainability into the core business goals and operations of the firm. Corporate entities are increasingly under pressure to demonstrate how they contribute to sustainability goals (Dunphy *et al.*, 2007). Perhaps more than any other sector, the construction sector is very central to the sustainability debate. This is due to the quantum of energy, water and materials

consumed, and the wastes generated during its construction and operative phase (Pearce *et al.*, 2012). Construction firms appear to be the melting pot of the activities of all other stakeholders in the sector as they interact with all other stakeholders' output. This places them delicately in the spotlight of the sustainability agenda. This study draws upon the strategic management literature in understanding strategic change within organizations. The resource base view (RBV) (Barney, 1991) and its more recent extension, the Dynamic Capabilities View (DCV) dominates this area.

The Nigerian construction context

The Nigerian government has taken little steps in promoting sustainable development. It participated in the Rio summit (1992), Johannesburg summit (2002) and the Rio+20 summit (2012). It is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and is also committed to the millennium development goals (Government of the Federal Republic of Nigeria., 2010). In 2008, it set up a stakeholder's conference on sustainable development. Since then, there has been little evidence of any significant momentum on sustainable development.

The Nigeria construction sector is projected to be the fastest growing (9.4%) in the world up to 2020 (Oxford Business Group, 2011, Mitchell, 2013). This is in part due to the sector's low contribution to the macro-economy of Nigeria (1.3% as against 10% for similar countries). Recent surges in commercial and private developments, complementing Government's massive patronage of the sector (up to 90%), is expected to account for much of this growth (Coffey International Development Ltd, 2014). Four distinct firm types were identified by Coffey International (2014): Mega international firms, medium sized foreign controlled firms, lower medium-sized indigenous firms and the micro, small and medium indigenous (MSME) firms. Market share is skewed in favour of the largest firms (estimated 60-70%), with the MSMEs accounting for only 10 percent of output. While foreign firms dominate the market, a positive of this is the potential for technology transfer (Ofori, 1994, Carrillo, 1996).

Majority of the researches on the Nigerian construction sector addresses its historic problems: low skills levels and productivity (Olomolaiye *et al.*, 1987), nature of construction businesses (Aniekwu, 1995), time and cost overruns (Mansfield *et al.*, 1994, Aibinu and Jagboro, 2002), housing (Awotona, 1990) and risks (Adedokun *et al.*, 2013). The subject of SC is still relatively new in the research agenda and not much is known about it in the Nigerian context. The Agenda 21 for SC in developing countries sets a research agenda for developing countries like Nigeria (du Plessis *et al.*, 2001). Du Plessis (2007) hinges the success of any sustainability initiative in Africa on a 'capable' and 'viable' construction sector. The research focused on framing SC as a possible source of competitive advantage (Tan *et al.*, 2011) and explores how firms seek to develop their capabilities (Teece *et al.*, 1997) in this regard.

STRATEGIC MANAGEMENT

Resource Based View

In the Nigerian construction sector, distinctions are made between foreign owned firms and their indigenous counterparts (Ngoka, 1979), their market positions (Coffey International Development Ltd, 2014), and the implications as a result. The RBV (Wernerfelt, 1984, Barney, 1991) focuses on strategies for exploiting existing firm-specific assets that are valuable, rare, inimitable and non-substitutable (VRIN attributes). However, the RBV has been criticised as being static and that firms run the risk of neglecting the influence of market dynamism (Eisenhardt and Martin, 2000).

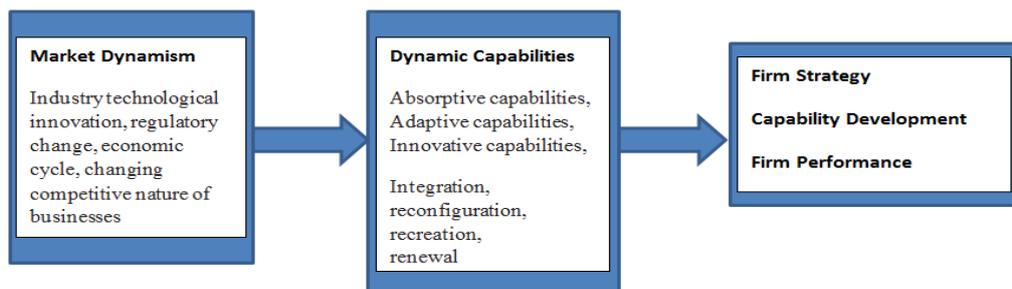
As a result, a previous dominant market position may become obsolete due to innovations from competitors or changing market demand. Thus, firms must seek to renew these VRIN attributes in order to gain or maintain market position (Helfat, 2007). This apparent weakness led to the development of the Dynamic capabilities View of the firm.

Dynamic Capabilities View

The DCV (Teece *et al.*, 1997) has its roots in evolutionary economics and was developed to address the weaknesses of the RBV. It is a firm-level framework which adds the dimension of ‘capabilities’ in rapidly changing environments to the RBV. The DCV seeks to explain how firms enter or maintain competitiveness in a more hostile, dynamic and global world (Bowman and Carter, 1995). It encompasses skill acquisition, learning and accumulation of organizational and intangible assets in which lies great potential for contribution to strategy. The DCV lens distinguishes the ‘difficult-to-replicate’, ordinary, zero level (technical) capabilities of firms from those higher level capabilities that are required to respond to fast moving business environments ‘open to global competition and characterized by dispersion’ marked by customer relevance and competitive considerations (Winter, 2003, Teece, 2009).

This framework resonates with competing firms seeking to engage new knowledge streams within the dynamic Nigerian construction sector. The DCV can be seen as a potentially integrative approach to understanding newer sources of competitive advantage (Teece *et al.*, 1997) especially in response to a changing environment such as the movement toward a sustainable construction sector. However, the DCV is not without its criticisms. It has often been labelled as inconsistent in definition and lacking theoretical foundations (Arend and Bromiley, 2009). This has been attributed to the DCV being relatively new (Green *et al.*, 2008). It still provides a good framework for this research compared to the RBV. A research model by Wang and Ahmed (2007) is adopted for this study (Figure 1).

Figure 1: Research Model for Dynamic Capabilities (Wang and Ahmed, 2007)



RESEARCH DESIGN

The research adopted a qualitative (Creswell, 2009), interpretivist approach in studying how firms integrate, build and reconfigure its competencies to address the rapid changing environments and global requirements for sustainability. A multi-case study (Eisenhardt, 1989) methodology was adopted for this study. The suitability of a case-study research design is that it investigates social life within the parameters of openness, communicativity, naturalism and interpretivity (Sarantakos, 2005). “*The concept of Dynamic capability includes the capacity with which to identify the need or opportunity for change, formulate a response to such a need or opportunity and implement a course of action*” (Helfat, 2007pg 2). As a result, themes from the

Dynamic capability framework and the Agenda 21 informed the development of the case study protocol.

Data Collection

Using the firm classification by Coffey International (2014) two firms were selected: one mega international firm (Multibrix Ltd) and one lower medium-sized indigenous firm (Dynamix Nig). Both names are fictitious for confidentiality purposes. The two firms have regional operations in Abuja, the capital city, Lagos the Commercial capital and Port Harcourt where most Oil and Gas operations take place. They have been in operation for upwards of 20 years, which anecdotally, suggests they are well established in the Nigerian context as most firms have a very short lifespan.

Interviews

The interviews focused on the firms' operating history in Nigeria, firm strategy, organizational structure and challenges faced in operation. Of particular importance were the firms' grasp of sustainability issues, its learning processes and absorption capacity. The interviews were directed at top level management, each being in depth and a little over one hour long. They were recorded, subsequently transcribed and anonymised. A total of ten interviews were conducted across both firms.

Corporate Reports

Archival records are standard sources of data on firm level change (Bryman, 2008) as they reveal the image the firm wants to create of itself. Only Multibrix Ltd produced corporate annual reports of which reports for years 2008-2012 were analysed. As for Dynamix Nig, a long term corporate strategic plan commemorating the 20th anniversary of the firm was obtained and analysed. None of the two firms had specific sustainability reports.

Data Analysis

The interviews were transcribed into Microsoft Word and NVivo 10 software was used to analyse the interviews against a set of categories that emerged from the responses of the interviewees. These include: understanding of the SC concept, ownership structure, corporate social responsibility, clients, reliability, policy and organisational culture. These were used to make sense of the firms' understanding of its strengths, market position, the prospects of sustainable construction and possible advantages from its enactment.

FINDINGS

The interviews sought to gain insight into how the firms understand and engage SC and if they saw any potential competitive advantage therein. On the other hand, in the event that they did not engage with SC, it sought to understand why and what other concepts the firms thought of as being important to their strategic development. The DCV research model by Wang and Ahmed was adopted and has the following themes: market dynamism, internal processes and configurations and capability development. The general profile of the firms is presented in Table 1 and the findings are as follows:

1. Understanding of Sustainability: this is drawn from the SC literature. A proper grasp of the principles of SC is required to mobilise for change within the organisation. The analyses of the interviews showed a very broad contrast with both firms' understanding of the concept. In Multibrix Ltd, all the respondents had a strong grasp of SC and its principles. The firm's respondents equally talked about drivers and barriers of SC both in the foreign and Nigerian context. The key drivers identified for foreign markets were legislation and long-term cost reduction. With respect to the local Nigerian market, the driver identified was

'international clients'. It was identified that both foreign and local markets shared common barriers such as high initial cost, low awareness and client demand. Some peculiar local challenges stand out though: cultural inertia resisting change, absence of legislation and incentive schemes, and inadequate systems to deal with change (see discussion section). The firm had gradually started to incorporate sustainable thinking and environmental consciousness into its operations since 2007. On the other hand, the Dynamix Nig staff had no understanding of SC as a concept as it exists in literature. However, while responding to questions on specific SC themes, they showed some level of comprehension, even though they did not previously link them to the SC concept. They had only recently encountered the concept while bidding for construction project in 2013.

Table 1: Profile of Both Case Study Firms

	Multibrix Ltd	Dynamix Nig
Type	Engineering, Procurement and Construction Firm (Vertically integrated)	Construction and Engineering Consultancy
Turnover (£)*	815,384,615	38,461,540
Staff Strength	Over 18000	Over 200
Ownership Structure	Public Liability Company	Privately owned
Geographical Spread**	3 regions	3 regions
Organizational Units	4 divisions, 3 service units, hierarchical organisation	4 subsidiary companies, flat organisation
Interviewees	Operational Director, service unit head, design head and LEED champion	Vice Chairman, 3 subsidiary head, one director of operations
Clients	Largely government, increasing number of corporate and private clients	Strictly private and corporate clients by unwritten policy

*Exchange rate £1= 260 Nigerian Naira ** Within Nigeria

2. Market Dynamism: Both firms' views on market dynamism appear predicated on the nature of clients each firm possesses. Multibrix Ltd appeal to a wider spectrum of high value clients in Nigeria's booming economy compared to Dynamix Nig. So while both firms alluded to the fact that they implement client's requirements and thus, Multibrix Ltd's higher profile clients appeared to account for its more robust mechanisms for dealing with change. They both sense the prospects for market driven sustainability.
3. Internal Processes and Capability Development: Multibrix Ltd claim to have put in place measures of sustainability since 2007. These include internal training sessions and appointment of a 'LEED champion' in this regard. It has also commissioned a flagship LEED standard project for one of its subsidiaries to showcase this capability to potential clients. This project, in addition to creating awareness is a way of diffusing knowledge within Multibrix Ltd. Dynamix Nig on the other hand claims to be in the process of learning about sustainability and have this as a clear objective in its short term strategic plan.

DISCUSSIONS

The research sought to explore the perspectives of two very different firms, one being multinational and the other strictly indigenous on the concept and practice of SC. In displaying their knowledge on SC, Multibrix Ltd personnel relayed a lot of personal experiences that were encountered outside of Nigeria. They displayed better understanding of a global context for change regarding SC and the roles of multiple stakeholders. Thus, specific advantage is derived from a diverse pool of staff with varied work experiences in both developed and developing countries. This knowledge is being enacted currently on three on-going projects which have been designed and are being constructed to LEED standards. They are however quick to point out 'ill-fitting' requirements of LEED to the Nigerian context as it is quite different from the market which it was designed for. This is indicative that a 'one-size-fits-all' solution is not feasible and there might be a need for a bespoke assessment methodology for

Nigeria. The choice of LEED is due to client requirement and the fact that the LEED is more widely used globally than any other environmental assessment tool.

With respect to the drivers of SC in the Nigerian context, the 'international client' refers to organisations typically based in developed countries that already have minimum benchmarks that are expected of their operations from a broader sustainable development point of view. An example was cited on how health and safety provisions became standard practice across most construction firms due to Oil and Gas clients' requirements. This resonates with the views of Ofori (1994) and Carrillo (1996) on technology transfer by multi-nationals in developing countries. Multibrix Ltd also made reference to the supporting systems for change being inadequate. For example, local materials manufacturers and suppliers did not have adequate product documentation or certification. As such, in the event where a locally manufactured product met certain criteria of quality, they were unable to use them.

The development of SC capabilities by Dynamix Nig. appears limited by absence of legislation (common to both firms) and client demand. The clients prominent for this class of firms are smaller scale commercial and residential clients. In the cases where an international client requested a LEED rated sustainable building, Dynamix Nig only then started to familiarize itself with the concept of SC and the criteria of LEED. Only then did they realize that there were certain aspects of their operations, notably community engagement and energy efficient lighting that were in line with SC. That tender has only been enough to trigger initial interest but not a full commitment to SC. In the absence of enabling legislation, it is likely that clients would continue to remain ignorant and/or indifferent to SC.

Many of the findings were consistent with the expectations of a developing country of Nigeria's statute. Differing priorities like those mentioned by du Plessis (2007) makes it no surprise that awareness and demand of sustainable buildings are very low. However, poor access and rising costs of water and energy supply is expected to have triggered demand for renewable sources of energy and smart water systems. Many sustainable construction materials are not locally manufactured and are relatively 'high end' for the average consumer and hence the poor demand once again. Overall, Multibrix Ltd fare much better in making sense and its engagement of the SC agenda. The reasons for this are quite clear: its large capital base, foreign networks, client base and a highly organised management structure. This competitive edge it has over its indigenous counterparts has been highlighted as far back as 1977 (Oladapo) and remains largely unchanged up till now.

The dynamic capabilities lens was used to explore the prospects of sustainable construction as a source of competitive advantage. The firms were able to state what they both perceived to be 'unique' and 'difficult to imitate' about them (their resource base). Multibrix Ltd has been in existence for over twice the time as Dynamix Nig. and its pattern of growth and survival matches the provisions of the DCV. Dynamix Nig. has grown in size and statute from its incorporation to fill up a gap where majority of the mega international firms and the medium sized foreign controlled firms are not interested (Coffey International Development Ltd, 2014).

CONCLUSIONS

From the analyses, it is apparent that the Nigerian construction sector is still in a very early phase of sustainable construction. Stakeholders are only just gaining awareness of the concept even though this seems to be happening at a very slow rate. However, there are prospects of market-led sustainability initiatives, largely driven by

international investors who seek to maintain standards identical to what they are used to in their previous places of operation. While the firms see the business case for sustainability, the pulse of their responses indicates that it would take a long time for this concept to diffuse through the sector. The study does little to assuage the criticisms of the dynamic capabilities view, but does not find anything to dispel them either. The provisions of the research model by Wang and Ahmed fits better with Multibrix Nig. due to its more formalised structures and processes. It is therefore concluded that to accelerate the uptake of sustainable construction, government intervention in terms of legislation and incentives is recommended.

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BENEFITS AND LIMITATIONS OF SOCIAL PRACTICE THEORY TO EVALUATE PRACTICES IN SUSTAINABLE OFFICE BUILDINGS: PRELIMINARY FINDINGS

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Despite the acknowledgement that buildings are a major consumer of natural resources, the gap between design and operational building performance continues to present a challenge to both the construction industry and building occupants. Occupant behaviour is recognised as a significant factor in understanding operational performance. Approaches rooted in psychology have typically been adopted to understand behaviour and develop interventions, with the 'individual' as the focus of analysis. Social Practice Theory (SPT) provides an alternative means of appraising the dynamics between elements which converge to form practices impacting on the operational performance of the building, moving the focus of analysis from the individual to the practice. The building features designed to support sustainable behaviour are therefore considered as material elements embedded in wider social systems and not simply as physical features designed to determine behaviour. The benefits and limitations of a social practice approach in this context are appraised through the analysis of research undertaken in BREEAM Excellent certified office buildings considering the practice of moderating comfort. Findings demonstrate that SPT provides an opportunity to contextualise the physical features of sustainable office buildings and permits a more complex analysis of 'why' and 'how' workplace routines and practices are undertaken.

Keywords: behaviour change, green buildings, social practice theory, sustainability.

INTRODUCTION

The built environment is implicated in unsustainable patterns of global resource consumption. Buildings contribute 40% of all annual energy consumption and up to 30% of all energy-related greenhouse gas emissions globally (UNEP-SBCI 2010). Non-domestic buildings are responsible for significant natural resource consumption, waste production and greenhouse gas emissions. Adaptive and mitigative measures to reduce the environmental impact of buildings, developed by both industry and policy makers, are embodied in technical and regulatory requirements at national and international level and in voluntary sustainability assessment and ratings systems.

BREEAM² is the most widely used sustainable building ratings system in the UK (Larsson 1998). Assessments of sustainable buildings are typically undertaken at design stage. Predictions of sustainable building performance however, often diverge

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² The Building Research Establishment Environmental Assessment Method

significantly from the in-use performance. A growing body of literature has emerged around this issue, termed the "*performance gap*"; the discrepancy between predicted and operational building performance (Menezes *et al.* 2011). The PROBE³ Studies undertaken in the 1990s, evaluated operational performance of 23 non-domestic buildings, concluding that, once occupied, energy use could be as much as double design stage predictions (UBT 2014). The Carbon Trust's 'Closing the Gap' report identified factors potentially contributing to building underperformance: discrepancies in design assumptions and modelling; built quality; building management and occupant behaviour (Carbon Trust 2012). Occupant behaviour has been evaluated in numerous studies.

Monfared and Sharples (2011) contend that assessments undertaken prior to occupation fail to rigorously consider the impact of end users. Occupants in sustainable buildings are typically considered in the context of monitoring behaviour or measuring satisfaction and initiatives aimed at 'managing' demand and 'changing' behaviour dominate. Such approaches are embodied in educational campaigns, social marketing, visual feedback systems, information campaigns, incentives, variable pricing schemes, technological developments, standardization and labelling (Shove 2003, Jackson 2005). The individual is the central unit of analysis in such linear attitude-intention-behaviour models which fail to robustly address social, cultural and contextual factors.

Developed in response to criticism of the individualistic approach, the systemic paradigm shifts focus from individuals to wider institutional actors such as organisations, companies and local authorities and relies on the principles of physical and environmental determinism; that desired behaviour can be achieved through the appropriate environment, infrastructure and technology in line with stringent regulation (Spaargaren, 2011). However this approach neglects consideration of individual's capabilities and the dynamics of social life. What is termed the agency-structure debate has emerged, highlighting the limitations of both the individualist and systemic paradigms. Sociological, practice-based theories offer a more balanced approach to addressing unsustainable patterns of consumption and lifestyles. Neither individualistic nor structuralist, focus is shifted from the individual to everyday practices whilst practices are considered entities, 'performed' by individuals or 'carriers' (Reckwitz 2002).

SPT provides an opportunity to reframe how occupants are analysed. Warde (2005) notes "*the principal implication of a theory of practices is that the sources of change behaviour lie in the development of practices themselves*" (140). This paper evaluates the application of SPT in understanding occupants in the specific context of sustainably designed office buildings, contributing to empirical research in this field.

Sustainable office buildings and their occupants

Heerwagen (2000) contends that office buildings are widely considered as a strategic means to achieve corporate ends. Sustainably designed offices may not only showcase the company and its 'Corporate Social Responsibility' policies, but may reduce emissions and resource consumption costs, increase productivity, health, comfort, well-being and provide a future strategic asset. Post Occupancy Evaluation (POE) is increasingly undertaken to provide a systematic review of buildings in occupation, however in the context of office occupants focus is typically limited to issues

³ Post Occupancy Review of Buildings and their Engineering

impacting on productivity (Stevenson 2009). Building Use Studies (BUS) methodology, developed within the PROBE studies, has been widely applied to gather data regarding occupant satisfaction in sustainable office buildings (Sawyer *et al.* 2008, Choi *et al.* 2012, Hauge *et al.* 2011, Steemers and Manchanda, 2009). Contemporary environmental policy places responsibility on individuals through the encouragement of 'green' purchasing, waste reduction, promoting efficiency through the adoption of 'green' technology and personal sacrifice (Shove 2010:1277). However, the influence of social context must not be disregarded "*individuals do not exist in a social vacuum...in some cases the surrounding context overrides all...cognitive factors*" (Hargreaves, 2011: 81). Theories of practices address issues of how demand is constituted and changed. SPT offers an alternative to individualistic models and may provide opportunities to reduce the performance gap through an understanding of practices.

Theories of Practice

Theories of practice are grounded in the works of Bourdieu (1977) and Giddens (1984), and propose a balanced cultural theory of social action and order. Practice theories regained prominence through a second wave of practice theorists (Reckwitz 2002, Schatzki *et al.* 2002, Shove 2003, Shove 2010, Shove *et al.* 2005, Warde 2005). Whilst there is no universal 'practice theory' Schatzki (2002) notes practice theories offer a perspective which is neither individualist nor holist, encompassing interactions between knowledgeable and capable individuals and social structures, such as technology, infrastructure and institutions. Reckwitz's (2002) widely cited definition of a practice describes "*a routinized type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.*" (Reckwitz 2002: 249). Elements are interconnected and converge over time to shape practices.

Practices may be analysed as entities however in order to exist, practices must be reproduced in daily life. The role of the individual is as the 'carrier' of the practice, notwithstanding that the individual is a "*knowledgeable and capable individual*" (Schatzki 2002: 2). Practices do not exist in isolation, they are dynamic and constantly evolving (Warde 2005, Shove and Pantzar 2012). For example, technology, economic growth and historical influences impact on practices. Individuals engage in multiple intersecting and overlapping practices. It is contended that interventions based on the isolated 'unsustainable' behaviours, will have limited success as they do not consider how practices are shaped and the totality of practices individuals are engaged in (Evans *et al.* 2012).

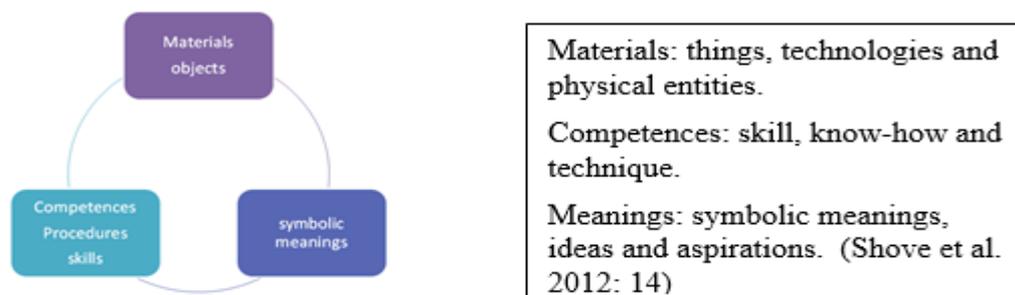


Figure 1: The Social Practice Framework

SPT has been applied to analyse diverse activities from Nordic walking (Shove and Pantzar 2005) to changes in the digitalization of music consumption (Magaudda, 2011). Criticism of the approach centres around limitations of its application to empirical data *"as general theories of practice...tend to be idealized, abstract, and insufficiently attentive to social processes involved in the creation and reproduction of practices"* (Warde 2005: 135). Analysis of practices is subjective, each theorist has *"their own unique understanding of how practices are constituted and reproduced"* (Strengers 2010: 6-7). How to undertake such analysis is also subject to wide debate amongst scholars. Reckwitz (2002) places the focus of analysis on the elements which constitute practices, Schatzki (2002) on connections between elements and Spaargaren and Van Vliet (2000) on links between practices, lifestyles and socio-technical systems of provision. Hargreaves (2011) contends that Shove and Pantzar (2005) provide an *"empirically helpful understanding of practices...that are dynamically integrated by skilled practitioners through regular and repeated performance"* (83). This approach is conceptualised in a Social Practice Framework (SPF, Figure 1) which deconstructs practices, comprising three elements: meanings; materials and competencies. This framework is adopted for analysis of initial findings in this paper.

SPT offers a perspective *"not only useful for studying stability in practices (Schatzki 2002) but also for gaining insight into how social change occurs."* (Halkier *et al* 2011: 9). This is of particular interest as moves to 'flagship' green offices are often presented as a catalyst, or in the language of practice theories 'points of disruption' to instigate a change in practices in work-related consumption routines. Focus is shifted from persuading or educating individuals to change their behaviours, to understanding the potential to render practices more sustainable. The findings which follow set out the potential of SPT for the analysis of the practice of moderating comfort within sustainable office buildings.

METHODOLOGY

Individualistic approaches often utilise self-report questionnaires, potentially subject to social desirability effects (Burgess *et al.* 2003). Shove (2003) notes that questionnaires seek to understand gaps or barriers and may imply individuals are simply awaiting 'better information' in order to make 'better' decisions. SPT however, necessitates a deeper, contextual understanding of actions in situ. A more complex understanding of daily life, as it is conducted, is required (Hargreaves, 2011).

In order to provide a more complex understanding of everyday practices in context, ethnographic research was undertaken. Ethnographic research aims to *"understand parts of the world as they are experienced and understood in the everyday lives of people who actually 'live them out'"* (Cook and Crang 1995: 4). Payne and Payne (2004) define ethnography as *"the production of highly detailed accounts of how people in a social setting lead their lives, based on systematic and long-term observation of, and conversations with, informants."* (Payne and Payne 2004:71). Ethnographic observations were undertaken at multiple case study sites, providing *"multiple measures of the same phenomenon"* (Yin 2003: 99). Three BREEAM 'Excellent' certified sustainable office buildings in England were selected as case studies (see Table 1).

Key practices were selected following a review of BREEAM Excellent criteria, reflected in the physical design of each case study building and linked to user interaction. Initial participant observations have been carried out over a 4 month

winter-spring period which will be supplemented by further observations over the following 8 months allowing seasonal variations to be taken into account. A field diary was used to record observations which were then thematically coded to identify key issues and core themes underpinned by the SPF.

This paper discusses initial findings surrounding the social practice of moderating comfort and lies within the scope of what is termed by Shove (2003) "*aspects of everyday life that are moving in increasingly resource intensive directions*" (Shove 2003: 17).

Social Practice Framework Analysis

As previously noted, the SPF is a starting point for the analysis of practices, providing a means to deconstruct a practice. Findings have been analysed in line with this structure, presenting the three elements of SPT: meanings, materials and competences.

Moderating Comfort - Meanings

Meanings in SPT are dynamic, shared understandings which "*emphasize tacit and unconscious forms of knowledge and experience through which shared ways of understanding and being in the world are established, through which purposes emerge as desirable and norms as legitimate*" (Shove et al. 2012: 12). In the context of sustainable office buildings, Monfared and Sharples (2011) contend that these buildings hold embedded meanings for their occupants, such as providing a 'green' solution whilst meeting conventional comfort expectations.

Findings suggested meanings associated with 'intelligent' buildings. For some respondents, across all buildings, the benefits of occupying a sustainable office were that the building would 'deal with' resource issues. The FM team were considered to be the gatekeepers of the building, with occupants powerless. One member of the FM team described the response of occupants to changing internal temperature "*the first hot day the windows opened and within 3 minutes I had HR on the phone 'we're freezing. We've all got our jackets on.'*" (Building A, FM team, female).

Perceptions surrounding building complexity were also reflected by members of FM teams who described complex buildings which 'the average' occupant could not comprehend. In the case of Buildings A and B, this may be linked to insufficient handover systems, as discussed later in this paper.

Meanings also centred on certain levels of comfort as a minimum working right; that a sustainable building should deliver a minimum 'understood' temperature (Shove, 2004), thus, "*There is more to comfort than temperature but exactly where the expectations lie along this range is, largely, a matter of culture and convention.*" (Chappells and Shove 2005: 33).

Meanings around temperature were also visual and linked to elements of competency; occupants of the buildings know how to dress, reflecting their understanding the temperature a sustainable office should maintain.

Positive findings around pride occupying a visibly 'green' building were noted. Respondents were demonstrably proud of their buildings, and the associated green status. This may also be linked to external practices of organisational loyalty. Some occupants perceive the sustainable building as flattening organisational hierarchy, not only in terms of the open plan design in all buildings, but in the shared experience of comfort. One occupant stated "*the acoustics in this building are really odd, sometimes*

it's really hard to work, especially if they are holding events in the atrium, but we're all in it together, even the CEO" (Building, B full time employee, female).

Table 1: Overview of case study office buildings

	BREEAM Cert.	Time in occupation	Floor area (sqft)	Single/Multi Tenanted	Key sustainable physical design features
Building A	Excellent	18 months	26,000 (over 3 floors)	Single- tenanted	Building Management System (BMS), regulating temperature - air exchange and heating, photovoltaic (PV) panels, motion sensor lighting, low useage water systems, solar shading, atrium, open plan with meeting rooms, limited car parking, cycle storage and changing facilities, city centre location.
Building B	Excellent	8 years	76,500 (over 2 floors)	Single- tenanted	BMS regulating temperature - natural ventilation, air exchange and heating, PV panels, motion and daylight sensor lighting, atrium, open plan with meeting rooms and café, limited car parking, cycle storage and changing facilities, town centre location.
Building C	Excellent	3 years (varies according to tenant)	61,000 (over 2 floors)	Multi- tenanted	BMS regulating temperature, natural ventilation, PV panels, Biomass boiler, motion sensor lighting and dimmer-switch street lighting, automatic meter reading, open plan with atrium and café, limited car parking, electric car charging points, changing facilities, city fringe location.

Building B is in the process of establishing a Green Team, each team member will be responsible for setting targets and encouraging colleagues to reduce energy, waste, water and travel more sustainably. However, some respondents commented "*support for the Green Team is not as strong as you would expect*" (Building B, member of Green Team, male). Other respondents confirmed this view, indicating that it was only certain "*keen green types*" who became involved in the Green Team. It is interesting to note the focus of the Green Team on resources and not the services consumed. Membership may be considered elitist; only environmental enthusiasts participate. Findings support the contention that in examining any single element of a practice, a full understanding of the practice is not gained.

Moderating Comfort - Competences

In examining meanings above, a number of interlinking competences were identified. Competences are embodied skills, know-how and techniques required to undertake

practices (Shove *et al.* 2012). Policy and schedules also impact on the development of required competences.

Initial findings highlighted the importance of understanding the sustainable design features of the office buildings. FM Teams in Buildings A and B described very limited handover processes, where cursory information and training were provided on technical systems. Both teams described a slow process of on-site learning, facilitated by informal discussions with sub-contractors. Building C had a more comprehensive handover and a Project Manager remained with the building following completion and handover, undertaking the role of FM.

Building A offered a building tour to all new occupants to encourage them to adapt their behaviour in line with the sustainable features of the building, although no Building User Manual (a requirement of BREEAM) existed. Building B also offered a tour to new occupants; however this often did not happen. New and existing employees in Building B rely heavily on the organisation's intranet for information regarding sustainable features. It was noted, however, that some respondents identified an inability to access this information and linked this to feelings of powerlessness. Another competency that is needed is an understanding that some automated controls can be overridden; lighting in meeting rooms once activated remains illuminated for 20 minutes once occupants have left the room (Building B). Occupants are able to override this feature by simply turning off the lights manually, however most do not as they *"think the building will do everything for them"* (Building B, FM, female).

Understanding occupancy hours appears to be a highly contextualised issue in each building. Building A operates the strictest core working hours, however flexible home working can lead to difficulties in maintaining passive heat (Building A, FM, male). Building B has highly flexible hours as does the multi-tenanted Building C. One respondent in Building B noted that although the office remains open until 8pm, the majority of occupants *"like to start early, and leave early as most people don't live here and have trains to catch or long car journeys, they want to miss rush hour"* (Building B, FM, female), however the building continues to operate as if it were at full occupancy until 8pm regardless of how many occupants are working. Findings show that competences may impact on the practice of moderating comfort and links between elements of practice begin to emerge.

Moderating Comfort - Materials

The final element considered in this deconstructed framework is materials. Materials refer to the physical entities which are implicated in the production and reproduction of practices (Reckwitz 2002, Shove and Pantzar 2005). Materials in findings relating to moderating comfort include BMS regulating temperature in all case study buildings, cooling and heating systems, motion controlled lighting and override controls, and windows, automated or manually operated. Materials also extend to technical regulatory requirements. Materials other than technical equipment are also important for moderating comfort, including in Building B, the provision of branded fleeces for all employees to wear in cooler temperatures. Meanings surrounding organisational loyalty may be important here. Storage areas for clothing encourage occupants to bring in clothing to respond to temperature changes and create a *"cardigan culture"* (Building C, Tenant, male), although meanings around this type of working uniform appear to be mixed.

Interrelatedness between the elements

Having examined findings in the deconstructed SPT framework, links between the elements of practice are emerging. For example, whilst occupants are able to control their own comfort, meanings associated with feelings of powerlessness over comfort in the building and a lack of required competences can subvert this ability. It is vital to reconstruct practices by understanding how elements interlink, the existence of a practice *"necessarily depends on the existence and specific interconnectedness of these elements and...cannot be reduced to any one of these single elements"* (Reckwitz 2002: 250).

DISCUSSION AND CONCLUSIONS

In analysing initial findings, the potential of SPT as a framework to understand occupants of sustainable office buildings has been considered. SPT provides an opportunity to contextualise the physical features of sustainable buildings. Shove and Pantzar (2005) note that it is not simply by designing a product, or in the context of this research, constructing a sustainable office building, that design intent is realised. Carriers of the practice are essential to shifting the practice from an abstract entity to a practice existing in its own right. This may involve the establishing of new links between elements of practice or the breaking of existing links.

Hypothesised links between elements of practices and between intersecting practices may be drawn from findings. Changing working routines and practices may be tangled up with a desire to 'be green', with what understandings of 'being green' are, with tacit rules of Corporate Social Responsibility, with policy and regulations, with technological development and design, with organisational culture and historical working practices. This wide range of issues reflects Hargreaves' contention that individual agents alone may be incapable of bringing about change as they are merely carriers of complex practices (Hargreaves 2002).

In considering three sustainable office buildings as case studies, with similar design features, at different points in their occupancy life, a picture of occupancy over time may be generated and further research may identify elements of practice common to each case study. Moreover this study aims to address concerns that buildings must be occupied if they are to rigorously consider the impact of end users (Monford and Sharples 2011). The limitations of SPT however, must be noted, as this highly contextual analysis prevents generalisations which could be drawn from quantitative datasets, however, it is contended, that in order to change practices and reduce resource consumption, the complexities of daily life and patterns of consumption must be understood. Further research is required to give findings greater contextual depth.

SPT extends the analysis of 'ways of doing' to the development of culture and conventions. The historical significance of working practices and their future trajectories are implicit in the deconstruction of practices. It is contended that SPT permits a wider, more complex analysis of 'why' and 'how' workplace routines and practices are undertaken, and how these practices have developed over time (Shove 2004, Shove and Pantzar 2005, Strengers 2010). The role of material elements, such as the physical features of the building, can then be understood in the context of how technology and design shape practices and ultimately how ambitions of more sustainable working practices may be achieved.

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INVESTIGATING THE LEVEL OF AWARENESS OF BUILDING ASSESSMENT TOOLS IN THE CONSTRUCTION INDUSTRY OF BOTSWANA

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Environmental building assessment tools have been developed to measure how well or poorly a building is performing, or likely to perform, against a declared set of criteria, or environmental considerations, in order to achieve sustainability principles. Knowledge of environmental building assessment tools is therefore important for successful design and construction of environmentally friendly buildings for countries. The purpose of the research is to investigate the knowledge and level of awareness of environmental building assessment tools among industry practitioners in Botswana. One hundred and seven paper-based questionnaires were delivered to industry practitioners, including architects, engineers, quantity surveyors, real estate developers and academics. Users were asked what they know about building assessment, whether they have used any building assessment tool in the past, and what they perceive as possible barriers to the implementation of environmental building assessment tools in Botswana. Sixty five were returned and statistical analysis, using IBM SPSS V19 software, was used for analysis. Almost 85 per cent of respondents indicate that they are extremely or moderately aware of environmental design. Furthermore, the results indicate that 32 per cent of respondents have gone through formal training, which suggests 'reasonable knowledge'. This however does not correspond with the use of the tools on the ground as 69 per cent of practitioners report never to have used any environmental building assessment tool in any project. The study highlights the need to develop an assessment tool for Botswana to enhance knowledge and further improve the level of awareness of environmental issues relating to building design and construction.

Keywords: sustainability, building assessment tools, Botswana.

INTRODUCTION

Concerns about the negative impact of buildings on the environment have stimulated interest in the development and use of environmental building assessment tools. Environmental building assessment tools assess the impact of buildings on the environment such as CO₂ emissions from the buildings energy use. Therefore the assessment tools improve knowledge and environmental performance of building stocks (Reed *et al.*, 2011). During the building's stages of design, construction and use, environmental building assessment tools gather information and report on performance (Mateus and Bragança, 2011). The information is on performance of various attributes including resource usage, waste, pollution and energy and water efficiency. Accordingly environmental building assessment tools share the primary

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objective of stimulating the market demand for buildings with improved environmental performance (Lee and Burnett, 2006).

Knowledge of environmental building assessment tools and their assessment criteria is essential for their successful implementation. Goh and Rowlinson (2013) argue that training on environmental building assessment tools is essential to understand their contents. Hence, knowledge and awareness of green buildings practices and environmental building assessment tool's assessment criteria in particular is important (Todd *et al.*, 2013). The tools however can improve users understanding of environmental design in buildings.

The purpose of this study is to investigate the level of knowledge and awareness of the role of environmental building assessment tools in the Botswana construction industry. To achieve this, the following objectives have been considered; to assess user's awareness on environmental design and the source of knowledge of such awareness, to develop an understanding of their knowledge of building assessment and design using environmental building assessment tools, to determine how users perceive the importance and use of environmental building assessment tools and finally investigate possible barriers as perceived by users or potential users. This was to establish the basis for potential use of an environmental building assessment tool by the users in Botswana. In the context of the paper, building assessment is carried out to assess a building's ability to demonstrate its contribution to sustainable development by providing greater satisfaction to users, enhance and better protecting the natural environment and be water and energy efficient. Environmental building assessment tools are used primarily for these purposes.

ENVIRONMENTAL BUILDING ASSESSMENT TOOLS

Environmental assessment of buildings measure how well or poorly a building is likely to perform, against a declared set of criteria or environmental considerations (Cole, 2005). They can be broadly classified as qualitative or quantitative tools (Reijnders and Roekel, 1999). Qualitative tools are based on auditing of buildings as a whole and putting a score to each investigated parameter resulting in one overall score of a building (Forsberg and von Malmborg, 2004). Scoring in this regard emphasizes different aspects of environmental performance (Reijnders and Roekel, 1999).

Quantitative tools on the other hand use a physical life cycle approach, focusing on aspects of a building like energy, indoor environment, building materials etc.in a fragmented manner (Forsberg and von Malmborg, 2004) .Various qualitative environmental building assessment tools exists worldwide such as the UK Building Research Establishment Environmental Assessment Method (BREEAM),US Leadership in Energy and Environmental Design (LEED), Green Star Australia, Singapore Green Mark, SBTool, South African Sustainable Building Assessment Tool (SBAT) and Japanese Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), all of which are relevant to the country of design and use.

The use of environmental building assessment tools generally promotes sustainability in the built environment. Reed *et al.* (2011) argue that they improve sustainability knowledge in each country's building stock. Moreover Cole (2012) point out that the tools are instrumental in mainstreaming green building practices. Besides defining the attributes of green buildings in practice, Todd *et al.* (2013) argue that they promote market transformation. The tools have been used extensively in their countries of origin possibly to transform markets and improve green building practices. BREEAM

and LEED are regarded as market leaders and to date have certified over 250 000 buildings and 44 270 projects respectively in the UK and US (BRE, 2014, USGBC, 2013).

Despite these positive uses, there are perceived shortcomings of use of environmental building assessment tools. Reed *et al.* (2011) asserts that the use of environmental building assessment tools is a complex process crippled by bureaucracy, and consequently is prohibitively expensive. Moreover, they tend to be used as checklists for scoring points rather than promoting sustainability. The tools follow the specific country's building regulations and other guidelines like the quality standards (Haapio, 2012). As a result, performance requirements of the tools are different across countries. The different performance requirements could yield different performance results or attributes. Therefore there are different principles and concepts of building performance, which creates complications for those who want to invest in property in different markets (Dixon *et al.*, 2008). In spite of the challenges, environmental building assessment tools are used actively in construction industries across the world.

BOTSWANA CONSTRUCTION INDUSTRY

Economic and Employment Contribution

Botswana has experienced a steady economic growth since independence in 1966. In June 2011 total workforce was estimated at 387,426 employees (CSO, 2012). Of these, 23,347 were employed in the construction industry. Since 2004 to 2011 the construction industry contribution to total employment has been more than 5%. The construction industry's contribution towards GDP has also been averaging 5% between the years 2004 and 2011. In 2011 the construction industry contributed about 7.4 billion Botswana Pula to the national economy (BOB, 2012) (1Botswana Pula=0.071 British Pound).

Size of the Industry

Firms that intend to undertake public works are required to register with the Botswana Public Procurement and Asset Disposal Board (PPADB). PPADB classify construction firms into different categories according to their financial and human resources, skills and experience relating to past or similar projects. The contractors are classed into classes OC, A, B, C, D and E. Class OC is the lowest and E is the highest for building works. At the time of the study there were 1767 construction firms registered in all classes (PPADB, 2013). Consultants on the other hand are not classified on any size but rather on speciality. They are registered as consulting firms who provide architectural, building engineering, project management, quantity surveying, electrical and mechanical engineering services. Likewise there were 193 such firms registered with the PPADB at the time of the study.

Environment Legislation

The Ministry of Environment, Wildlife and Tourism has the overall responsibility of formulating and implementing environmental legislation. The current legislations were not specifically formulated for the construction industry but there are some that have nonetheless been applicable to the industry. These include; Environmental Impact Assessment Act 2011 Mines and Minerals Act 1977, Waste Management Act 1999, Atmospheric Pollution Prevention Act 1971 and National Monuments and Relics Act (DEA, 2013). The main legislation used for construction activities is the Environmental Impact Assessment Act.

METHODOLOGY

The study investigates the importance of knowledge and awareness of environmental building assessment tools by construction industry practitioners for successful implementation. A questionnaire survey was used in this study. The choice was made because questionnaires can be sent to many people who can fill them anonymously (Leedy and Ormrod, 2013). Furthermore they provide a reduced risk for bias due to the presence of the researcher, have wider coverage, and offer stable, consistent and uniform information with less variation (Sarantakos, 2005). The questionnaire comprised of four parts. Part one requested the profile of respondents. Part 2 was intended to ask respondents to rate their environmental awareness and the main source of that information. Part 3 asked respondents about their understanding of building assessment and its importance. Also they were asked about their knowledge of building design using environmental building assessment tools and the possible barriers to the implementation of environmental building assessment tools. Part 4 asked respondents about attributes that are important to assess environmental performance of buildings. All survey data was examined and analysed using IBM SPSS V19 software. A pilot study was conducted prior to the main study to test the suitability of the questionnaire

Forsberg and von Malmborg (2004) identified local authorities, architects, designers, consultants, building owners, investors and contractors as the main decision makers intended to use building assessment tools. It was the endeavour of the study to target those groups who have influence on the use of the assessment tools. Consequently in the study, groups of users including, building engineers, architects, construction/project managers, private developers, quantity surveyors, environmentalists, real estate developers, government employees and academics were purposively invited to complete the questionnaire. A total one hundred and seven questionnaires were distributed and sixty five were returned back as per Table 1.

Table 1: Summary of Respondents

Category	Respondents
Building Engineers	25
Architects	8
Quantity Surveyors	15
Construction/Project Manager	4
Private Developer	1
Government Employee	1
Researcher	1
University Lecturer	7
Others (Quality Controller)	3
Total	65

IBM SPSS V19 software was used for analysis and mostly data was analysed with descriptive statistics. The non-parametric Kruskal-Wallis test was conducted to determine whether there were statistically significant differences between users regarding knowledge of building design using environmental building assessment tools and their importance in design and construction. This was to determine whether there was any bias in rating from any categorised group and how significant it was. The Kruskal-Wallis Test tests whether the distribution of ordinal variables is the same in three or more groups by comparing the sum ranks (Norusis, 2002). Testing was done at 5% significance level. The grouping variable was position in the organisation. The study reports preliminary findings on an on-going research.

RESULTS AND DISCUSSIONS

Environmental Awareness

Responses show that 30.6% of the respondents are extremely aware of environmental issues pertaining to building design and construction (Figure 1). Majority of respondents (58.1%) however report moderate awareness. The remaining 11.3% were somewhat and slightly aware. There was no respondent who responded that they were not aware. There were however three respondents who did not answer the question so it is probable that they were not aware as well or they just missed the question. The level of awareness from the results indicates that in theory users understands the concepts of environmental building assessment tools.

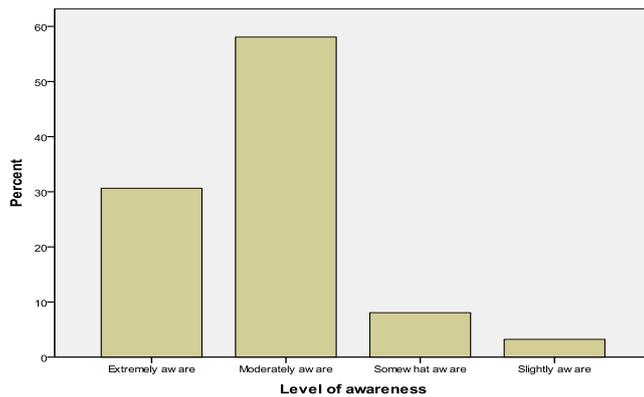


Figure 1: Level of Awareness

It was important to find where users get knowledge and awareness of environmental issues pertaining to building design and construction. As shown from Table 2, respondents reported the three main source of information as from building regulations, personal research and formal training. Formal training was reported in 32.3% of the cases which perhaps is indicative of reasonable knowledge. Building regulations was reported in 49.2% of the cases. This somehow suggests the building regulations include relevant information for environmental design and construction and perhaps could be relevant for use if an environmental building assessment tool could be introduced for use. Personal research at 36.9% of cases may suggest users have interest on environmental issues relating to building design and construction. The results points to interest of users on environmental issues related to building design and construction.

Table 2: Source of Information

Source of Information	Responses		Per cent of cases (%)
	N	Per cent (%)	
Formal Training	21	17.2	32.3
Building Regulations	32	26.2	49.2
Personal Research	24	19.7	36.9
Media Articles	18	14.8	27.7
Short Courses/Conferences/Seminars	10	8.2	15.4
Co-Workers	9	7.4	13.8
Clients	6	4.9	9.2
Other Sources	2	1.6	3.1
Total	122	100	187.7

Building Assessment

To appreciate the importance of using environmental building assessment tools, users have to understand what building assessment is. To assess the understanding of respondents regarding building assessment, respondents were asked “*what they understood by the term building assessment and its importance to the construction industry?*” The responses were varied and categorised into five themes including compliance to codes, feasibility study, building performance, quality assurance and environment protection. A combined 40% of responses mentioned that building assessment is primarily assessing the performance of buildings and protecting the environment as indicated in Figure 2.

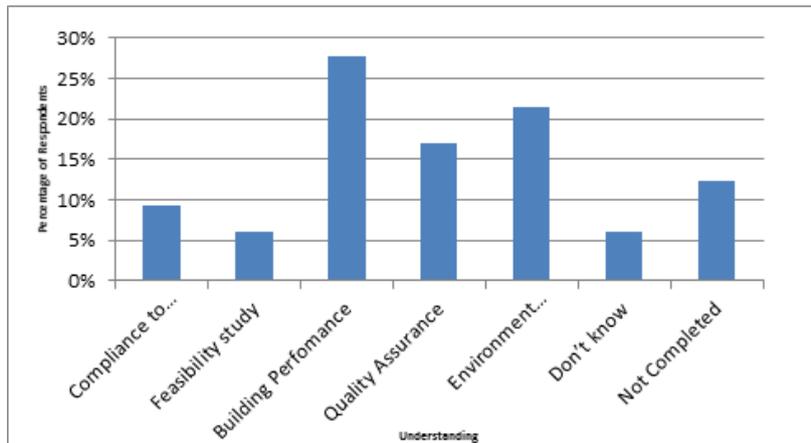


Figure 2: Users Understanding of Building Assessment

Most of the responses mentioned building assessment is monitoring the performance of buildings. Some of the excerpts from three users to illustrate this are recorded below:

Respondent 6: “*It’s about assessing the buildings in terms of the designs, environmental impacts as well as construction. It is important especially for quality assurance and environmental friendliness*”

Respondent 2: “*Building assessment is very broad but could mean checking for compliance to design codes and assessment for rating on standards e.g. LEED*”

Respondent 16 “*Enables the developer to determine materials used on the building and its effect on the environment*”.

In the context of the paper building assessment is carried out to assess a building’s ability to demonstrate its contribution to sustainable development by providing greater satisfaction to users, enhance and better protecting the natural environment and be water and energy efficient. The responses from users indicate that they are aware of the rationale of building assessment and attribute it mostly to assessing the performance of a building in view of protecting the environment and satisfying stakeholders through quality assurance of the building.

Knowledge of Building Design Using Environmental Building Assessment Tools

To design adequately for the environment, designers need to have adequate knowledge of using environmental building assessment tools. From Table 3 69.8% of respondents reported sufficient to excellent knowledge of building design using environmental building assessment tools. 27% reported they have insufficient knowledge and 3.2% reported they did not know of building design using

environmental building assessment tools. A Kruskal Wallis Test revealed no statistically significant difference in rating of knowledge of building design using environmental building assessment tools across the sampled groups, $\chi^2 = 6.765$, $df = 8$, $p = 0.562$.

Table 3: Knowledge of building design using assessment tools

Rating	Frequency	Valid %	Cumulative %
Excellent	6	9.5	9.5
Good	20	31.7	41.3
Sufficient	18	28.6	69.8
Insufficient	17	27.0	96.8
Do not Know	2	3.2	100.0

Test Statistics

Kruskal Wallis Test

$\chi^2 = 6.765$, $df = 8$, $p = 0.562$

Importance of Environmental Building Assessment Tools in Design and Construction of Buildings

In order to find the importance of environmental building assessment tools in design and construction of buildings, respondents were asked to rate on a scale of 1-5. One meant that environmental building assessment tools are not important and should not be a priority in design and construction while five meant that it was a priority. The results in Table 4 show that majority of the respondents believe that environmental building assessment tools are important in the design and construction of buildings. 68.9% of respondents rated 4 or 5 while the remaining 31.1% rated 3 or below. A Kruskal Wallis Test revealed no statistically significant difference in rating of importance of environmental building assessment tools in design and construction of buildings across the sampled groups, $\chi^2 = 8.280$, $df = 7$, $p = 0.309$.

Table 4: Importance of assessment tools in Design and Construction of Buildings

Rating	Frequency	Valid %	Cumulative %
1	4	6.6	6.6
2	4	6.6	13.1
3	11	18.0	31.1
4	22	36.1	67.2
5	20	32.8	100.0

Test Statistics

Kruskal Wallis Test

$\chi^2 = 8.280$, $df = 7$, $p = 0.309$

Use of Environmental Building Assessment Tools in past projects

Sixty nine per cent of respondents reported never to have used any environmental building assessment tools in past or present projects. This when compared with the level of awareness where more than eighty per cent have reported extreme or moderate awareness shows a gap between awareness (theoretically) and implementation. Environmental building assessment tools are used to measure

environmental performance of buildings during design and construction. Therefore, adequate awareness and knowledge should perhaps translate into implementation.

Users reported awareness of existing environmental building assessment tools from elsewhere. BREEAM was reported in 21.5% of cases. This was followed by both LEED and Green Star Australia at 18.5% of cases each. The South African SBAT was only reported in 7.7% of cases. SBTool and CASBEE were reported in 6.2% and 1.5% of cases respectively. Majority of cases however points out that respondents are not aware of any environmental building assessment tool with 52.3% of cases reporting such. Knowledge of the environmental building assessment tools is likely from formal training and personal research.

Possible Barriers to Implementation of Environmental Building Assessment Tool

Successful implementation of environmental building assessment tools may sometimes be hindered by certain barriers. Consequently identification of those barriers is important for the successful implementation of environmental building assessment tools. Respondents were asked to state possible barriers to the implementation of environmental building assessment tools and Table 5 show the responses. Lack of knowledge and prohibitive costs were cited as the biggest possible barriers accounting for 33.8% and 30.8% of cases respectively. Lack of awareness at 24.6% of cases was cited at the third biggest barrier. A sizable number (20.0%) of cases were not completed.

Table 5: Barriers to Implementation of environmental building assessment tools

Barriers	Responses		Per cent of cases (%)
	N	Per cent (%)	
Lack of Knowledge	22	22.2	33.8
Corruption	5	5.1	7.7
Costs	20	20.2	30.8
Lack of Information	5	5.1	7.7
Lack of Resources	1	1.0	1.5
Lack of Standards/Legislation/Regulations	7	7.1	10.8
Lack of Technology/Technical Skills	4	4.0	6.2
Construction Industry Informal	1	1.0	1.5
Political/Government Support	5	5.1	7.7
Lack of Awareness/Ignorance	16	16.2	24.6
Not Completed	13	13.1	20.0
Total	99	100.0	152.3

CONCLUSIONS

The study has found that users deem environmental building assessment tools important for assessing environmental performance of buildings. The fact that no environmental assessment tool been developed in Botswana did not prevent users from acquiring knowledge through other means. Most of the users reported that they are aware of environmental issues related to building design through personal research building regulations and formal training. It is indicative of positive interest and likelihood for successful introduction of an environmental building assessment tool.

This is in line with Goh and Rowlinson (2013) assertion that understanding and knowledge of environmental building assessment tools will lead to their use.

The Kruskal-Wallis Test conducted did not reveal any statistically significant differences between users regarding knowledge of building design using environmental building assessment tools and their importance in design and construction. All groups were in agreement in their rating to the statements, which shows no bias from any group. The results indicates that majority of users perceive environmental building assessment tools important in design and construction of buildings. In addition, most users have sufficient to excellent knowledge in building design using environment building assessment tools. Despite their knowledge, fewer users have used environmental building assessment tools in past projects. Therefore, there is limited practical experience using environmental building assessment tools.

Possible barriers for successful implementation however highlight the practical challenges of using environmental building assessment tools. It is not surprising therefore that lack of knowledge, lack of awareness and costs are deemed the biggest barriers. This is in line with previous studies, for example Reed *et al.* (2011) who argued for the prohibitive costs of using environmental building assessment tools.

Environmental building assessment tools have been found to transform green building practices (Todd *et al.*, 2013). This perhaps presents a case for the development of such tool which will not only monitor and assess environmental performance, but transform green buildings practices. It could further enhance the knowledge and awareness of users on environmental building design. To conclude, there is an indication that knowledge and awareness of users in Botswana is adequate for the introduction of an environmental building assessment tool. The assessment tool may further enhance that awareness and knowledge and may result in transformation of green building practices in the Botswana built environment. However, it has to be driven by Government since there is no competent body to drive it forward in contrast to other countries where there are Green Building Councils which can act in this capacity.

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IDENTIFYING PROJECT SUCCESS CRITERIA FOR UK SOCIAL HOUSING ASSET MANAGEMENT SCHEMES

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Embedding the principles of sustainable development and sustainable communities into social housing organisations represents one of the biggest challenges faced by the sector over the last decade. The increasing recognition of the limitations and failings within existing practice has led to calls from both external policy stakeholders and the National Housing Federation for project appraisals to consider an ever increasing number of non-financial benefit enhancing features of UK social housing projects. An important stage in this transformational process will be the identification of the main project centric criteria against which community benefit can be appraised. Relevant literature relating to sustainable communities is reviewed, resulting in the identification of over 400 theoretical features of neighbourhood sustainability. In an attempt to refine these criteria into a more pragmatic list the results of 11 semi-structured interviews held with senior professionals drawn from across one typical social housing organisation, together with the results of 7 validating interviews are reported. Analysis of the collected data established an emergent list of 6 principal success criteria and a further 49 sub-criteria against which project centric benefit can be appraised. The paper concludes by proposing further work relating to the development of a suitable methodology for the appraisal of community benefit in practice.

Keywords: social housing, asset management, sustainable communities, project success.

INTRODUCTION

Since the 1960s the UK government has sought to confront and eradicate the problems associated with poor neighbourhoods and the social exclusion often suffered by ensnared residents by implementing top-down housing focused renewal initiatives across all housing tenures. The principal aim of these interventions was to improve the sustainability of communities through the eradication of sub-standard housing. Yet research undertaken by the Social Exclusion Unit (2000:7) suggests the vast majority of these schemes have, at best, had a limited impact on the communities they sought to help. With improvements in housing conditions, employment and crime often patchy and short-lived. As a result, many of the deprived communities targeted have since reported increasing levels of social exclusion and stigmatisation (Robinson *et al* 1998).

The problem now facing social housing providers is how to overcome these challenges and ensure the mistakes of past are not repeated by organisations seeking

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to quickly transform their stock through a combination of physical improvement, stock rationalisation and ultimately reduction (Kempton 2010; Morrison 2013) in order to respond to the fast changing business environment (Sommariva and Patel 2013). Consequently, the quest for sustainable asset management calls for an exploration of new ways of evaluating projects to ensure they better address the needs of the community.

The work in this paper makes the case for the consideration of a range of project success indicators linked to the potential community benefits offered by successful asset management. The paper is structured so that relevant literature related to project success indicators, social housing asset management and sustainable communities are reviewed to establish current levels of knowledge and make the case for further empirical data to be collected through 18 semi-structured interviews. The work concludes by proposing a range of potential socio-economic project success criteria for use by social housing organisations.

LITERATURE REVIEW

Asset Management in the Social Housing Sector

The Royal Institution of Chartered Surveyors (RICS) defines asset management as the:

"Process which aligns business and property strategies, ensuring the optimisation of an organisation's property assets in a way which best supports its key business goals and objectives" (White and Jones 2012).

Yet what the term asset management means for social housing providers has been the focus of some debate. Guris and Neiboer (2004) and, more recently Morrison (2013) have alluded to the existence of two distinct schools of thought. The first, aligning with the definition provided by the RICS and other seminal sources, suggests asset management to be a highly market orientated and commercial process, whereby the organisation strategically repositions its stock in order to effectively manage financial returns. Whereas the second school of thought views asset management as a largely task-orientated process, whereby social housing organisations do not proactively seek out commercial opportunities but restrict themselves to performing traditional social housing tasks such as managing the organisations existing assets and addressing the needs of their tenants (Neiboer and Gruis 2014). Despite the clear differences in approach, it remains unclear where the UK social housing sector is positioned following a decade of substantial reform. For example, Albanese's (2007) evaluation of three case study organisations, using a mixture of data collection strategies, suggests the UK social housing sector has started to adopt a 'market orientated' approach. Whereas Gibb and Trebeck's (2009) extensive evaluation of four social housing organisations operating in the North East of England suggests that as providers individually respond to the difficulties associated with sector transformation, not all are adopting a 'market orientated' approach to asset management.

In the context of this research, however, asset management was seen as a 'market orientated' activity whereby emphasis is placed on a broad range of activities, including the speculative development of affordable housing in a diverse range of geographical areas, continuous renewal of its products and services through ongoing improvement and regeneration of their existing rental housing stock and the

enhancement of social return, a traditional objective of such organisations (Albanese 2007; Gibb and Trebeck 2009; Nieboer and Gruis 2014).

The case for appraising the Success of Asset Management Projects

Over the last two decades there has been a growing recognition that social housing providers cannot invest in housing alone, it is now imperative that organisations recognise the importance of generating a financial return whilst also having a successful and sustained impact in the communities they serve in order to create successful neighbourhoods (Mullins 2010:3). Clearly, this requires the asset manager to look beyond simple housing investment as suggested by Kempton (2010) and take account of the wider economic, social and environmental needs of the community.

This assertion is however not a recent one, as early as 1981 academics were identifying the limitations of existing approaches to asset management. The seminal work of Bell (1981) called for an increased recognition of the importance of considering the wider estate when evaluating potential asset management interventions. An argument reaffirmed in Coleman's (1985) highly influential, yet controversial study of two social housing estates in London. Like Bell, Coleman was highly critical of the existing asset management approaches, which she asserted did little more than "*restore the estate to something like its pristine condition with all its detrimental designs intact and able to exert the same malign influence that they did from the start*" (Coleman 1985:122). An argument reaffirmed in later studies such as Power's (1999) highly regarded evaluation of 50 social housing estates across five European countries and Lupton's (2003) evaluation of 12 declining neighbourhoods located throughout England.

Regrettably, however, despite the growing evidence supporting community centric or sustainable asset management, social housing organisations are continuing to default to bricks and mortar led strategies to the exclusion of the needs of the communities within which the physical structures are located (Haran *et al* 2011). Due in part to the difficulties associated with interpreting and measuring the success or otherwise of a project (Higham and Fortune 2011).

Project Success

Delivering project success for the client is a key duty of the Project Manager, with project success ultimately defined as the project managers' ability to control time, budgets and resources over the projects life cycle. Abeysekera and Mclean's (2001) qualitative research undertaken with 5 senior project managers in New Zealand, suggested, success is, however, more narrowly measured, with a successful project being accepted as one delivered within a pre-determined time schedule whilst not exceeding the client's budget. Yet Cooke-Davis (2002) asserts that such measures are really only testament to the project managers' ability rather than actual measures of success. With success, ultimately being measured against the overall project objectives, which may not be synonymous with the effectiveness of the project manager. Muller and Turner (2007) however, suggest project success can be divided into success factors and success criteria. Success factors are defined as those aspects of the project that are most likely to influence eventual success. Whereas success criteria are the project attributes against which eventual success is determined.

Gunathilaka *et al*'s (2013) evaluation of 180 academic papers identified in excess of 600 potential measures of project success, leading the researchers to question the validity of the evidence, give both the lack of empirical data presented in the papers

together with the researchers' obsession with identifying further measures of success. Rather than deepening our understanding of their impact, in real world situations through empirical analysis. However, a more detailed appraisal of the potential success factors identified in Gunathilaka *et al's* (2013) work identified that the majority of the existing indicators focused on the appraisal of relatively standardised criteria associated with mainstream construction projects. Which were unlikely to be applicable to asset management projects undertaken in the social housing sector, given the strong focus placed on, amongst other things, the enhancement of social value.

Success criteria for social housing asset management

Despite the unsuitability of existing project success criteria to the appraisal of social housing projects, there has been considerable activity in the development of frameworks for the implementation of sustainability within the built environment, and specifically in relation to the delivery of sustainable construction projects. Amongst this body of published works are a number of studies attempting to map the key attributes of sustainable communities.

This growing body of work includes Long and Hutchins (2003) mapping of key attributes of sustainable communities, the work identified nine principal or high level features of sustainability together with an additional 49 lower level attributes. The work was later placed at the core of guidance issued by both the Housing Corporation and the Office of Deputy Prime Minister for the delivery of sustainable housing projects. Sir John Egan's (2004) government commissioned review of the skills required to implement sustainable communities identified seven essential attributes including: social and cultural wellbeing, strong governance, environmental awareness, enhancement of the built environment, improved transport and connectivity, a strong local economy and access to services. Together with 46 lower level success indicators for the creation of a sustainable community although he failed to articulate how these features would be measured. Treanor and Walker's (2004) mixed method study using a combination of secondary data, derived from both policy guidance notes and academic outputs, supplemented with primary data collected from the examination of neighbourhood profiling models developed and implemented by five case study organisations identified in excess of 80 socio-economic indicators they suggest could be adopted for the appraisal of existing neighbourhoods. The comprehensiveness of the existing body of evidence, which identifies in excess of 500 possible success criteria for social housing projects has resulted in social housing providers having to make difficult decisions as to which aspects of the guidance were most relevant to the creation of a sustainable community and those which should be rejected in any appraisal of eventual success.

Latterly Turcu (2013) attempted to refine this complex list of indicators, into a shorter, more pragmatic set of 26 success criteria for housing led regeneration projects delivered as part of the Housing Market Renewal Fund (HMRF). Despite the work, reducing the vast array of potential indicators to a more pragmatic set of 26. To develop the pragmatic set of urban sustainability indicators, data was collected from private homeowners living in previously regenerated communities in the north of England using structured interviews, before being independently by regeneration experts drawn from academe and local government. Despite the robustness of the methodology and appropriateness of indicators, it remains unclear how these factors would translate across to the social housing sector, where due to differences in project deliverables, funding methodologies and spatial complexity with HMRF operating at a

regional rather than primarily local level, the project success criteria required are likely to be significantly different.

The literature reviewed above has examined the development of models, frameworks and toolkits that have been developed to assist professionals appraise the likely outcome of housing-led regeneration projects in the UK. The lack of consensus on the nature and extent of the attributes of the relevant project related sustainability factors to be measured together with the conflicts between the models proposed, in terms of both their detail and in the nature of their overarching features, indicated that further work was needed. As a result, this study resolved to establish the more significant of the over-arching features of sustainability that could be adopted by practitioners as potential measures of success for planned maintenance, stock rehabilitation and other major asset management schemes undertaken by UK social housing providers.

RESEARCH APPROACH

The research reported, set out to identify the features of sustainability against which possible housing projects can be evaluated and success determined at the level of delivery in the social housing organisation. To meet the objectives of the study, the researchers adopted an interpretivist philosophical position making use of an inductive research strategy and a qualitative case study methodology. Yin (2014) identifies two main approaches to case study research – single case or multiple case designs. The wider literature suggests that a multiple case approach is arguably more robust, although Yin argues that the single case study approach is justifiable when, inter alia, the case is representative or typical. The disparate nature of asset management and investment appraisal in the social housing sector (Guris and Neiboer 2004), together with the widespread differences in the asset management approaches adopted by UK social housing organisations (Albanese 2007; Gibb and Trebeck 2009) called the suitability of a multiple case study design into question. As a result, a single case study based on a 'typical' medium sized registered social landlord was deemed to be the most appropriate approach for this study. However, to strengthen the validity of the research, the findings were exposed to external verification, through a second round of semi-structured interviews.

Interview Design and Sample Selection

To achieve a balanced view within the case study, it was considered relevant to draw a sample of those directly involved, at a senior management level, with the delivery of sustainable communities. As such, a sample of convenience consisting of eleven senior managers was drawn with assistance of the director of asset management. The participants were invited to take part in a semi-structured interview held, at their offices and lasting approximately 45 minutes. The aim of the interview was to establish the meaning and values associated with the terms 'sustainability', 'sustainable development' and 'sustainable communities' to explore how the features identified could be incorporated into major asset management projects, in the hope of creating sustainable communities. Following transcription and analysis using Nvivo qualitative software the initial findings were subjected to external validation by a panel of seven asset management experts drawn from other social housing organisations. To ensure the validity of the sample, the seven experts were selected from organisations listed in the 2013 National Housing Federation directory of members using discriminate sampling. The adoption of discriminate sampling allowed the researcher to maximise the opportunity of collecting relevant data from a small sample by ensuring the sample reflected the overall population (Punch, 2014). In this case, the sample was

discriminated based on type, size and location, with only those organisations within a 100 mile radius of Sheffield selected.

DATA ANALYSIS

The analysis used open coding to identify the various sub-categories associated with the central themes identified from the literature. The first phase involved open coding the data. Once a large number of nodes had been identified, axial coding revealed relationships between nodes and sub-nodes. As the analysis continued, each category was developed to reflect the content of the data collected and draw out more detailed categories within each area. In developing this process, the data was repeatedly analysed. Through this process the initial themes were distilled into six overriding categories containing 49 sub-themes or potential project success indicators which could be adopted for the appraisal of social housing asset management projects.

Feature 1: Built Environment

As expected, the physical and financial characteristics of the housing stock are critical to the evaluation of project success. Various constraints associated with the existing stock appear to frustrate the sector's ability to provide the quality and type of housing to which they aspire. However, as interviewee 4 identifies, this was not simply a case of an unwillingness to accept housing which had not met the minimum standards for decent homes compliance. It was more importantly, prospective tenants raising concerns about the design, layout and the mix of housing within particular estates. All the interviewees suggested no amount of rehabilitation would be successful if issues relating to the size, type and layout of the stock were not addressed. For example, the director of regeneration cited an example of a successful rehabilitation scheme in an area with a large black and minority ethnic (BME) community. Where the housing stock was transformed from typically 2 bedroom flats and 3 bed roomed houses, too 5 or 6 bed roomed properties specifically targeted towards the BME community. Finally, a number of interviewees identified the importance of eradicating fuel poverty by targeting investment towards improving the thermal performance of the existing stock and retrofitting renewable technologies. Whilst interviewees 3 and 4 suggested the effects of rehabilitation on reactive maintenance costs, especially those associated with tenancy churn would be a significant indicator of success.

Feature 2: Local Environment

The interviewees suggested the design and management of the immediate local environment was fundamental to the success or otherwise of a neighbourhood, with perceptions of the neighbourhood heavily influenced by the levels of social malice, including littering, graffiti and vandalism encountered. However, the interviewees suggested these levels of social malice were often exacerbated by the layout and design of the immediate environment, with features such as poor lighting and narrow alleyways both increasing residents' fear of crime, whilst acting as a magnet for ever increasing levels of littering, fly tipping and vandalism. The lack of designated car parking (on or off road) and the provision of large private gardens to the front and rear of the properties were also met with hostility by a minority of residents. Some of whom viewed the garden as just another aggravation. However, some of the interviewees opined that a greater number of residents simply decided to ignore the garden because of either the appearance of the neighbourhood or their lack of pride or interest in the community. Yet, other suggested this situation could also be seen working in reverse. Indeed interviewee 9 had observed in communities with a strong

sense of pride and commitment, this had motivated even the most reluctant resident to make an effort. Yet for the social housing organisation, these issues can have a catastrophic effect on the commercial viability of the neighbourhood. Leading to a situation similar to that purported by broken window theory, whereby the problems escalate uncontrollably, further negatively affecting the appearance of the neighbourhood. Yet as interviewee 11 pointed out, improvements to the local environment alone would be unlikely to trigger a substantial and sustained improvement in community, however, were these improvements undertaken alongside other activities, it was highly likely they would make a substantial contribution.

Feature 3: Market Demand

Unsurprisingly, the first major issue identified was the demand for the neighbourhood. Interviewee 1 opined that higher demand neighbourhoods would receive significantly higher levels of investment; however, any investment would be invariably concentrated on increasing supply. Interviewee's 6 and 7, however, challenged this view, opining that, in the current marketplace all neighbourhoods, good or bad, were over-subscribed. Yet, interviewee 5 asserted that despite this upward trend in demand, some estates continued to exhibit low demand and unpopularity. With high levels of churn, short tenancy durations and longer than average void periods resulting from higher than average numbers of tenancy refusals, despite the length of the waiting list.

Although the organisation actively monitors the demand statistics as part of its strategic asset management planning, the interviews revealed a number of contributory issues, which would need to be considered if stock investment were to be proposed in response to falling demand. Indeed a number of the interviewees suggested that whilst day-to-day housing management issues such as 'problem tenants' would normally fall outside the scope of asset management, in some neighbourhoods, the dominant stock type was exacerbating housing management problems. For example, an abundance of flats would invariably attract socially excluded, problematic or transient tenants triggering to higher levels of churn. However as interviewee 11 commented, the resulting effect of such high levels churn is often the destabilisation the wider community, leading to increasing turnover and harder to let housing as the neighbourhood's reputation is diminished.

Feature 4: Local Economy

In addition to the physical characteristics of the housing stock and the design of its immediate environment, the interviewees highlighted the importance of the local economy to the sustainability of the neighbourhood and the success of future asset management interventions. A number of the interviewees highlighted the impact of benefit dependency and unemployment on the community. Suggesting the implications of high levels of benefit dependency together with the ongoing reform of the benefit system was severely affecting the organisation, with an increasing number of tenants facing financial difficulty and ultimately eviction.

As a result, the social housing provider identified itself as having a significant social obligation to enhance the employment opportunities in the local community. Examples of ways in which the organisation attempted to achieve this objective included investing in craft training facilities alongside its housing led regeneration activities, whilst also encouraging contractors to localise their supply chains and provide both short work placements and apprenticeships. Indeed interviewee 1 suggested that on one £4m affordable housing development this and similar initiatives

had resulted in £850,000 of community benefit and the creation of eight permanent posts. Whilst the development itself enhanced tenure diversification within the community, which the majority of interviewees felt was important if regeneration investment was to be successful in the longer term.

Although alongside employment creation, retailing was seen by most of the interviewees as a key aspect of a sustainable community, with those living in the organisation's neighbourhoods attaching significant importance to the fact that they had access local shops. With the development manager, opining that by simply attracting a new retailer into a neighbourhood, this simple intervention was likely to trigger both social and physical improvements. Yet, the interviewees suggested that simply having existing shops or attracting new retailers into an estate was in itself insufficient. It would then be essential to the long-term survival of these businesses that the social housing provider supports them to ensure that issues associated with crime and anti-social behaviour is managed.

Feature 5: Society and Community

The notion of community or society was certainly an important issue to all those working for the social housing provider. Potentially, this resulted from the clear social ethos within the organisation, with a clear focus on social benefit as opposed to return on investment for shareholders, effectively putting society at the centre of the social housing movement. As such, any investment would need to evidence success through the enhancement of community benefit.

With this in mind, a number of the interviewees suggested that, integrating crime reduction into any asset improvement projects would make a significant difference. Whilst the use and cultivation of drugs was highlighted as the most significant focus of criminal activity across the property portfolio, it was suggested that other crimes, including burglary, domestic violence and the theft of electricity were apparent on some socially excluded estates. Yet, as interviewee 9 attested it is not social exclusion per se leading to the noticeable increase in crime, it was often organised criminals taking advantage of the residents' vulnerability. In addition to the levels of crime, anti-social behaviour considerations were also seen as a key dimension of social sustainability within neighbourhoods. With a number of interviewees, commenting on the need to ensure physical improvements to the fabric of the estate also attempted to mitigate the effects of anti-social behaviour. However, when exploring the nature of anti-social behaviour on the estates, it became clear that other more complex social issues were making a significant contribution. As such, rehabilitation of the housing stock alone would be unable to eradicate all forms of anti-social behaviour. However, some issues could possibly be mitigated if the social housing provider looked to invest in facilities for the teenagers and young people on the estate. Yet, surprisingly interviewee 8 asserted that spending money on improving rundown community facilities such as playgrounds, without first considering their location could intensify existing neighbourhood problems.

The notion of community, from the perspective of access to facilities and services, was a clear underlying issue within the literature; however, it did not dominate any of the interviews. This would suggest that ensuring tenants have access to facilities and services within their own community were perhaps a bi-product of neighbourhood improvement and regeneration rather than a central focus. As interviewee 8 asserted simply providing such facilities would really only be part of the solution. As it would then fall to the residents to ensure that, the services provided remained viable. Yet,

interviewee 6 suggested the provision of facilities and services by the social housing organisation extend beyond physical community assets, to incorporate the provision of other support services to residents. Importantly, for estate improvement, it was clear that providing play space and services for young people remains an important feature of a sustainable neighbourhood. Yet, it was also made clear that the provision of such resources must be aligned to the needs of the residents, not merely based on the assumptions of those designing or specifying the improvements.

Feature 6: Governance

The final major theme emerging from the interviews was the need to ensure that strong communication links exist between the organisation and its customers. The interviewees collectively highlighted the importance of consultation and communication with their tenants, together with the importance they attach to the existence of resident groups. The final emergent theme within this section was the need to capture the views of wider stakeholders, and to look outside the organisation in some instances to ensure that the community benefit is embedded.

CONCLUSIONS

Despite the highly regarded and indeed controversial findings of Alice Coleman's (1985) comprehensive study of social housing, which suggested, inter alia, asset management alone would do nothing to improve the day-to-day realities of living in unsustainable housing estates, little had been achieved. Exponents of such approaches to asset management attest the seed of failure was inherent in the predominant bricks and mortar focus of previous attempts at neighbourhood intervention with success or failure measured using conventional success indicators. Instead, the housing professionals interviewed suggest the success of such projects should be reflected by the social value returned to the community (Higham and Fortune, 2011).

In an attempt to advance knowledge in this area, this study looked to identify a range of project success criteria, which could be applied to social housing asset rehabilitation schemes. The findings from a series of semi-structured interviews conducted with senior housing professionals identified 49 potential project success criteria, grouped into six principle areas, including Built Environment, Local Environment, Market Dynamics, Local Economy, Society, and Governance have been identified. Whilst this study has not gone as far as identifying clear 'solutions' to the debate around sustainable asset management. The intention of this paper was to highlight the need for more research aimed at assisting social housing organisations to plan and deliver housing investment schemes that not only restore estates to their previous pristine condition but also enhance the sustainability of the local community.

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APPLICATION OF SUSTAINABILITY PRINCIPLES IN POST-DISASTER RECONSTRUCTION

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The link between a sustainability agenda and post-disaster reconstruction is gaining increasing attention. However it is not clear how sustainability thinking affects outcomes of reconstruction programmes. This paper identifies key factors that influence how sustainability principles are integrated into decisions for reconstruction. This is based on empirical research conducted in Christchurch, New Zealand, following earthquakes in 2010 and 2011. The discussion focuses on the role of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) in the city's reconstruction. SCIRT is a collaborative organisation that was established to deliver the rebuild of infrastructure networks (wastewater, water supply, stormwater and roads) through an alliance agreement for design and construction. Information has been gathered through semi-structured interviews with professionals involved in the reconstruction, supported by an investigation of relevant government reports and project documentation. It is clear that constrained finances place a significant limitation on what can be achieved in post-disaster reconstruction. Working within this limitation however, there are several factors that shape how sustainability principles are incorporated into decisions for the design and construction of infrastructure. Some of the key factors identified through the Christchurch case study are: (a) Decision boundaries: organisational arrangements influence how and what decisions are made regarding the nature of infrastructure reconstruction or repair; (b) Conflicting timescales: there is a trade-off between the short-term need to restore services and longer-term considerations of improved system development and maintenance; (c) Best practice: opportunities to adopt sustainable approaches (as defined in the business-as-usual infrastructure construction) can prove to be elusive where adhering to a pre-conceived level of 'best practice' may not be appropriate; (d) Resilience: the concept of resilience is clearly embedded in options analysis for repairing or rebuilding infrastructure, helping to facilitate a longer-term perspective.

Keywords: decision analysis, post-disaster reconstruction, resilience, sustainability.

INTRODUCTION

The sustainability agenda places emphasis on the *"integration of environmental, social and economic concerns in policy, precaution in the face of uncertainty, viable livelihoods to reduce poverty, the long as well as the short term, inclusive and innovative approaches"* (Handmer and Dovers 2013: 52). Reconstruction can be an opportunity to implement solutions informed by sustainability principles, such as considering the impact of future hazards, climate change and creating safer communities (Hayles 2010). It is an opportunity to address vulnerabilities in the built environment, where the most vulnerable aspects tend to be those that require

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rebuilding (Amaratunga and Haigh 2011). Yet, there is little guidance around how to accurately capture this opportunity and define realistic outcomes.

Kulatunga (2011) suggests that it is impossible to truly define a ‘sustainable reconstruction’ given the large variance in the nature of a disaster and the context in which it occurs. Reconstruction by its very nature has a number of defining characteristics that are different from business-as-usual infrastructure development. While decision-support tools can help to assist thinking, rigid information-heavy assessments do not necessarily translate to a post-disaster context where decisions must be made in a “*fast-paced, information-poor environment*” (Olshansky and Chang 2009: 206). Reconstruction can also entail ongoing uncertainty over scope and funding long after construction has commenced. Furthermore, perception of what is important can change with the urgency and needs within a post-disaster environment. So the question remains, how do we begin to outline and address sustainability in the changeable, uncertain context of reconstruction?

The aim of this paper is to develop insight into the decision-making processes associated with reconstruction of horizontal infrastructure networks (focusing on wastewater, water supply, stormwater and roads). The argument is based on an initial investigation in an ongoing study into the reconstruction of Christchurch, New Zealand. The research follows an inductive approach where theory is developed from a mixture of literature, observations and experience (Hunter and Kelly, 2008). Approximately 60 semi-qualitative interviews with engineers and executives involved in the reconstruction have been conducted over 2013/14. Information has also been gathered through a review of government and academic reports, infrastructure design guidance and project-specific design reports. Full interview analysis is not yet completed, however sufficient progress has been made to indicate early insights. Quotes used in this paper are anonymous, but context is provided through the interviewee role. Roles are categorised into: leadership (executive), leadership (design), designer and ‘other’ (this includes finance, planning and environment).

The early insights of the research in Christchurch are linked to key concepts discussed in sustainability and in reconstruction literature. This paper explores factors that impact on the ability to address short- and long-term social, environmental and economic issues. Four key factors are discussed: decision boundaries in reconstruction management, inevitable trade-offs in ambitions, feasibility of implementing perceived ‘best practice’ environmental initiatives and the role of resilience as a concept that encourages long-term thinking. The first two factors are discussed in relation to the impact of overall governance arrangements. The second two factors are discussed in relation to specific design and construction initiatives.

RECONSTRUCTION IN CHRISTCHURCH: CONTEXT

Christchurch is the main urban centre in the Canterbury region of New Zealand, with a population of approximately 370,000. The city experienced a series of major earthquakes from 2010 to 2011, with the most damaging earthquake occurring in February 2011. The estimated cost of recovery is \$NZ 40 billion (approximately £20 billion) (New Zealand Treasury 2013). This is almost 20% of New Zealand’s annual gross domestic product (GDP) - a substantial impact on the national economy.

Christchurch provides a developed country reconstruction scenario where established infrastructure networks sustained significant damage (see Figure 1 for a visual indication of the damage). Table 1 outlines Christchurch’s network characteristics and

estimated damage. The estimated cost of repairing wastewater, water supply, stormwater and road networks within the Christchurch City Council (hereafter: Council) boundaries, (i.e. excluding damage in neighbouring rural districts) is \$NZ 2.5 billion.

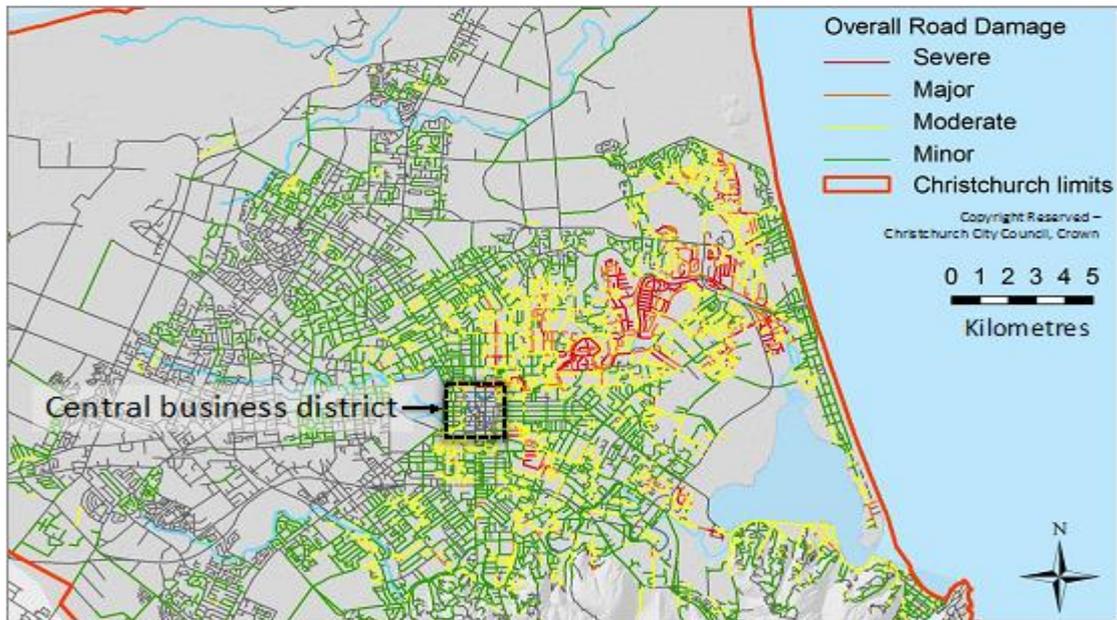


Figure 1. Indication of road network damage. Map sourced from SCIRT.

Table 1: General description and indication of earthquake damage to Council owned and operated infrastructure networks (includes the state highways owned by NZTA). Data is from various sources including liaison with Council and SCIRT staff (numbers are approximate).

	General network description (prior to September 2010)	Indication of damage
Waste-water	1900 km of mains; primarily a gravity-fed system dating from the 1890s; a significant portion of pipes in central Christchurch pre-date 1940; pipe material: predominantly concrete, earthenware and UPVC 25, typically laid deeper than water supply; 145 pump stations; 1 main treatment plant serving Christchurch.	Approximately 660 km of pipes; > 80 pump stations; treatment plant damaged but remained partially functional.
Water-supply	Artesian well supply from various sites (154 wells), no treatment required; 8 main reservoirs; 159 pump stations; approximately 1700 km mains and 1700 km sub-mains and cross-overs; pipes dating from early 20 th century (although only a small percentage pre-date 1940); pipe material: predominantly HDPE, AC, MDPE80 and PVC (note: presence of AC a result of use in post World War II growth).	Approximately 70 km of pipes; >60 pump stations and reservoirs.
Storm-water	Consists of roadside channels and gutters; 790 km pipes; 130 km open boxed and unlined channels; 30 pump stations; 2600 km streams and tributaries; 80 km rivers; 100 detention basins; 2 lakes; 17 km of levees.	Approximately 30 km of pipes; >10 pump stations; levee settlement and cracking.
Roads	2300 km of roads - 1980 km sealed, 360 km unsealed; 705 km constructed pre-1956 (reference date beyond which roads are constructed with sufficient depth to meet 'modern' traffic loading); approximate average construction age across the network is 50 years; surfacing is predominately single or double coat chipseal (surface dressing) or asphaltic concrete; 325 road bridges; 960 retaining walls.	Approximately 1000 km of carriageway (120 km with major or severe damage, 210 km with moderate damage), >240 retaining walls; 30 bridges significantly damaged.

INTEGRATING SUSTAINABILITY: KEY FACTORS

Decision boundaries

Amongst the key decisions that need to be made in the early phase of recovery is the design of institutional mechanisms for managing the recovery (Global Facility for Disaster Risk Reduction and Recovery - GFDRR 2011). New institutions may be set up or the capacity of existing institutions may be enhanced to manage the increased workload, or some form of hybrid model of the two may be used (GFDRR 2011). Each approach creates organisational boundaries and requires a different distribution of roles and responsibilities, which ultimately impacts on how decisions are made.

The approach in Christchurch could be described as a hybrid model. The Canterbury Earthquake Recovery Authority (CERA) was created under legislation as the overarching lead recovery agency covering the wider region. It is one of the three clients of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT). SCIRT's role forms key element within a wider construction process for the city; it is implementing the repair of the publically owned and operated networks in Christchurch (these networks are described in Table 1). SCIRT was created to facilitate an expedited rebuild, where the extent of damage was considered to be beyond Council's management capacity. Council and the New Zealand Transport Agency (NZTA) are the asset owners and are also clients of SCIRT. SCIRT was created under an alliance agreement (formalised in September 2011). The contract arrangement is distinctive, involving three client organisations and five major contracting organisations (forming five separate construction/delivery teams). Designers from 20 consultancies work within four design teams based in one office. SCIRT was set up with a limited operational lifetime and its work is due for completion in 2016. The alliance agreement sets boundaries for SCIRT's scope of work. The basis of the agreement is to restore services to Christchurch City, with the primary objective: *"To return the infrastructure networks to a condition that meets the levels of service prior to the 4 September 2010 earthquake within the timing constraints of the rebuild."* (Council, NZTA and CERA 2013: 3).

Examining the rebuild of the stormwater network provides insight into the challenges of addressing long-term environmental and social issues. SCIRT's remit is to repair the 'hard-engineered' assets such as pipes and sumps. It excludes responsibility for damage to the open waterway network and the levees along the lower reach of the Avon River. This limits SCIRT's responsibilities and ability to address problems. As one leader in design commented: *"as engineers they [the team] want to go out and resolve the solution"* but it may be that *"SCIRT's requirement [that is, SCIRT's remit to resolve the solution] is nothing - the changes are nothing to do with damaged infrastructure, it's damaged land."*

Flood risk was exacerbated in some areas due to earthquake-induced land settlement. Resolving changes in flood risk in Christchurch is influenced by a complex mix of factors including physical options to remediate, level of protection required, funding, insurance, district planning, legislative requirements and personal circumstances of property owners (Gillooly 2014). The vulnerability of some areas was recently highlighted in both March and April 2014, when rain resulted in repeated flooding of some private properties. It is not under SCIRT's remit to systematically address and provide holistic solutions for flood issues in Christchurch. Council has retained ownership of developing solutions for these issues. This was a governance choice that was made early in the recovery. It was not the only option, but one that was chosen for

political and economic reasons. The result is an organisational boundary in the recovery that has ramifications around the coordination of solutions across different agencies. One leader in design commented: *“The difficulty has been SCIRT works at a different pace to council and other organisations through the necessity of our programme and because of that it has been quite difficult to navigate through that process.”* The organisational boundaries potentially impact the timing and nature of the technical solutions; however, it is too early in the process to determine the impacts for Christchurch.

Organisational boundaries are a prominent factor in shaping decision making. These boundaries have an influence on the nature of remaining three factors and will thus continue to arise in discussion as these factors are addressed.

Trade-offs

The United Nations Development Programme and the International Recovery Platform (c2010) identify that one of the major challenges of infrastructure reconstruction is balancing the costs of alternative strategies to reinstate infrastructure services with long-term development benefits. The tension between speed of recovery and deliberation on how to make improvements is ubiquitous to the reconstruction process (Olshansky and Chang 2009). As described above, the longer-term requirements around flood-risk management are not being delivered within the recovery work coordinated by SCIRT. This is causing some delay in SCIRT work. Uncertainty over design arrangements for levees on the Avon River (which is under consideration by Council) impacts on SCIRT reconstruction options for roads adjacent to the levees. Thus, the nature of institutional boundaries is inherently linked to the trade-offs over timing. At the time of writing, this delay is posing a potential risk to the overall programme but is not yet having a material impact.

The pressure to restore services as quickly as possible limits the ability to consider wholesale changes to infrastructure networks (or vice versa). In discussing the strategic planning for a project, an executive commented, *“it is all about time and balancing a rapid response with an appropriate response.”* One designer remarked that their ability to explore possible solutions was limited due to the short-term pressure to restore services: *“because of the operational issues... we needed a solution quick and we’ve got to get started.”* Also, SCIRT’s work is predicated on a basis of restoring a system ‘like for like’ using modern equivalent materials. This limits scope of possible change from the outset of the reconstruction programme. Efforts are made to integrate improvements such as increasing pipe capacity or rebuilding a pump station in a less vulnerable location. However, improvements such as increasing capacity may require seeking funds beyond that approved for SCIRT work. Availability of extra funding is limited given the significant base-cost of the rebuild.

Limitation in scope is also attributable to the level of damage sustained, where the extent of damage impacts on the opportunity to consider wholesale change. Network damage in some areas of Christchurch justified a complete rebuild of a section of the wastewater network, but assets in other areas of the city remained in a reasonable or repairable condition. Hallegatte and Dumas (2009) refer to this as ‘technological inheritance’, which constrains the ability to integrate modern technologies and standards during reconstruction. Despite extensive damage to infrastructure, or the communities it supports, destruction is rarely complete and repair is often lower in up-front cost than replacement. As can be seen in Figure 1 and Table 1, despite extensive damage in some areas in Christchurch, most of the infrastructure remains operational.

Environmental initiatives

Reviewing environmental-based initiatives moves into the realm of what may be viewed as the grassroots of sustainability thinking. For infrastructure, the essence of the ‘environmental’ theme of sustainability assessment is about understanding the overall impact of resource use in a project, reducing material use, eliminating waste and general environmental impact. This is manifested in various practices such as: reducing runoff, using recycled or recyclable materials and management of energy use and greenhouse gas emissions. For SCIRT, waste minimisation is identified as the core element of their “*sustainability culture*” (SCIRT, n.d. a), thus it is worth specifically addressing. Low-carbon design and operational carbon assessment is a related factor but it will not be addressed in detail here given limited space. Suffice to say, it is not an explicit aspect of SCIRT’s approach, although efforts towards reducing waste and lifecycle assessment in design (both described later) may be associated with low-carbon design.

Recycling of material appeared to be a potential opportunity for the reconstruction of roads in Christchurch given the repetitive nature and scale of work across the city. For example, in terms of infrastructure networks, roads directly damaged by earthquakes needed either resurfacing or a full-depth rebuild. Marginally damaged roads may also be trenched to access and fix damaged pipes that lie underneath. These efforts can result in a significant waste stream of discarded pavement and sub-base material.

However, this opportunity is constrained by a number of factors. Recycling material in-situ is being implemented in some cases for pavement rehabilitation. Yet the quality of in-situ road base can be highly variable, even within a street. Therefore, specifying re-use of this material poses a risk to the quality and durability of the construction work. As one leader in design expressed: “*We would like to use a lot of the materials that we are digging out, for reuse – but again it comes down to cost... No matter what people talk about, cost is the driver*”. Also, a particular factor for Christchurch is that there is an abundant supply of locally sourced, low-cost, high-quality aggregate for the road base and for backfilling trenches. This significantly reduces the incentive to recycle material, as it cannot be justified economically. This is critical when funds are highly constrained; funds not invested roads could be allocated to other aspects of the reconstruction. The availability of cheap aggregate also reduces the viability of investigating other innovative alternatives. One interviewee concerned with environmental management mentioned a potential initiative around recycling cement kiln dust. This involved using cement kiln dust in trench backfilling. However the idea did not gain traction due to cost and uncertainty over performance of the material in the ground.

Waste minimisation is a performance target for delivery teams at SCIRT and is perhaps the most visible environmental initiative beyond compliance with environmental consent requirements. There are incentives in place to promote more sustainable practice; efforts towards waste minimisation impacts on delivery team performance rating. This rating has commercial ramifications as it influences the percentage of work allocated across the five contracting organisations. While SCIRT is an alliance organisation, this incentive (amongst others) has been set up to maintain an element of competition between the delivery teams and to support improvement in performance throughout the five-year contract.

It is worth taking a moment to look at sustainability assessment of infrastructure in a business-as-usual context. Sustainability rating schemes for civil infrastructure

(current schemes are CEEQUAL in the United Kingdom, Envision in the United States and the Infrastructure Sustainability Council of Australia's IS Scheme) specify goals for recycling materials, diverting waste from landfill, and maximising use of local materials. This is often done through stating percentage by volume of project materials that should be reused or recycled to meet certain performance criteria. To an extent, these tools may provide some guidance around potential issues to address in reconstruction, but the same priorities and possibilities do not necessarily apply in a post-disaster scenario. Determining 'best practice' performance that could be consistently applied to different recoveries is perhaps not even feasible given that every disaster is different. The challenge around developing a waste minimisation scheme for SCIRT's work is discussed below.

It took approximately two years to develop a waste-stream reporting framework across the five delivery teams (who also manage sub-contractors). The process started with developing a waste management audit tool, which was designed to provide delivery teams with a consistent basis on which to track waste. This has since been advanced to capture percentage of waste eliminated, reused, recycled or disposed. However there is not yet enough reliable historic information to track trends. This may seem like slow progress but it needs to be viewed in the context of the disaster. For example, immediately after the event, environmental consent requirements were relaxed to allow direct discharge of wastewater into waterways. The imperative was to avoid waste-associated health issues. Moving into reconstruction, SCIRT had a role in creating formalised, consistent approaches to decision making. The initial focus was on ensuring compliance with consent requirements. Once some basic processes were in place, the organisation could then start to move beyond compliance and create waste minimisation goals. These goals are reviewed as performance improves.

Resilience: a concept for long-term thinking

While environmental initiatives represent traditional thinking around sustainability, resilience-based thinking has gained political currency more recently with concern around the impact of natural hazards on infrastructure performance and ultimately, community wellbeing. With this in mind, this section first provides general context to resilience as a concept that supports decision-making processes in reconstruction. This leads into a specific example of how resilience is used in decision making at SCIRT.

Within the infrastructure sector alone there are various nuances in the use of the term 'resilience'. A common theme or underlying essence of resilience is the capacity to adapt. While there is much debate over meaning and no widely accepted definition, the following conceptual definition for infrastructure resilience provides a good synthesis, suggesting that "*resilience entails three interrelated dimensions: reduced failure probabilities; reduced negative consequences when failure does occur; and reduced time required to recover. This suggests that infrastructure resilience to disasters is not purely a technical problem, but involves societal dimensions*" (Chang 2009: 1). Achieving these dimensions may involve averting failure through adaptation, increasing flexibility and increasing robustness (Fiksel 2006).

There is no real consensus on operationalising resilience (Blackmore and Plant 2008). The general basis of resilience assessment is to provide a structured, systematic analysis to assess vulnerabilities in a system, determine appropriate points of intervention and to prioritise investment. A resilience framework is not designed to lead to a specific decision, but to support a better-informed decision process (Mansouri *et al.* 2009). Considering resilience of an infrastructure network can

contribute to understanding the broader context of design in order to evaluate costs, benefits and risks from a systems perspective (Fiksel 2006).

Lifelines engineering at regional level in New Zealand adopts this type of assessment approach, although it has not been explicitly framed as a ‘resilience framework’ in the past. Lifelines engineering formally began in New Zealand in 1989 and this eventually led to a report in 1997 that assessed the vulnerabilities of lifelines infrastructure to a range of hazards (Christchurch Engineering Lifelines Group 1997). Subsequent investment by utilities organisations in mitigation of seismic impact helped to reduce the effects of the recent earthquakes (Fenwick 2012).

Resilience is also a concept that has a role in shaping design decisions in the current reconstruction effort. Resilience at SCIRT is: “*the ability for the infrastructure (the roads, pipes etc.) to resist future earthquake damage. Improved infrastructure resilience can be achieved by using better materials, adopting higher construction standards, creating new systems, or minimising hazards*” (SCIRT, n.d. b).

With the exception of the Port Hills in the southeast of the city, Christchurch has a relatively flat topography. The wastewater network is predominately a gravity-based system with pipes laid at a low gradient. These systems proved to be highly vulnerable in areas subject to lateral spread, liquefaction and subsidence in an earthquake. In catchments that sustained heavy damage, SCIRT engineers considered alternative technologies as well as straight ‘like for like’ replacement of the gravity-fed sewers. The alternative options - low-pressure or vacuum sewers - typically require higher initial capital costs, but are less likely to sustain critical damage in an earthquake large enough to induce liquefaction.

As part of the design process for these catchments, lifecycle assessment of wastewater network options considered the costs of a possible future earthquake sufficient in size to cause liquefaction in Christchurch. Key features of this assessment included analysing costs over 30 years (using an eight per cent discount rate) and incorporating the cost of replacement or repair in five years’ time as a result of earthquake damage. The possibility of another earthquake was determined through considering likelihood predictions from geoscience experts. A ‘net resilience capital cost’ captures the estimated additional cost of an option alternative to the conventional gravity network system. The lifecycle assessment does not include the ‘incremental resilience’ provided by use of modern materials (SCIRT 2013), which would be used in all options. The lower vulnerability of the alternative options to earthquake damage meant that these options tended to become more cost-competitive through consideration of lifecycle costs, compared to an assessment of capital costs alone. The key benefit of this assessment approach is that it captured the overall value of introducing a system that is more resilient under earthquake loading.

One might criticise this as a technocratic approach to recovery focused on physical reconstruction. However, referring back to the definition of resilience presented earlier, this design process goes some way in addressing the interrelated dimensions of resilience through attempting to reduce the possibility of future damage. It adopts a disaster risk management philosophy; the underlying consideration is to reduce the impact of future earthquake damage on the infrastructure. The key decision lay in balancing cost with the potential for avoided future damage. There is uncertainty associated with the assumptions made in the assessment (e.g. the eight per cent discount rate could be debated) and there are limitations in the factors considered (e.g. neither embodied carbon or the cost of loss of service were a factor). However, the

process has served as rational (if somewhat limited) basis for incorporating lifecycle considerations into design.

CONCLUSIONS

Reconstruction presents both opportunities for and challenges to incorporating sustainability principles into decisions. The post-disaster environment is perceived to provide a window of opportunity for improvement that would not have otherwise been possible under business-as-usual development. However, it is highly challenging to address the short-term pressure to reinstate services while also considering long-term social, environmental and economic issues.

Four factors that influence how sustainability principles are integrated into decisions for reconstruction have been discussed. Firstly, it is certain that organisational boundaries affect the nature of decisions and how the reconstruction process is managed. This is an overarching issue that impacts on the other factors. Secondly, it is inevitable that there are trade-offs in ambitions, particularly because ‘technological inheritance’ will limit the possibility for wholesale change. The opportunity for improvement or change is limited by what existed before, the level of damage sustained and the cost and time implications of doing something different. Thirdly, the feasibility of implementing ‘best practice’ environmental initiatives is problematic in a post-disaster environment; it is difficult to determine what is ‘best practice’ and it can take time to establish appropriate targets. However, in a cost-constrained context, commercial incentives help to improve performance. Finally, resilience is a concept that facilitates long-term thinking, which is a fundamental concept of sustainability. Incorporating resilience into decision making for infrastructure in Christchurch has materialised both through pre-disaster action to reduce network vulnerabilities and through post-disaster options assessment.

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MATHEMATICAL MODELLING OF EMBODIED CARBON EMISSIONS OF BUILDING PROJECTS

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It is increasingly recognised that if the emphasis remains on reducing operating carbon emissions (OC) of buildings, embodied carbon emissions (EC) will eventually attain a significant proportion of buildings' lifetime carbon emissions (LC). Emphasis on minimising EC is equally desirable if LC is to be reduced. A first step to minimising EC is quantification, in order to know what quantities to minimise. However, several prevalent approaches of quantifying EC pose challenges in promoting potential alternative actions to reduce EC. In many cases, besides the limitations associated with the boundaries usually adopted, it is difficult (if not impossible), to attribute the respective sources of energy (e.g. diesel, coal, biomass etc.) to the resulting EC. This paper presents a mathematical model for computing EC of building projects and in contrast to previous studies, a concept of disaggregation is adopted in order to identify EC with the respective energy sources. The approach enables the specific sources of energy to bear on the quantification of EC, in a manner that allows differentiation of the contribution of the different sources of energy. The model is presented in a series of mathematical equations. The major benefit associated with the nature of the developed model is that, even without recourse to material substitution (e.g. timber for concrete), it is possible to achieve emission reductions from the same material by optimising the parameters (e.g. energy used in manufacturing and transportation) associated with its EC.

Keywords: building projects, embodied carbon emissions, mathematical model.

INTRODUCTION

The building sector has earned a reputation of being both energy and carbon intensive – it consumes up to 40% of the global final energy and releases 50% of the annual global emissions (WBCSD 2012; UNEP 2009). Meanwhile, national and international climate-change regulatory regimes (e.g. UK Climate Change Act 2008; Kyoto Protocol 1998) set ambitious targets to progressively reduce carbon emissions to the smallest possible count. Such ambitions do not exclude buildings, given the reputation of the sector. The total lifetime carbon emissions (LC) of a building arise from embodied carbon (EC) (e.g. emissions from material manufacture and transportation) and operating carbon (OC) (e.g. emissions from lighting and heating). Focussing only on reducing OC, as the case has hitherto been, has a knock-on effect on EC. Several studies (e.g. Iddon and Firth 2013; Sartori and Hestnes 2007) report that reducing OC increases the relative contribution of EC to LC. Even though it is widely acknowledged that OC takes the larger proportion of LC, with the current trend, it may not be the case in the near future – OC will approach 100% of LC. Avoiding this likelihood necessitates simultaneous efforts of reducing EC too.

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Initiatives of reducing EC should begin with quantifying it in a disaggregated but not aggregated approach. In disaggregated approaches, the different energy sources (e.g. diesel, coal, biomass etc.) that contribute to EC can be readily accounted for, unlike aggregated approaches. The major shortcoming of aggregated approaches is that they assume emissions from the different energy sources to be homogeneous. Such assumptions present shortcomings similar to those in economics, when inflation is interpreted based on a specific ‘basket of goods’, yet goods in that basket may widely differ (e.g. in quality, preference, and price changes), making the sole inflation figure rather non-representative for different goods. For instance, the study (Huberman and Pearlmuter 2008) used a carbon emission factor of 100kgCO₂ per unit energy for all the different energy sources that were involved in calculating EC. Such an approach and several similar ones (see Kua and Wong 2012; Broun and Menzies 2011; Dimoudi and Tompa 2008) stifle potential efforts to minimise EC. Without articulating what each energy source contributes to emissions means that it would be difficult, if not impossible, to trade off for better options (i.e. opting for energy sources with lower emissions). Relating to the inflation analogy again, the figure for inflation may not provide enough information for someone to identify goods that might be cheaper. Meanwhile, disaggregated approaches are not easily achievable especially in processes (e.g. steel manufacturing) where it is difficult to distinguish the proportions of various sources of energy used (see Hammond and Jones 2011). Even so, the benefits associated with disaggregation make the temptation to disaggregate EC irresistible. Although some studies (Gustavsson *et al.* 2010; Dias and Pooliyadda 2004) attempted to disaggregate EC, they still leave a lot to be desired – the boundaries they adopted did not take full account of components (i.e. materials, plant, and workforce) that contribute to EC of a building project.

From extant literature reviewed, aggregation is promoted in various ways, commonest of which include: use of ball-pack average carbon emission factors for varying materials (see Aye *et al.* 2012; Huberman and Pearlmuter 2008); use of generic country average emission factors (see González and García Navarro 2006; Cole 1998); and use of emission factors with undisclosed energy sources (see Broun and Menzies 2011; Dimoudi and Tompa 2008; Asif *et al.* 2007). EC results possess significant levels of uncertainty due to variation of energy mixes, among other reasons (Hammond and Jones 2010). Aggregation certainly compounds such uncertainties. In this paper, we present a mathematical model that can facilitate disaggregation in the quantification of EC of building projects.

METHODOLOGY

This work was about developing a mathematical model and therefore, the methodology adopted followed standard mathematical modelling principles. Mathematical modelling “...*mimic[s] reality by using the language of mathematics*” (Bender 1978: 1). Several texts on mathematical modelling (e.g. Meerschaert 2007; Edwards and Hamson 2001; Hangos and Cameron 2001; Murthy *et al.* 1990; Burghes and Wood 1980) suggest that it generally involves: formulating the problem, stating assumptions, mathematical formulations (e.g. equations), solving the mathematical equations and interpreting the results, verifying that the mathematical model is correct and finally, using the mathematical model/solution to address the problem. However, rarely are all these stages executed, or even executed in a perfect sequence. It is usual for a mathematical modelling process to involve rounds of iterations, often excluding some steps that are not of interest or are out of scope (Burghes and Wood 1980). Since the major aim of this paper was to present a mathematical model, the scope was

limited to problem formulation, assumptions, mathematical formulations, and verification.

Problem formulation

Problem formulation necessitates a thorough understanding of the world associated with the problem (Berry and Houston 1995; Murthy *et al.* 1990). As elaborated in the introductory part of this paper, the problem to address was elicited from the extant literature. The major prevalent problem was aggregation of EC results and this work set out to address this problem by developing a mathematical model that can accord disaggregation. The task was to develop a model to compute EC of buildings in a way that enables the energy sources to bear on the quantification, in a manner that allows differentiation of the contribution of the different energy sources.

Assumptions

Relaxing assumptions drifts the model away from the reality of the problem, whereas stringent assumptions present difficult solutions (and analysis) but drift the model closer to the reality of the problem (Burghes and Wood 1980). A balance between strictness and relaxation of assumptions is necessary. In deriving assumptions, Bender (Bender 1978: 2-3) suggested that a model should delineate the world into three parts: the part to be neglected, the part potentially affecting the model but not included, and the part the model studies. Too many considerations (i.e. number of variables) can complicate the model, whereas neglecting the ‘correct’ ones can invalidate conclusions drawn from the model (*ibid.*). The assumption stage is therefore concerned with delineating the appropriate variables of the model. The biggest proportion of a building’s EC occurs prior to commissioning the building i.e. during the pre-construction and construction phases. Upon review of literature, it was concluded that the appropriate model’s input variables were:

- emissions from construction materials, including process emissions (e.g. resulting from chemical reactions like calcination of lime during cement manufacture) and material transportation emissions (see Chang *et al.* 2012; Monahan and Powell 2011; Asif *et al.* 2007; Nässén *et al.* 2007);
- emissions from plant (i.e. equipment, appliances, machinery and the like) used during construction; this includes emissions from transportation of plant and emissions from onsite-use (see Hughes *et al.* 2011; Kofoworola and Gheewala 2009; Guggemos and Horvath 2006); and
- emissions from workforce, limited to emissions associated with the mode (or energy used) for commuting to and from the construction site (see Gustavsson *et al.* 2010; Cole 1998).

Mathematical formulations

Caution should be exercised when choosing the appropriate mathematical formulations to define relationships between variables (Edwards and Hamson 2001). Meerschaert referred to the ‘formulation stage’ as “*selecting the modelling approach*” and noted that “... *success at this step requires experience, skill, and familiarity with the relevant [mathematics] literature*” (Meerschaert 2007: 8). In order to formulate a model, it is imperative to understand the various alternative kinds of formulations (Murthy *et al.* 1990) in order to choose a model that is appropriate for the problem in question.

Type of mathematical model used

The taxonomy of mathematical models is delineated by various attributes. Quantitative models respond to questions of inquiry prescribing quantification (e.g. how much?, how many?), whereas qualitative models are broadly concerned with studying a system and its properties, without necessarily reducing anything to numbers (Saaty and Alexander 1981). A quantitative model was appropriate in this case since modelling dealt with numbers (e.g. quantity of emissions). Unlike dynamic models which are suited for studying systems that entail processes evolving over time (e.g. spread of a disease), static models are time independent (Meerschaert 2007; Murthy *et al.* 1990). The proposed model considered static systems whereby emissions are computed at a specific instance in time. This was appropriate due to the great uncertainty usually associated with anticipating change in policy and technology related to emission reductions. Since in deterministic systems the values of the variables are predictable with certainty and rather not random as the case is for stochastic or probability systems (Edwards and Hamson 2001; Murthy *et al.* 1990), a deterministic approach was adopted for the modelling exercise. Furthermore, various types of equations can be used in mathematical modelling: differential, integral, algebraic, and difference (Meerschaert 2007; Edwards and Hamson 2001; Murthy *et al.* 1990). In Murthy *et al.* (1990), it is indicated that static-algebraic formulations are suitable for modelling deterministic systems. Of the 54 equations in the 25 models (related to embodied energy, greenhouse gases, waste and time-cost parameters of building-projects) of previous studies that were reviewed in Abanda *et al.* (2013), 40 equations were 'static-algebraic'. Thus algebraic equations were considered appropriate for deriving the model. Consequently, the derived mathematical model was a quantitative-deterministic-static-algebraic type of model.

The analysis technique

Life cycle assessment (LCA) is a commonplace technique of analysing environmental profiles of buildings. The life cycle of a building consists of its construction, use, maintenance, demolition and related waste handling (Gustavsson and Joelsson 2010), all of which have impacts on the environment. Research suggests that as the interest to reduce such impacts developed (Van Ooteghem and Xu 2012), the need for better methods to understand and therefore quantify the impacts (e.g. energy use, emissions, water use) in a lifecycle perspective increased, which saw LCA emerge (Sartori and Hestnes 2007). Combined with energy, LCA evolved into lifecycle energy analysis (LCEA). LCEA of buildings is the LCA analysis that uses energy as the measure for gauging the environmental impacts of buildings (Huberman and Pearlmutter 2008). The LCEA method is deemed appropriate for buildings and its intentions are not to substitute LCA but rather, enable assessment of energy efficiency (Fay *et al.* 2000). In the procedure, LCEA accounts for all energy intakes throughout the building's life time and upon understanding the amount of energy, the associated carbon emissions can be deduced and the environmental impacts of the building can also be conceptualised (Ramesh *et al.* 2010). For the developed model, it subscribed to the partial LCEA approach of cradle to construction site as per modules A1 to A5 (BS EN 15978:2011) and relevant LCA standards (see ISO 14040: 2006; ISO 14044: 2006).

Modelling techniques adopted

Commonly referenced are three primary modelling techniques used in LCEA: process analysis (PA), input-output analysis (IOA), and hybrid analysis (HA). In Alcorn and Baird (1996: 319), PA is referred to as one entailing "... *systematic examination of the direct and indirect energy inputs to a process*". In other words, PA deals with tracing

all the energy inputs of products that are dependent on the process (Mortimer 1991). Meanwhile, the IOA method credits its roots from macro-economics, as it was initially developed in economic research problems and later adopted for energy analysis (Hammond and Jones 2008; Bullard *et al.* 1978; Roberts 1978). IOA traces energy flows by analysing monetary flows to and from economic sectors, through mapping the financial output of each sector with the corresponding energy used (Alcorn and Baird 1996). HA, as the name suggests, is an amalgam of PA and IOA. Since HA combines data from PA and IOA in various ways (Crawford *et al.* 2006), hybrid-variants can be realised (e.g. PA-based and IOA-based hybrids), depending on dominance of a method in the approach adopted. As such, each of these three – PA, IOA and HA – methods has its own merits and demerits.

Several studies (e.g. Murray *et al.* 2010; Hammond and Jones 2008; Crawford *et al.* 2006; Lenzen and Dey 2000; Alcorn and Baird 1996; Mortimer 1991) discuss the merits and demerits associated with PA, IOA and HA, based on which a judgement can be made on the appropriate technique to adopt. PA is suitable for assessing direct but not indirect impacts, while the reverse applies for both IOA and HA. For indirect impacts, PA is criticised for the subjectivity involved in deciding the truncation point (Lenzen and Dey 2000). The unavoidable use of sector averages in IOA implies that the method poses challenges in evaluating a specific individual product (Murray *et al.* 2010). Thus IOA is usually associated with aggregated results (Bourgault *et al.* 2012). PA is suitable for a specific process or product and can also take into account technological advancements in the system under study (Gustavsson *et al.* 2010). Although PA does not give ‘complete’ results, by 50% sometimes (Lenzen and Dey 2000), accuracies of up to 90% can be registered (Hammond and Jones 2010; Murray *et al.* 2010). Most models based on static-algebraic formulations – to which the derived model in this work subscribes – are usually based on PA (see Abanda *et al.* 2013). Since the interest of this work was centred on disaggregation using algebraic equations, PA techniques were adopted.

Verification

Verification involves “*determining whether the model is behaving correctly*” (Hangos and Cameron 2001: 29) i.e. does the model give the correct or expected output? Although verification is often presented last in sequence, in reality, it is usually done concurrently with other stages (i.e. formulation stage and solution stage). In this work, verification was done concurrently with the formulation of equations. Meanwhile, in modelling, “*mathematical modelling of a physical world makes sense only if the models are dimensionally correct*” (Berry and Houston 1995: 121) or rather, dimensionally homogeneous (Bender 1978). Therefore, as a tool, dimension analysis can be used to verify that the developed model’s formulations are correct. The fundamental dimensions of physical quantities are Mass (M), Length (L) and Time (T) (Berry and Houston 1995; Murthy *et al.* 1990; Bender 1978), from which all other dimensions of quantities can be derived. If all the terms which constitute an equation have the same dimensions, then it can be claimed that the equation is dimensionally homogeneous (Bender 1978: 35). Consequently, as a verification measure, derived equations were rigorously checked for dimension homogeneity.

RESULTS AND DISCUSSION

EC of a building project equals to the sum of emissions from materials, emissions from plant, and emissions from workforce (see Hughes *et al.* 2011; ICE 2010). The model was thus composed of a series of equations related to emissions from materials,

plant, and workforce. In each equation, a dimensionless disaggregation factor was introduced. This factor is defined as the proportion of energy used (e.g. for manufacturing, transportation), derived from a specific energy source j . Multiplying the disaggregation factor with the carbon emission factor of that energy source enables the outputs of the model to be presented in a disaggregated manner.

Emissions from construction materials

Emissions from manufacturing and transporting n construction materials, using e different sources of energy are given by Equations (1) and (2) below, respectively. Three options A, B, and C, were considered in Equation (2). Option A is applicable where the weight of materials is significant and known, and the distance of transportation can be estimated. Option B is applicable where the weight of materials is insignificant (whether known or unknown) and the quantity of energy used is known. Option C is suitable where weight of materials is insignificant (whether known or unknown) and the distance of transportation can be estimated:

$$EC_{m1} = \sum_i^n \rho_i (\sum_j^e V_{ij} C_j^a \theta_j^a + S_i) \quad (1)$$

$$EC_{m2} = \left[\begin{array}{l} \sum_i^n \rho_i (\sum_j^e W_{ij} X_j^a C_j^a \alpha_j^a); \text{ If option A conditions apply} \\ \sum_i^n \sum_j^e W_{ij}^a C_j^a \alpha_j^a; \text{ If option B conditions apply} \\ \sum_i^n X_j^a (\sum_j^e C_j^b \alpha_j^a); \text{ If option C conditions apply} \end{array} \right] \quad (2)$$

where: EC_{m1} is the total emissions from manufacturing materials (in kgCO₂); ρ_i is the quantity of material type i (in kg); V_{ij} is the quantity of energy j to manufacture a unit of material i (in kWh/kg); C_j^a is the carbon emission factor (in kgCO₂/kWh) per unit energy j used; θ_j^a is a disaggregation factor in manufacturing material i ; S_i is a constant for process emissions per unit of material i (in kgCO₂/kg); EC_{m2} is the total emissions from transporting materials (in kgCO₂/kg); W_{ij} is the quantity of energy j to transport a unit of material i per unit distance (in kWh/kgkm); X_j^a is the transport distance for material i (in. km); α_j^a is a disaggregation factor in transporting materials; C_j^b is the carbon emission factor per unit distance (in kgCO₂/km) with respect to the corresponding transportation energy j ; W_{ij}^a is the quantity of energy j to transport material i (in kWh).

Emissions from plant

Emissions from operation and transportation of p plant, using e different sources of energy are given by Equation (3) and (4) respectively:

$$EC_{q1} = \sum_q^p \varphi_q (\sum_j^e U_{qj} C_j^b \theta_j^b) \quad (3)$$

$$EC_{q2} = \sum_q^p \varphi_q^b (\sum_j^e Y_{qj} X_j^b C_j^b \alpha_j^b) \quad (4)$$

where: EC_{q1} is the total emissions from operating plant (in kgCO₂); φ_q is the number of plant type q ; U_{qj} the quantity of energy j used for operating plant q (in kWh); C_j^b is the carbon emission factor (in kgCO₂/kWh) per unit energy j used; θ_j^b is a disaggregation factor in operating the equipment; EC_{q2} are the total emissions from transporting plant; φ_q^b is the weight of plant q (in kg); Y_{qj} is the quantity of energy j to transport a given weight of plant q per unit distance (in. kWh/kgkm); X_j^b is the transport distance for plant q (in km); α_j^b is a disaggregation factor in transporting the plant. Options mentioned in Equation (2) about material transportation can equally apply to transportation of plant in Equation (4).

Emissions from workforce

Emissions from transporting workforce for duration r , using e different sources of energy were given by Equation (5) considering two options A and B. Option A is applicable where the duration of using the workforce and the quantity of energy used per unit duration are known. Option B is applicable where the duration of using the workforce, the quantity of workforce, the distance travelled, and the modes of transport used are all known.

$$EC_l = \left[\begin{array}{l} \sum_f^r \beta_f (\sum_j^e Z_{fj} C_j^c \alpha_j^c); \text{ If option A conditions apply} \\ \sum_f^r \beta_f L_f X_j^c (\sum_j^e C_j^d \alpha_j^d); \text{ If option B conditions apply} \end{array} \right] \quad (5)$$

where: EC_l is the total emissions from transporting workforce (in kgCO₂); β_f is the duration f workforce is used (in days); Z_{fj} is the quantity of energy j to transport workforce per duration (in kWh/day); C_j^c is the carbon emission factor of the transport energy used (in kgCO₂/kWh); α_j^c is a disaggregation factor for transporting workforce; L_f is the number of people in the workforce required; X_j^c is the distance travelled by a person per duration (in km/day); C_j^d is the carbon emission factor per person per unit distance depending on the mode (e.g. bus, train, cycle) of transport used (in kgCO₂/personkm); α_j^d is a disaggregation factor for the mode used in transportation.

Conditions (constraints) subjected to the model

The direct and indirect emissions (defined as per Defra/DECC 2013) were to fulfil Equation (6), whereas the disaggregation factors for all the different sources of energy e were to sum to unity, as expressed by Equations (7) and (8):

$$C_j^{a,b,c,d} = D_j + I_j \quad (6)$$

$$\sum_j^e \theta_j^{a,b} = 1; 0 \leq \theta_j^{a,b} \leq 1 \quad (7)$$

$$\sum_j^e \alpha_j^{a,b,c,d} = 1; 0 \leq \alpha_j^{a,b,c,d} \leq 1 \quad (8)$$

where: D_j and I_j are the direct and indirect emissions resulting from energy source j , respectively.

The final model

The final derived consolidated model for the total embodied carbon emissions (EC_T) of a building project is given by Equation (9) below.

$$EC_T = (EC_{m1} + EC_{m2}) + (EC_{q1} + EC_{q2}) + EC_l \quad (9)$$

Model verification

All derived equations were checked for dimensional homogeneity and they satisfied this condition. An example of Equation (1) is illustrated below:

$$EC_{m1} = \sum_i^n \rho_i (\sum_j^e V_{ij} C_j^a \theta_j^a + S_i)$$

from inspection, the above equation can be broken down into three terms which are: EC_{m1} , $\rho_i V_{ij} C_j^a \theta_j^a$ and $\rho_i S_i$, whose dimensions can be deduced as follows: EC_{m1} is measured in kgCO₂ (i.e. mass) and thus $[EC_{m1}] = M$; ρ_i is measured in kg and thus $[\rho_i] = M$; V_{ij} is measured in kwh/kg and thus $[V_{ij}] = (ML^2T^{-2})/M$; C_j^a is measured in kgCO₂/kWh and thus $[C_j^a] = M/(ML^2T^{-2})$; θ_j^a is a dimensionless constant and thus $[\theta_j^a] = 1$; S_i is measured in kgCO₂/kg and thus $[S_i] = M/M$. Substituting the deduced dimensions into the three terms of the equation shows that $[EC_{m1}] = M$,

$[\rho_i V_{ij} C_j^a \theta_j^a] = (M \times (ML^2T^{-2})/M \times M/(ML^2T^{-2}) \times 1) = M$, and $[\rho_i S_i] = (M \times M/M) = M$. Therefore, Equation (1) is dimensionally consistent.

IMPLICATIONS

Considering a building project, if attention is drawn to materials, as they are a major source of EC, many studies have hitherto concentrated their efforts on discussions involving material-type comparisons (i.e. what is the ‘greenest’ amongst steel, timber, and concrete?). This work contends that it is equally important to highlight ‘green from what energy source?’ On a suitable energy-mix palette, it is equally possible to achieve emission reductions by varying the disaggregation factors related to that material, without recourse to material substitution. For instance, in Equation (1) and (2), the disaggregation factors θ_j^a and α_j^a can be varied until a desired level of emissions from materials is attained. This may for instance imply reconsidering where the construction materials are sourced from. In Equation (5), a construction practice can vary α_j^a , which is related to the proportion of the different modes or energy sources used for transporting workforce, in order to arrive at a desired level of emissions. Demonstration of how the model can contribute to several of such 'real-world utilities' falls in the last phase of mathematical modelling – using the model to address a real-world problem. The present work sets the foundation to embark on this phase that is beyond the scope of this paper.

CONCLUSIONS

It has been argued that the prevailing approaches of computing EC do aggregate results and this stifles plausible alternatives to reducing EC. Using mathematical modelling, this paper has presented a mathematical model for computing EC of building projects. The model considers all plausible components of a building project that cause emissions. More importantly and contrary to most previous efforts, the model can present disaggregated outputs. Although a disaggregated approach may not be easy to apply in some cases, it is worth the effort. The approach enables the specific sources of energy to bear on the quantification, in a manner that allows differentiation of the contribution of the different sources of energy to the resulting EC. In that way, it is possible to achieve emission reductions by varying the disaggregation factors, which are the proportions of energy sources used. This opens up more alternatives of reducing EC, thereby promoting sustainable construction.

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TOWARDS A LIFE CYCLE FRAMEWORK FOR BRIDGE MANAGEMENT SYSTEMS IN THE UK: INSIGHTS FROM A CRITICAL REVIEW OF INTERNATIONAL APPROACHES AND MODELS

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Effective Bridge Management Systems (BMS) are of paramount importance to bridge owners and bridge managers. BMS in the UK encompass an inventory of existing bridge stock, schedule of inspections, condition rating of structures, budget planning, deterioration modelling, bid for maintenance funds, and maintenance repair and rehabilitation, but fail to consider sustainability and long-term options. A Life Cycle Assessment (LCA) approach is currently being proposed to address this problem, which can be incorporated into a BMS. In order to achieve this, a critical analysis was performed on international literatures in the area of BMS study. This presents insights of previous approaches and models towards improving existing BMS functionalities, while responding to generic requirements. Findings revealed that the incremental improvement of BMS does not consider sustainability options to enable sustainable decisions to be made regarding bridge management activities. Therefore, systems should start considering sustainability optimization criteria which can be delivered through a life cycle approach.

Keywords: asset management, bridge management system, life cycle assessment, sustainability.

INTRODUCTION

Bridges play a vital role in economic development. Bridges provide a means of transporting goods and services from place to another (Wilmer, 2012). Managing bridge networks across the country is a major challenge to governments and bridge-owners (Flaig and Lark, 2000; BOF, 2004; Duffy, 2004; Gattuli and Chiaramonte, 2005). Challenges faced by bridge-owners are; bridge deterioration due to ageing, increased traffic and environmental conditions (BOF, 2004). The need for urgent attention towards the ever increasing deterioration problems paved the way for the emergence of bridge management.

Bridge management provides guidelines for effective decisions for the maintenance, strengthening, assessment and continuous use of bridges (Gattuli and Chiaramonte, 2005; Hallberge and Racutanu, 2007). In respect to this, bridge-owners have developed tools to meet the objectives of bridge management. A bridge management system (BMS) is a software tool developed by bridge experts to collect and store information, designed to support decision-making regarding resources for operations,

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maintenance, rehabilitation, upgrading and reconstruction of bridges (Austroads, 2002; 2004; 2009).

Important developments have taken place in recent years in UK BMS. However, these developments have not considered sustainability options. Therefore, the purpose of this work is to identify the useful state-of-the-art from international approaches and models of BMS to enable the future development of a framework for BMS in the UK. To achieve this, a literature review was conducted on international model. The understanding from this review allowed a case for in-cooperating a life-cycle assessment in BMS to be presented. To start with, an area that encompasses bridge management and other highway asset is discussed.

ASSET MANAGEMENT

Asset management is a strategic approach that identifies the best allocation of resources for the management, operation and enhancement of the highway infrastructure to meet the current and future needs of the customers (Road Liaison Group, 2005). In addition, asset management is a systematic and coordinated activity which enables organisations to become sustainable by managing their performance, risk and expenditure to achieve organizational strategic plans (IAM, 2008). The integration of asset management principles increases organisational performance, especially in the area of product and service delivery (Road Liaison Group, 2005; IAM, 2008)

Appropriate asset management planning is required to inform key stakeholders of the functional characteristics of these assets, and to ensure they deliver the right services, while meeting sustainability and cost effectiveness criteria (Austroads, 2009). Transportation network embodies the most expensive infrastructural assets (Elbehairy, 2007). Network includes roads, bridges, railways, waterways and air ports. Yet bridges are one asset with distinct features, which requires specific management strategies; hence, asset management for bridges (Figure 1) is developed as a separate and critical category within wider asset management planning (Austroads, 2004; IAM, 2008; Austroads, 2009; HMEP, 2013).

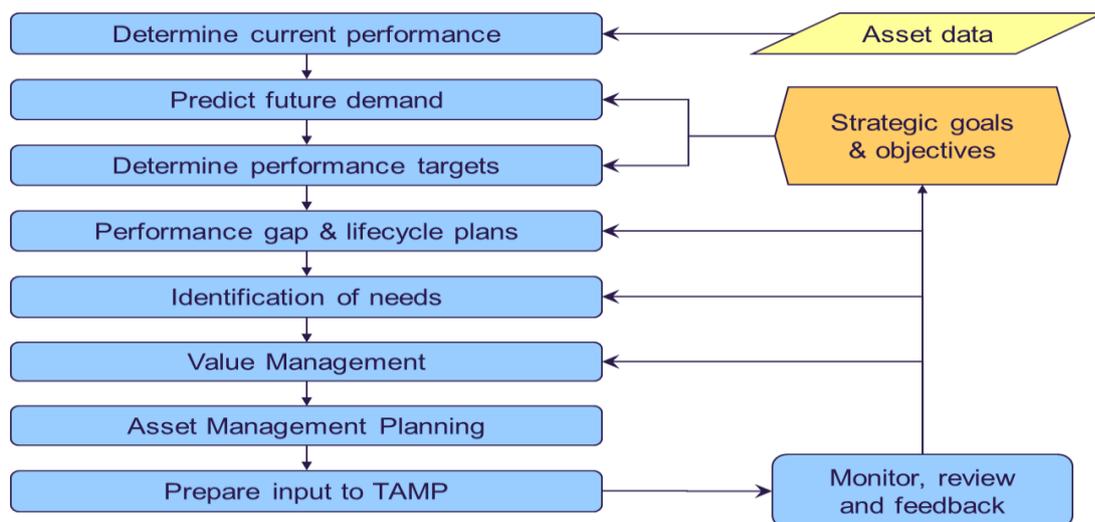


Figure 1. Asset Management for Bridges (Adapted from: Brown, 2013)

The components of asset management for bridges are indicated in Figure 1. A holistic determination of performance target and ability to predict future demands is the strategic goal and objectives of asset management for bridges.

BRIDGE MANAGEMENT FRAMEWORK

Bridge management is an aspect of the road network asset, focused on bridges (Austroads, 2009). It is the means by which a bridge network is catered for from conception to disposal (Ryall, 2001). Bridge management is the process by which agencies monitor, maintain, and repair deteriorating systems of the bridge using available resources (Elbehairy, 2007). It involves a systematic approach of carrying out work activities related to planning, design, construction, maintenance, rehabilitation and replacement of bridges (Deshmukh and Bernert, 2000).

Bridge management within the UK evolved rapidly after the completion of a 15-year national programme of assessment and strengthening, which started in 1987 and ended in 2002 (Flaig and Lark, 2000; BOF, 2004). The assessment was initiated as a response to a government initiative to increase the load carrying capacity of bridges from 30tons to 40tons (Duffy, 2004; Cole, 2008). This paved the way for various guidance and design codes to emerge, which includes the Design Manual for Roads and Bridges (DMRB) developed by UK highway Agency.

BMS in the UK

Evolution of BMS in the UK started with the first generation of BMS, which used an electronic inventory as an advancement of earlier inventory sheets (Flaig and Lark, 2000; Kim, 2001). The second generation of BMS was designed to help manage bridge maintenance task, with inventory, assessment, inspection, maintenance and repair data (Flaig and Lark, 2000 and Kim, 2001). The third generation of BMS has attributes of making decision and proposing repair and strengthening options (Kim, 2001). This stage of BMS, therefore calls for a closer look at investigating a system with attributes of aiding decision making, while considering environmental and cost implications. This is a noteworthy point, as the UK construction industry is tending towards achieving a sustainable future (Steel *et al.*, 2003; Cole, 2008)

The first electronic based UK BMS was the National Structure Database (NAT) (Flaig and Lark, 2000; Gordart and Vassie, 2001; Duffy, 2004) that was introduced to replace the traditional manual system. The system was sensitive enough to store and process inventory and inspections. Systems from other countries could not be integrated into the UK NAT because they were designed to attend to the needs of the country they originated from (Flaig and Lark, 2000). Austroads (2004) mentioned that most countries have adopted the American Association Society of Highway Officers' (AASHO) code, in developing their own BMS. However, the UK is an exception, despite the fact that, Americans are leading in terms of workable BMS (Austroads, 2004; Kirk, 2008).

Another BMS developed in the United Kingdom was Bridgeman, created by Oxfordshire County council and is based on life cycle costing techniques (Cole, 2008). Steele *et al.* (2005) developed a BMS for Surrey County Council called COSMO; this was based on a Life Cycle Assessment (LCA) approach but could not aid decision-making, as it was impossible to generate sufficient data for implementation purposes. However, COSMO requires improvements to meet with the new updated Highway asset management code of practice.

Critical Review of BMS Trends (from 2000 to 2013)

Deshmukh and Bernhardt (2000) investigated the degree of uncertainties in the data collected during inventory analysis. The core of their research was to inform system users of uncertainties in the data collected during inventory stage, and how it can

affect the reliability of the decisions made by BMS. Their aim was to examine uncertainties associated with condition assessment, which are quantified using mathematical and statistical principles. They added that most BMS employ a probabilistic deterioration model by using the Markovian model and several techniques to measure data uncertainties.

Deshmukh and Bernhardt (2000) used a deterioration model and reliability model to compare predicted condition with actual conditions of bridges. The result gave a correlative coefficient factor. The correlative coefficient can be used to quantify uncertainties in condition assessment data. In order to test the applicability of the correlative coefficient, they used three case studies (3-bridges) and results indicate that the level of uncertainties was very low from the coefficient of correlation obtained from these bridges. Using this methodology Deshmukh and Bernhardt (2000) demonstrated that uncertainties of data collected for inventory analysis in BMS is negligible. Therefore, most data collected at the inventory stage can be used by a BMS; this may also depend on the experience of the inspector collecting the data.

The approach employed by Deshmukh and Bernhardt (2000) was rich enough to carry out the research purpose, but an area of concern was; though three different parts of the bridges for the case studies was mentioned, there was no record about the defect that occurred at these parts, which is essential in working out uncertainties.

Flaig and Lark (2000) wanted to investigate what the users of BMS expect from the system (BMS). They mentioned that most bridge owners were not satisfied with the performance of their BMS as it is not able to meet their desired requirements. Flaig and Lark (2000) mentioned that the increase in the load-carrying capacity of a bridge from 38-ton vehicle to a 40-ton vehicle as mandated the highway authorities to engage in the use of BMS, in order to cope with the challenge. However, users of the system are not satisfied with the fundamental attributes of these systems. In order to investigate this issue - user satisfaction- surveys were sent to users to find out their views, on how the system should be improved to meet their demands. The questionnaire was designed to ask questions concerning current practice, attitudes towards BMS, preference, inspection and experience with existing systems.

Flaig and Lark (2000) were able to identify from their survey that more information is required from BMS to increase decision making potential. They revealed that BMS at this time operated on a theoretical basis rather than being practical to meet with the demands of a bridge manager; this resulted in their dissatisfaction. While Flaig and Lark (2000) were able to achieve their aims, it is possible to argue that a more accurate response could have been derived using a qualitative approach, here a semi structured interviews would be used to investigate the phenomena. This will mirror the true state of what the users actually require of their system rather than ticking boxes.

Duffy (2004) presented an idea to develop a centralized BMS. This stemmed from the increasing challenge posed to bridge managers when a bridge stock is increased and needs to be managed. Duffy (2004) mentioned that the National Roads Authority (NRA) in Ireland, are bestowed with the responsibility of maintaining all national roads. Therefore, they require a BMS to coordinate inspection and repair activities in order to manage their bridge stock. However, Duffy (2004) observed that having a BMS does not guarantee a well-managed bridge stock, as individual local authorities needed to develop their own BMS, which resulted in poor value for money and

increased rate of deterioration. Duffy (2004) therefore suggested that there was a need to develop a centralized system to manage bridge stock efficiently.

In this vein, the Eirspan – a BMS – was now developed in Ireland, which functioned on the bases of Denbro (Germany's BMS) and as a centralized system. Duffy's methodology was to identify the user problem, which was lack of a centralized system. However, Duffy did not give a background methodological approach to how the problem "*lack of centralized system*" became a cause for poor value for money and increase rate of deterioration. How this was produced (either through an interview or questionnaire survey) we are not informed. Nevertheless, Duffy's paper was able to encapsulate the need for a centralized BMS in order to improve management strategies.

Hanji and Tateishi (2007) reported on a government initiative to increase the performance of structures. This was born out of the desire to generate positive decisions about maintaining and preserving highway structures. Hanji and Tateishi (2007) mentioned that most US bridges are over 40 years old, and 40% of them are structurally incapacitated and need attention in the form of repairs, rehabilitation and replacement. To achieve these objectives the Federal Highway authorities arranged a programme called Long-Term Bridge Performance (LTBP) which was similar to Bridge Management in Europe (BRIME) (Godart and Vassie, 2001), conducted to advance the performance of structure for long-term use. Duffy pointed out that it was necessary to implement BMS if the initiative objectives were to be met.

Therefore, for both LTBP and BRIME, the aim was to introduce a BMS that serves as a catalyst for achieving the aims and objectives (enhancing decision-making regarding maintenance and preservation of bridge structure). This is, however, to emphasise the increasing need of a BMS in order to enhance bridge management performance. The question is;- should we focus on continuous development of new BMS or focus on evolving the existing BMS to improve performance of structure.

Hallberg and Racutanu (2007) reported on how the Swedish Road Administration (SRA) has developed their own BMS called Based Bridge and Tunnel Management System (BaTMan), used for operational, tactical and strategic management. They mentioned that, unlike other BMS, BaTMan falls short of Maintenance, Repair and Rehabilitation (MR&R) options within its operation resulting into capital loss. They claimed that existing systems are not predictive in terms of identifying environmental dilapidation of structural elements and materials.

However, a system that operates on predictive bases has now been developed called Life Cycle Management System (LMS). The LMS is partly based on Life Cycle assessment (LCA), Life Cycle Cost, Ecology etc. The idea of integrating a LCA to evaluate environmental options was innovative; however, questions regarding implementation became another concern for experts in this field. Similar to Duffy (2004), Hallberg and Racutanu (2007) also identified the need to have a BMS, but their focus was on its functional characteristics.

Shim and Hearn (2007) wanted to improve the functionality of BMS. This stems from the fact researchers have now started to see the need to improve the existing system functionalities rather developing new ones. Improving the system functionalities can enhance the generation of information. Shim and Hearn hope to improve the output of BMS by proposing a Non-Destructive test (NDE) in the system. They confirmed that the NDE test is a tool for carrying out integrity test which can be categorized into four stages – element protection test, vulnerability test, attack test and damage test – which

can be integrated into a BMS. They added that NDE is used for bridge tests and BMS provides information concerning the state of bridges; hence, NDE could be embedded into a BMS.

The argument here is that-; though NDE is known to be a field test arrangement, how will this sit within a BMS framework. Again a clear justification for opting for NDE needs to be informed, as we cannot verify this option based on the categorical principles of NDE alone. We are told that NDE is categorised into four stages, how these stages will be synthesised with BMS was not clearly informed in the methodology. This paves way to questioning the validity of combining NDE test and BMS.

Lee *et al.* (2008) reports on the need for a comprehensive BMS that has the functionality of using historical data to predict future performance. Hitherto, there were no BMS with such attributes. Lee *et al.* (2008) highlighted that predictions for future structural performance could not be effectively determined in the absence of usable data from bridge's elemental historical condition. Moreover, future structural performance can only be delivered, when access to historical information is available.

Hence, all the future prediction previously made using a deterioration modelling technique is inaccurate. Lee *et al.* (2000) mentioned that there are several prediction techniques already in use (such as regression, Markov models, Bayesian method, fuzzy technique, Genetic Algorithm, Case Based and Artificial Neural Network [ANN]) but they do not have access to historical bridge condition during analysis. To bridge this short falls, Lee *et al.* proposed ANN-Based Backward Predictions Model (BPM), which improves the accuracy of future condition rating by providing historical bridge condition data. Thus, the functionality of the BMS is now improved.

Tarighat and Miyamoto (2009) proposed a Fuzzy inference system in a BMS. This was conceived to improve the area of uncertainties during data collection. Though Deshmukh and Bernhardt (2000) informed that uncertainties during data collection are negligible; Tarighat and Miyamoto (2009) are of the opinion that uncertainty and impression play a great role during practical bridge inspection. This stems from the fact that, most inspections are visually based hence subjective and uncertain. Therefore in order to bridge this shortfall the fuzzy inference was introduced. According to Tarighat and Maiyamoto (2009), the fuzzy rating system can enhance better decision-making by dealing with imprecise, imperfect and uncertainties of data collected.

The Fuzzy inference is a Non-Destructive Test (NDT) oriented system, which agrees with Shim and Hearn (2007) on the need for BMS to employ NDE characteristics. Tarighat and Miyamoto (2009) and; Deshmukh and Bernhardt (2000) have employed different research strategies to validate their point, although their findings contradicted. A consensus could be reached if a holistic methodology was employed to investigate the type of uncertainties available and if they are quantifiable. This would help evaluate the need to focus on a type of uncertainty.

Akgul (2013) developed a BMS that incorporates a visual and Non –Destructive Test (NDT) based inspection into a BMS. This was conceived as part of the initiative for improving the current state of BMS. Akgul mentioned that, a project was undertaken in Turkey to integrate element condition and condition-rating models into existing BMS, and in order to implement this, it was necessary to merge visual and NDT based inspection characteristics.

The method adopted was to explore a whole range of literature, thereby ensuring a strong theoretical background. Akgul (2013) observed how researchers in this field have improved BMS, and termed their approach 'optimization'. Findings revealed that most BMS comprised prioritisation or ranking capability only, and that there is a need for improvement in the area of optimisation of maintenance and repair actions. This suggests that the quest to improve BMS functionalities is a way of optimizing its outputs in order to increase the level of performance. Akgul's (2013) theoretical approach was clear and convincingly presented.

Hong *et al.* (2013) argued that; BMS should adopt a preventive – proactive – approach rather than examining the rate of deterioration alone. They observed that most BMS operated on the basis of the rate of deterioration; this suggests that structures must deteriorate before a maintenance method is proposed. To bridge this gap, Hong *et al.* (2013) initiated a system that can inform bridge managers of the element that may deteriorate next, which therefore aids proactive decisions to be made regarding the structural element.

Preventative maintenance can be achieved by predicting the deterioration of structural elements and development of a maintenance plan. Hong *et al.* (2013) mentioned that, the rate of deterioration of an element has been extensively examined by researchers in this field. But the ability to take proactive measure is yet to be explored. Hong *et al.* reported that a preventative approach in BMS could be examined using three factors namely; condition assessment, deterioration prediction and intelligence maintenance. Central to Hong *et al.*'s (2013) argument was the need for an improvement in BMS, but this improvement should employ a proactive measure to enhance system efficiency. Although Hong *et al.* (2013) presented an exceptional idea, but an area of concern is that, the system will be forced to accommodate and process several data, which may lead to inaccuracy.

DISCUSSION

The above literature draws attention to the state-of-the-art of BMS, paving way for a conceptual framework to emerge. Three conclusions are derived from the synopsis, which are;

- BMS has evolved and continues to evolve to allow further improvement.
- BMS have strictly concentrated on the maintenance aspect of Bridge Management and Asset Management, in respect to decision making and funding options.
- Specific features of BMS have improved without observing the actual need of users.

The review has flagged users' satisfaction and system functionality as a dominant theme. Now a major concern is user satisfaction of the current attribute of these systems, now that so many functionalities have been integrated. Conversely, the construction industry is at the fore front of achieving sustainability, thereby taking into cognisance every activity within the sector. An approach of making BMS respond to sustainable issues is therefore proposed. Hence, BMS should include mechanism for integrating sustainability, in response to this situation. Moreover, uncertainties over future demand and climate conditions and implications of bridge management on

the environment are more important issues to be considered than uncertainties over probabilistic failure mode.

Since BMS helps to prioritize maintenance activities, it is logical to embed a LCA assessment approach into a BMS. LCA provides cradle-to-grave environmental implication of construction activities (Ortiz *et al.*, 2009), therefore BMS would have the propensity to provide information on the best possible maintenance techniques with reduced environmental impact.

CONCLUSIONS

The purpose of this study was to explore the state-of-the-art of BMS to enable the future development of a framework for BMS in the UK. Components and attributes of Bridge management and Asset management have been interrogated to pave the way for BMS (a tool for BM and AM) to emerge. Stemming from a critical review, it is concluded that incremental improvements in various BMS models do not consider sustainable options, which will allow effective decisions to be made with regards to bridge management activities. Therefore, systems should start considering sustainability optimization criteria, in order to enhance effective decision making and extend the longevity of infrastructure.

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THE IMPORTANCE AND IMPLEMENTATION OF SUSTAINABILITY FACTORS IN MALAYSIAN RAILWAY PROJECTS

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The growth of global railway infrastructure development has encouraged many countries including Malaysia to develop railway as a key strategy to enhance the national transportation infrastructure and strengthen economic competitiveness. Nevertheless, the development of railway infrastructure projects demands massive land use, high cost, huge resources and time. These demands have great impact on the economy, environment and social wellbeing. Implementation of sustainability factors in transportation infrastructure projects particularly in railway projects has been recognized as an important mechanism to minimize these impacts. Albeit, it is not clear as to what extent do sustainability factors are incorporated in Malaysian railway projects. The objectives of this paper are to identify the importance of sustainability factors in railway projects from the stakeholder's perceptions and to investigate level of its implementation in Malaysian railway projects. A questionnaire-based survey was conducted in Malaysia among the railway projects main stakeholders: the client, consultants and contractors. The data were analyzed by means of statistical analysis i.e. ranking of variables based on the mean values. Paired t-test was then used to identify whether there are any significant differences between the factors perceived as important and actual implemented. The findings show that the level of importance and implementation of sustainability factors in Malaysia railway project is still in moderate level. It is anticipated that the findings reported in this paper could be important for future strategies and guidelines for improving the sustainability performance of railway infrastructure projects development.

Keywords: Malaysian railway project, stakeholder, sustainability factors.

INTRODUCTION

Infrastructure projects include transportation, water supply, solid waste, communication's networks, energy, etc. Such projects always have multiple objectives, involves people with many different perspectives who must come together to complete the projects successfully (Clevenger *et al.* 2013). Hence, infrastructure projects present significant opportunity to promote sustainability since they are large in scope, multidimensional, costly and time consuming (Clevenger *et al.* 2013; Lothe 2006).

Sustainability of infrastructure transportation development is basically defined through its impacts on the economy, environment and social benefits; measured by system efficiency and effectiveness (Jeon and Amekudzi 2005). The greater efficiencies created by sustainable infrastructure will lead to reductions in waste,

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energy consumption, land degradation, biodiversity loss and minimization in the consumption of non-renewable resources (United Nations ESCAP 2007). Hence, implementation of a sustainable concept in infrastructure projects development has become crucial due to it has a great impact on surroundings and involves many parties (Bueno *et al.* 2013; Litman and Burwell 2006; Jeon and Amekudzi 2005).

In Malaysia, the government has urged construction project key players and developers to be responsive to the need for better environmental and social protection by taking proactive actions to promote and implement sustainability factors (Zainul Abidin 2010). Nevertheless, the weakness in the area of sustainability development still emerged, and it is not clear as to what extent do sustainability factors are incorporated in Malaysia infrastructure sector although its importance has been highlighted (Pereira and Hasan 2004 and Saadatian *et al.* 2012).

According to Naidu (2008), railway system has emerged as a very essential mode of public transportation in Malaysia. However, Malaysian transportation infrastructure projects that proposed by Government agencies and private sectors have often not been subjected to rigorous scrutiny and evaluation, which resulted in poor performance, project delays and stranded facilities (Naidu 2008 and Khalid *et al.* 2012). An example of these issues can be seen from the failures of all three urban rail transit systems in Kuala Lumpur – the STAR and PUTRA lines and the Kuala Lumpur Monorail system that was rendered unsustainable and was rescued by the Government (Naidu 2008). Hence, the purpose of this paper is to examine the level of importance and implementation of sustainability factors in Malaysian railway projects.

SUSTAINABILITY FACTORS OF INFRASTRUCTURE PROJECTS

A number of studies have been conducted reviewing the existing of infrastructure project sustainability factors from different perspectives. For example, Vanegas (2003) presents a sustainable infrastructure project factors in facilities and civil infrastructure projects development. Similarly to CEEQUAL assessment manual that aimed to improve sustainability in infrastructure projects of civil engineering works and public realm project (Lim, 2009). There are 12 key sustainability factors in the CEEQUAL Assessment Manual. Ugwu and Haupt (2007) in their studies have proposed sustainability factors for assessing the sustainability of built infrastructure that grouped under economy, environment, society, resource utilization, project management and, safety and health. On the other hand, Shen *et al.* (2007) developed a framework of sustainability performance checklist to help understanding the major factors affecting a project sustainability performance across its life cycle.

A study by Lim (2009) proposed a set of sustainability factors and its implementation impact particularly on road infrastructure projects. The proposed sustainability factors clustered into environmental, economic, social, engineering, community engagement, relationship management, project management, institutional sustainability, health and safety, resource utilization and management. Besides that, Federal Highway Administration, FHWA also have introduced INVEST to address sustainability throughout the project stages i.e. systems planning, project development, and operations and maintenance (Clevenger *et al.* 2013).

Division of Transport for New South Wales (2012) has developed a Transport Project

Sustainability Framework to ensure that their transportation system is sustainable over time and sustainability performance is continually improved. They focus on the three spheres of sustainability i.e. environmental, social and economic.

The examination on the existing studies of infrastructure projects leads to the formulation of a list 19 sustainability factors for measuring the sustainability performance of railway projects as presented in Table 1.

Table 1: Matrix of sustainability factors of infrastructure projects

Theme	Sustainability factor	New South	Invest 2012	Lim 2009	Ceequal 2008	Ugwu &	Shen et al.	Vanegas 2003
Environment	Site selection							
	Water quality	√	√	√	√	√	√	√
	Air quality	√		√	√	√	√	
	Noise & vibration	√	√	√	√	√	√	
	Waste management	√	√	√	√	√	√	√
	Ecology & Biodiversity	√	√	√	√	√	√	
	Visual impact		√		√	√		
	Energy & carbon emissions	√	√	√	√		√	√
Project management	Type of contact			√	√	√	√	
	Procurement method			√	√	√		
	Project risk			√				
Economic	Life cycle cost		√	√		√	√	
Social	Cultural heritage	√	√	√	√	√	√	
	Health & safety		√	√	√	√	√	
	Stakeholder relationships	√		√	√			
	Inter modality transport		√	√	√		√	
Engineering/ Resource utilization	Material selection			√	√	√		
	Constructability			√	√	√		
	Functionality performance			√				√
		Wales 2012				Haupt 2007	2007	
					√	√	√	√

All of these developed sustainability factors reviewed above have a similar aim that is to encourage the organization to include sustainable practices in their company's strategy and daily work practices. The advantage of implementation sustainability factors is that it can affect the project performance (Lim 2009; Transport for New South Wales 2012; Ugwu and Haupt 2007 and Vanegas 2003). Apart of that, sustainability factors also facilitate stakeholders, owners and engineers measuring the progress towards sustainable development by comparing the performance achieved with the intended performance (FIDIC, 2004).

METHODOLOGY

The method adopted for this research was based on the questionnaire survey of three principle target groups within the Malaysian construction industry, focusing on railway projects. A seven-page questionnaire was distributed to the three-targeted groups that involved in the railway projects development (the clients, consultants and contractors) representing a mixture of professional in order to provide a holistic view and enriches the research finding.

Based on the literature review, a list of 19 significant sustainability factors was produced for the respondents to identify their level of (1) perceived importance criticality and (2) actual implementation to the Malaysian railway project. Respondents were required to rate each question on a five-point Likert scale that required a ranking (1-5). The measurement of the Likert scale is translated, as 1 (not important) to 5 (extremely important). The implementation of each factor was rated from 1(not implemented) to 5(essentially implemented).

The purpose of the first question is to identify the awareness of the project clients, consultants and contractors on the importance or needs of these 19 sustainability factors in Malaysian railway projects. Besides, different project key players have their own concerns, priorities and interest which resulting in different expectation in the implementation of sustainable construction project delivery (Lim, 2009 and Lothe, 2006). Thus, investigating the level of importance and implementation of sustainability factors in Malaysian railway projects is crucial.

All of these questions have been tested in a pilot study conducted on 9 respondents (who were representative of each targeted-group). Comments were made about the structure and length of some sentences, ambiguous words and the way the questionnaire was presented. Some of the comments and suggestions from the pilot survey were taken into consideration before actual distribution of the questionnaire to 96 identified respondents. The results of real data collection were analyzed using the Statistical Package for the Social Science (SPSS) software.

DATA ANALYSIS AND RESULTS

The reliability of the 5-point Likert scale measured was determined using Cronbach's alpha coefficient on the variables. The reliability of the perceived importance and level of implementation were found to be 0.912 and 0.928. Since both of the value fall within the acceptance range of above 0.7 (Pallant, 2010), the data collected and used in this study are considered very good internal consistency reliability (Pallant 2010; Leech *et al.* 2011).

In accordance with Pallant (2010) and Leech *et al.* (2011), Paired sample t-tests (also referred to as repeated measures) can be used when to compare the mean scores for the same people on two different occasions. For instant, the use of Paired sample ttests to identify the significant differences between the Knowledge Management

Factors mean score perceived important and actual implementation in

Telecommunications (Chong *et al.*, 2006) as well as, in Information and Communication technology (ICT) (Siong, 2006). In this case, the Paired sample ttests were used to compare the variables mean scores to determine any significant differences that occurred between the 19 sustainability factors perceived important and actual implementation in Malaysian railway projects.

Response Rate

A total of 96 questionnaires were sent to a different target groups. Thirty-three questionnaires were returned within two months of being sent out, making the total response rate 34.4 percent. This response rate was finally achieved after several efforts were made in terms of personal contacts and follow-up calls. 6 (30%) respondents were from the clients, followed by 15 (38.5%) from consultants and 12 (32.4%) were from contractors. A response rate of 34.4 percent is acceptable. This in line with the opinions of Takim *et al.* (2008) and Dulami *et al.* (2003) that response rate in the construction industry for postal questionnaires above 20 percent is not uncommon and acceptable.

Respondent's designation and experience

Table 2 shows the profile of the respondents. The survey indicates that, 78% of respondents have more 10 years' experience followed by 21% of them has least 10 years' experience. This shows that the respondents have an extensive experience, which helps to provide this study with reliable data.

Table 2: Respondent's designation and years of experience

Position	Experience			
	Less than 5 years	5 - 10 years	11 - 20 years	More than 20 years
Manager	0	5	11	9
Director	0	0	0	4
Senior engineer	0	2	2	0
Percentage (%)	0	21.2	39.4	39.4

Means factors scores for level of importance and implementation

Table 3 presents the result analysis of 19 sustainability factors considered by the respondents for measuring the sustainability of railway projects. The analysis primary deals with ranking the factors based on their mean score values to determine their level of perceived importance (PI) and actual implementation (AI) in railway projects.

Degree of perceived importance

The average mean score values for level of perceived importance held by respondents (see Table 3) is 3.96 (SD = 0.60) and classified as 'moderate important'. Out of 19 SF, the respondents rated seven SF 'very critical', which classified as 'high important'.

These seven SF are Air Quality, Noise and Vibration, Water quality, Ecology and Biodiversity, Site selection, Project risk and Functionality performance. The remaining 12 SF are also significant and classified as 'moderate important' with the mean scores value ranging from 3.68 to 3.99.

Degree of actual implementation

Similar to the degree of actual implementation for all the 19 SF that was also classified as 'moderate implemented' by the respondents with an average mean score 3.49 and standard deviation is 0.74.

Table 3: Means factor scores for level of importance and implementation of SF

Theme	Sustainability factor (SF)	Perceived Importance (PI)			Actual Implementation (AI)				Dif. PI-AI	
		R	Mean	SD	Level	R	Mean	SD		Level
Environment	Air quality	2	4.21	0.42	High	8	3.55	1.00	Moderate	-0.66
	Noise & vibration	2	4.21	0.42	High	14	3.33	0.48	Moderate	-0.88
	Water quality	4	4.14	0.65	High	1	3.94	0.72	Moderate	-0.20
	Ecology & Biodiversity	5	4.02	0.59	High	12	3.45	0.89	Moderate	-0.57
	Site selection	6	4.03	0.41	High	3	3.84	0.56	Moderate	-0.19
	Visual impact	10	3.91	0.49	Moderate	17	3.13	0.50	Moderate	-0.78
	Waste management	13	3.81	0.66	Moderate	10	3.53	0.71	Moderate	-0.28
	Energy & carbon emissions	14	3.70	0.77	Moderate	18	3.09	1.16	Moderate	-0.61
Project management	Project risk	3	4.17	0.44	High	2	3.85	0.61	Moderate	-0.32
	Procurement method	8	3.96	0.77	Moderate	11	3.47	0.87	Moderate	-0.49
	Type of contact	16	3.68	0.73	Moderate	16	3.21	0.92	Moderate	-0.47
Economic	Life cycle cost	8	3.96	0.61	Moderate	7	3.64	0.69	Moderate	-0.32
Social	Inter modality transport	8	3.96	0.63	Moderate	5	3.70	0.85	Moderate	-0.26
	Stakeholder relationships	9	3.93	0.76	Moderate	9	3.59	0.77	Moderate	-0.34
	Cultural heritage	12	3.82	0.73	Moderate	15	3.30	0.64	Moderate	-0.52
	Health & safety	15	3.69	0.55	Moderate	13	3.39	0.39	Moderate	-0.30
Engineering/Resource utilization	Functionality performance	1	4.23	0.70	High	4	3.71	0.79	Moderate	-0.52
	Constructability	7	3.99	0.46	Moderate	19	3.02	0.74	Moderate	-0.97
	Material selection	11	3.88	0.58	Moderate	6	3.66	0.72	Moderate	-0.22
Average Mean			3.96	0.60	Moderate		3.49	0.74	Moderate	-0.47

Key: 1-not important; 2-less important; 3-moderate important; 4-high important; 5-extremely important; 1-not implemented; 2-less implemented; 3-moderate implemented; 4-high implemented; 5-essential implemented; R - rank; Dif. (difference); SD – standard deviation.

Mean difference

Based on the result of Table 3, the average Mean score for Perceived importance is 3.96 (SD=0.60) and the average Mean score for Actual implementation is 3.49 (SD=0.74). These result demonstrates that, there is a significant difference between the sustainability factors of Perceived important (PI) and the Actual implementation (AI) in Malaysian railway infrastructure project, with the average mean decrease of 0.47, t-value = 3.70, and sig. $p < 0.009$ (two-tailed) as shown in Table 4.

Table 4: Comparison of level of PI and level of AI of sustainability factors

Theme	Sustainability factor (SF)	Paired sample t-test				Sig (2-tailed)
		Mean	SD	t-value	df	
Environment	Site selection	0.19	0.44	2.45	32	0.020
	Water quality	0.20	0.47	2.46	32	0.019
	Air quality	0.66	0.97	3.60	32	0.001
	Noise & vibration	0.88	0.65	7.77	32	0.000
	Waste management	0.28	0.69	2.35	32	0.025
	Ecology & Biodiversity	0.57	0.79	3.29	32	0.002
	Visual impact	0.78	0.74	6.01	32	0.000
	Energy & carbon emissions	0.61	0.97	3.60	32	0.001
Project management	Type of contact	0.47	0.72	3.76	32	0.001
	Procurement method	0.49	0.91	2.78	32	0.009
	Project risk	0.32	0.46	3.93	32	0.000
Economic	Life cycle cost	0.32	0.67	2.91	32	0.011
Social	Cultural heritage	0.52	1.15	2.58	32	0.015
	Health & safety	0.30	0.34	4.93	32	0.000
	Stakeholder relationships	0.34	0.55	3.53	32	0.001
	Inter modality transport	0.26	0.73	2.03	32	0.048
Engineering/ Resource utilization	Material selection	0.22	0.53	2.37	32	0.024
	Constructability	0.97	0.91	6.12	32	0.000
	Functionality performance	0.52	0.76	3.92	32	0.000
Average Mean		0.47	0.71	3.70	32	0.009

Key: SD - standard deviation; df - degrees of freedom; sig. - probability (p) value

DISCUSSION

Based on the statistical analyses above, this research has fulfilled its objectives by examining the level of perceived importance of sustainability factors in railway projects and the level of its implementation. For the result of the level of perceived importance, 63% (12 out of 19) sustainability factors were rated as moderate important and 37% (7) sustainability factors were rated as high important. The average means score value is 3.96 (SD = 0.60) and classified as 'moderate important'. Similarly to the level of actual implementation of all the 19 SF that were rated as 'moderate implemented' by the respondents during the railway project development with an average mean score is 3.49 (SD=0.74).

A paired-sample t-test was conducted to identify significant differences between factors perceived as important and actual implementation. The findings revealed that, there was a significant decrease between all the level of perceived important (M=3.96, SD=0.60) and the level of actual implementation (M=3.49, SD=0.74) of the sustainability factor in Malaysian railway project with an average mean difference of 0.47, t-value = 3.69, $p < 0.05$ (two-tailed). This indicates that, the key players of

railway project did not implement the sustainability factors to the extent that they were perceived as important. From the findings above, the level of importance and implementation of sustainability factors in Malaysia railway project can be clustered into two types as illustrated in Table 5.

Table 5: Level of PI and AI of sustainability factor in Malaysian railway projects

Cluster type	Level of PI equal to Level of AI	High PI, but moderate AI
Environment	<ul style="list-style-type: none"> •Visual impact •Energy & Carbon emission •Waste management 	<ul style="list-style-type: none"> •Site selection •Water quality •Air quality •Noise & Vibration •Ecology & Biodiversity
Project management	<ul style="list-style-type: none"> •Type of contract •Procurement method 	<ul style="list-style-type: none"> •Project risk
Economic	<ul style="list-style-type: none"> •Life cycle cost 	
Social	<ul style="list-style-type: none"> •Cultural heritage •Health & Safety •Inter modality transport •Stakeholder relationship 	
Engineering/ Resource utilization	<ul style="list-style-type: none"> •Constructability •Material selection 	<ul style="list-style-type: none"> •Functionality performance

Key: PI - perceived importance; AI - actual implementation

The above findings demonstrate that, the awareness on the importance of 19 SF in railway project among the respondents is still at moderate level. This may be due to the lack of awareness on the benefits of SF in railway project. This is supported by research from Idris (2014) and Zainul Abidin (2010) found that there is a lack of awareness on sustainable construction among the key players of the construction project. Although some of the respondents express that they were aware on the importance of sustainability factors, the issue is not in their priority list. One of the reasons is due to lack of precise indication of sustainability clause in project's contract or specification. This can also be due to that they only emphasize on profit, hence, refuses to acknowledge sustainability in the projects (Idris, 2014).

Nevertheless, there are some respondents who wanted to apply these sustainability factors, but the effort was obstructed by financial constraints. These respondents also suggested that the sustainability factors should be considered or incorporated in the early project i.e. planning stage in order to improve the level of its implementation. Zainul Abidin (2010) point out that planning stages are the most critical stage to integrate the sustainability issues in order to have the most effect on the overall pursuit project, whereas integration after that will be seen as a burden and add more cost to the budget. Besides that, the respondents have also highlighted on the need to create awareness on the important of the sustainability concept within entire construction industry in Malaysia, particularly the client. According to most of the respondents, government should take the lead by encouraging the implementation of sustainable practices through the strong enforcement of legislation, tax incentives and funding especially for sustainable construction projects. This is because the public policies, regulatory frameworks, clause in project contract and specification do not encourage the improvement of the construction sector towards sustainability.

CONCLUSION

This paper examines the current views on importance and implementation of sustainability factors in Malaysian railway project. Based on the literature reviews, 19 critical sustainability factors of infrastructure projects have been identified. These 19 sustainability factors were grouped into five themes namely: environment, economic, social, engineering/resource utilization and project management.

The results of the study depict the level of awareness of sustainable factors among project key players is still at moderate level. Similarly to the level of implementation of sustainability factors in Malaysian railway project which also still at moderate level. This demonstrates that, the concept of sustainable factors has not been widely applied in railway projects. This is in line with Zainul Abidin (2010) findings that the implementation of the sustainability concept in Malaysian construction projects is still in the infancy stage.

In relation to the findings of this paper, it can be found that the concept of sustainability factors has not been widely implement in railway projects due to a few impediments such as lack of precise indication of sustainability clause in project's contract/specifications, financial constraint, lack of awareness, lack of enforcement, etc. Hence, those issues will be interrogating further in the next paper.

The above findings help enhancing our understanding on the 19 critical sustainability factors that must be considered or implemented by the stakeholders, particularly the clients, consultants and contractors during the railway project development. It is hoped that the results of the study could provide insight into the Malaysian railway project development as well as provide valuable knowledge and guideline, especially to the stakeholders (client) in improving the sustainability performance of railway projects.

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REVERSE LOGISTICS (RL) IMPLEMENTATION AMONG CONTRACTORS IN AUSTRALIA: PRACTICES AND BARRIERS

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This paper aims to investigate the perceptions of Australian contractors concerning the prevailing practices and barriers to the implementation of reverse logistics (RL). A review of literature identified 18 practices and 16 barriers to the implementation of RL. Using a triangulated data collection approach, 6 semi-structured interviews and 49 questionnaires were used to collect data. The quantitative survey data was subjected to descriptive and inferential statistics with correlation analysis to examine the strength of relationship among the barriers, whereas content analysis was employed for the interview data. The results indicated the following barriers as most significant: (i) lack of incorporation of salvaged materials by designers; (ii) regulation restrictions to usage of recovered materials and components; (iii) potential legal liabilities; (iv) higher costs; and (v) longer time associated with deconstructing buildings. Relative to the prevailing practices, the top five ranked were as follows: (i) reduction of waste on projects; (ii) clearer understanding of the benefits; (iii) clearer understanding of the challenges; (iv) clearer understanding of the different aspects of reusing building materials; and (v) Enhancing the green image of the organisation. The results of the interviews also confirmed the findings from the survey, and identified the following barriers: (i) lack of support from the government in terms of financial incentives to increase the competitiveness of reused and salvaged items in the market; (ii) The attached stigma and resistance of supervisors, designers, and some authorities towards using salvaged and reused materials; and (iii) Technical barriers associated with usage of salvaged materials. The majority of the interviewees identified economic issues as the major drivers of RL practices. The identified barriers could be used as a ‘road map’ for the development of appropriate solutions for the successful implementation of RL, and to improve the environmental related decision making processes of the contractors.

Keywords: reverse logistics, barriers, supply chain management.

INTRODUCTION

Reverse logistics is defined as “*the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of creating or recapturing value, or proper disposal*”. (Rogers

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and Tibben-Lembke, 1999, p. 271). From a construction perspective, some studies have identified reverse logistics as a mechanism for easing up the detrimental environmental effects. For example, Pokharel and Mutha (2009), acknowledges that the focus of RL is on waste management, material recovery (recycling), parts recovery or product recovery (through remanufacturing). However, construction and demolition (C&D) waste from the construction industry plays a pivotal role in the recovery rate of waste in South Australia (SA). In total, the construction activities contributed to over 2.2 million tonnes (over 50% by weight) of the materials resource recovered within South Australia. While the waste is generated from forward logistics activities such as waste management practices, some reverse logistics (RL) best practices associated with resource recovery within the SA construction industry continues to be problematic, and still remains under explored. As observed by Abdulrahman *et al.*, (2014), there are limited RL studies focussed on developing counties. Elsewhere, in developed and developing countries such as the U.K and China respectively, the construction industry is renowned as the greatest contributor of C& D wastes (Oyedele *et al.* 2013; Wang *et al.* 2010). While the concept and principles of reserve logistics (RL) are not new as shown by the plethora of studies in other countries and industries (Steward and Kuska, 2004), the implementation of practices and principles has not reached satisfactory levels within the building industry (Schultmann and Sunke, 2007; Kibert, 2012; Leigh and Patterson, 2006). Furthermore, despite anecdotal evidence suggesting that local people have used materials and components salvaged from old buildings, the uptake of RL and studies examining the desirable practices are very limited within the Australian construction industry context.

The rest of the study is structured as follows: The following section presents and summarises a review of the literature on practices and drivers affecting RL implementation. Following the review is a summary and identification of gaps in RL knowledge. This is followed by the mixed methods methodological approach adopted for this research study. An explanation of the statistical methods employed for the quantitative part of the study and associated techniques for analysis of the qualitative data, as well as interpretation of the findings are presented. The final section addresses recommendations made and conclusions.

LITERATURE REVIEW

Practices affecting the implementation of RL

In order to present a detailed and structured review of the practices affecting RL, it is necessary to describe how these ‘practices’ are framed and conceptualised in the construction industry. The following three groupings: (i) Industry; (ii) organisation and (iii) project were selected based on the propositions as set out in the seminal work in RL and the model of the environment forces affecting RL activities as proposed by Carter and Ellram (1998). According the same study (Carter and Ellram, 1998), it identified and viewed the operational task environment for the RL as distinctly comprising of following four factors: input, regulatory, output and competitive. The study further argued that the task environment was surrounded by the macro environment which consisted of the general social, political, legal and economic trends (Carter and Ellram, 1998 pg. 94). This macro environment could thus be equated to the ‘industry’ level of prevailing RL practices whereas the ‘organisation’ RL practices were associated with such groupings as the suppliers (input), buyers (output), government agencies such as the EPA (regulatory) and competitors

(competitive). The final listing of the RL practices and associated studies is presented in Table 1 and based on the extensive review of literature by Hosseini *et al.* (2014).

Table 1: Practices for RL and similar studies

Practices	Previous studies ¹
OrgPrac1=Clear understanding of the benefits of deconstructing buildings	Crowther, (2001); Sassi (2004, 2008); Addis, (2006b); Guy <i>et al.</i> (2006)
OrgPrac2=Awareness of deconstructing procedures	Greer (2004); Schultmann and Sunke (2007b)
OrgPrac3=Understanding of challenges associated with deconstruction	Pulaski <i>et al.</i> (2003); Sassi (2004); Guy <i>et al.</i> (2006); Leigh and Patterson (2006); Gorgolewski (2008); Weil <i>et al.</i> (2008); Saghafi and Teshnizi (2011); Kibert (2012)
OrgPrac4=Understanding of different aspects of reusing buildings	Greer (2004); Schultmann and Sunke (2007b)
IndsPrac1=Availability of salvaged building products, components and materials	SA Government (2012)
IndsPrac2=Availability of deconstruction and dismantling service providers	SA Government (2012)
IndsPrac3=Existing demand for salvaged and used building products	O'Brien <i>et al.</i> , (2002); Addis (2006a); Gorgolewski (2008); Hiete <i>et al.</i> (2011);
IndsPrac4=Facilities to recover the used products after deconstruction	Schultmann and Sunke (2007b)
IndsPrac5*=Regulatory and financial incentives in favour of deconstruction	Carter and Ellram (1998); Kibert <i>et al.</i> (2000a); Guy and McLendon (2002); O'Brien <i>et al.</i> , (2002); Smith <i>et al.</i> (2007); Saghafi and Teshnizi (2011); Huscroft <i>et al.</i> (2013).
IndsPrac6*=Regulatory and financial incentives for promoting use of salvaged materials	Tibben-Lembke and Rogers (2002); Sassi (2004); Dowlatshahi (2000); Nordby <i>et al.</i> , (2009); Da Rocha and Sattler (2009); Kibert (2012); Densley <i>et al.</i> , (2012); Yeheyis <i>et al.</i> (2013)
IndsPrac7=Quality control compliance for used products	Crowther (2001)
ProjPrac1=Deconstruction is implemented in our projects	
ProjPrac2=Utilisation of salvaged materials in new buildings	Chini and Bruening (2003); Razaz (2010)
ProjPrac3=Reducing the amount of waste generation as part of strategic objectives	Genchev <i>et al.</i> (2012); Zero Waste (2011)
ProjPrac4=Enhancing the green image as part of strategic objectives	Addis (2006b); Laefer and Manke (2008); Kralj and Markic (2008).
ProjPrac5=Organisational support for using salvaged materials in new buildings	Carter and Ellram (1998); Dey <i>et al.</i> (2011) ² ; Genchev <i>et al.</i> (2012); Huscroft <i>et al.</i> (2013)
ProjPrac6=Organisational support for deconstructing buildings	Carter and Ellram (1998); Dey <i>et al.</i> (2011) ² ; Huscroft <i>et al.</i> (2013)
ProjPrac7=Organisational support for designing buildings based on designing for RL principles	Carter and Ellram (1998); Dey <i>et al.</i> (2011) ² ; Huscroft <i>et al.</i> (2013)

Notes: *The review of the literature for the two industry practices is combined due to the common denominator of 'regulatory and financial incentives'; ¹Previous studies arranged in chronological order, and for the full listing of references, please refer to Hosseini *et al.* (2014); ²Supply chain logistics related study

Barriers affecting the adoption and implementation of RL

The literature on developing and developed countries and across different industries such as services, manufacturing and construction is replete with a number of studies on the major barriers affecting the implementing of RL. Drawing upon the approach undertaken by Ho *et al.* (2012) study aimed at examining the major factors that may influence industries to implement reverse logistics, these barriers can be categorised into internal (i.e. intra-organisational) and external (inter-organisational). Similarly, the seminal study by Carter and Ellram (1998) though focussed on the drivers than the

barriers, conceptualised the drivers into ‘internal’ and ‘external’ and linked the ‘company factors’ to internal whereas the ‘task environment’ as external. According to Hosseini *et al.* (2014), the barriers (see Table 2) associated with RL can be categorised into the following three groups: (i) organisational barriers (OrgBr), (ii) operational barriers (OperBr) and (3) Social (SocBr).

Table 2: Major barriers associated with RL

<i>Description</i>	<i>Scholarly Support¹</i>
OrgBr1=High costs of adopting RL	Jindal and Sangwan (2011); El Korchi and Millet (2011); Tan and Hosie (2010); Lau and Wang (2009); Del Brío and Junquera (2003)
OrgBr2=Uncertainty about the results	Jindal and Sangwan (2011); González-Torre <i>et al.</i> , (2010); Zilahy (2004)
OrgBr3=Restraining organisational policies (e.g. overlooking design for reverse logistics)	Abdulrahman <i>et al.</i> , (2012); Ravi and Shankar (2005); Rogers and Tibben-Lembke (1998)
OrgBr4=Lack of awareness within the organisation	Jindal and Sangwan (2011); Presley <i>et al.</i> , (2007); Post and Altma (1994)
OrgBr5=Immaturity and low investment in knowledge management and information systems	Zhu <i>et al.</i> , (2008a); Ji (2006); Ravi and Shankar (2005); Rogers and Tibben-Lembke (1998, 2001)
OrgBr6=Lack of human resources with necessary qualifications	Ravi and Shankar (2005); Hillary (2004); Post and Altma (1994)
OrgBr7=Inappropriate organisational structure (and size)	González-Torre <i>et al.</i> , (2010); Post and Altma (1994)
OrgBr8=Lack of support from management	Jindal and Sangwan, (2011); Zhu <i>et al.</i> , (2008); Ravi and Shankar (2005); Rogers and Tibben-Lembke (2001)
OrgBr9=RL is not a priority in the organisation’s investments	Presley <i>et al.</i> , (2007); Rogers and Tibben-Lembke (1998, 2001)
OrgBr10=Resistance to change in the organisation	Jindal and Sangwan (2011); Ravi and Shankar (2005); Hillary (2004)
OperBr1=Deficient structure of the industry for adopting RL	Qiang <i>et al.</i> , (2013); Del Brío and Junquera (2003); Rogers and Tibben-Lembke (2001)
OperBr2=Lack of support from parties in the supply chain	Qiang <i>et al.</i> , (2013); Jindal and Sangwan (2011); González-Torre <i>et al.</i> , (2010)
OperBr3=Inadequacy of technologies (emphasis on information communications technologies)	Jindal and Sangwan (2011); Ji (2006); Ravi and Shankar (2005)
OperBr4=Lack of standardised processes and lack of shared understanding of the best practices	Abdulrahman <i>et al.</i> , (2012); Lau and Wang (2009)
OperBr5=Lack of knowledge in the industry	Jindal and Sangwan (2011); Ji (2006); Ravi and Shankar (2005)
OperBr6=Unfavourable business culture	Hillary (2004)
SocBr1=Perceptions about the low quality of products of RL	González-Torre <i>et al.</i> , (2010)
SocBr2=Lack of support from professional associations, non-government organisations	Hillary (2004)
SocBr3=Inappropriate governmental regulations	Jindal and Sangwan (2011); Abdulrahman <i>et al.</i> , (2014)*; González-Torre <i>et al.</i> , (2010); Tan and Hosie (2010)
SocBr4=Bureaucratic problems in granting of licences and location permits	Zilahy (2004)

Notes: ¹For full listing of references, please refer to Hosseini *et al.* (2014)

RESEARCH METHOD

To investigate the perceptions of Australian contractors concerning the prevailing practices and barriers to the implementation of RL, the following research methods were employed in the study.

Measurement instrument

The questionnaire distributed to the South Australian construction contractors (SACC) comprised four distinct sections as follows: The first section covered the demographics. The second section was designed to evaluate the prevailing practices for RL implementation. The third was aimed at capturing the drivers for incorporating RL in the building lifecycle, and finally the fourth section was focused on identifying the barriers (see Table 1) to the implementation of RL. The three sub instruments (practices, drivers and barriers) were all measured on a 5-point Likert scale where 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; and 5 = strongly agree. Thus (3) represented indifference, i.e. neither agree nor disagree. The findings reported here relate to only the first, second and fourth sections of the questionnaire dealing with the demographics, practices and barriers respectively. It was also beyond the scope of this study to report all the results.

Data analysis

This paper aims to investigate the perceptions of Australian contractors concerning the prevailing practices and barriers to the implementation of reverse logistics (RL). 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 two statistical methods were used: (1) frequency analysis and (2) ranking analysis. Review of the literature shows that such approaches have been adopted before in survey related studies (Chileshe and Yirenkyi-Fianko, 2012). Rank differentiation was employed for the practices and barriers having the same mean score through utilisation of the lowest standard deviation (Chileshe and Yirenkyi-Fianko, 2012). The results of the validity and internal consistency for both sub instruments were as follows: 0.875 (F-statistic = 16.569 sig. = 0.000); and 0.887 (F-statistic = 8.002) for the practices and barriers sub instruments respectively. The results were deemed as acceptable in light of the Cronbach values exceeding the recommended of 0.7 (Nunnally, 1978).

Characteristics of the sample (quantitative study)

A total of 539 questionnaires were distributed using two modes of administration: (i) Postal survey administered to 260 contractors randomly drawn from the Civil Contractors Federation (CCF) and Master Builders Association (MBA) of South Australia (SA); and (ii) email survey comprising 286 questionnaires to representatives and contracting organisations belonging to a number of professional bodies such as the AIB, AIPM and AIA. A total of 49 completed questionnaires were returned as follows: 23 via email and 26 via post thus generating an overall response rate of 9.09%. While this number might be deemed as small when compared to the overall population of contractors within the selected sample, in comparison with previous studies (Lim and Ling, 2012; Yong and Mustaffa, 2012), this sample size was adequate, and further complimented by the qualitative data. For example, the study by Lim and Ling (2012) only had a sample size of 32 respondents whereas Yong and Mustaffa (2012) employed a smaller sample size of 14 respondents. In both studies, only the quantitative approach was employed. Some characteristics of the respondents at the organisational level based on the principal type of construction work showed that the majority 15(31.3%) of the respondents were involved in more than 2 types of construction work (CW), followed by 7(14.6%) in residential. The rest were evenly spread across commercial (12.5%); more than 3 types of CW (12.5%). The least of the respondents (8.3%) were involved in industrial type of work. The respondents

comprise 27 (56.3%) executives (C.E.O, President and Vice president), 8 (16.7%) project managers, 5 (10.4%) other category of senior management, 3 (6.3%) site engineers, an equal number 2 (4.2%) of field superintendents and supervisors and 1 (2.1%) construction manager. The proportions of the respondents in terms of organisation size (number of employees) were: The majority 65.3% (32) had less than 24 employees, followed by 24.5% (12) with more than 25 but less than 114 employees. The minority, 10.2 % (5) had more than 115 employees. The following sub sections now presents a discussion on the qualitative study protocol.

Study protocol (Qualitative approach)

All the interviews except for one were conducted in the interviewee's respective organisations. While there was a possibility of recording the actual sessions, this approach was discounted. As pointed out by King and Horrocks (2010), people are uncomfortable about being recorded and hence it is important to obtain consent to do so. Instead, the responses as made were written down by one of the two researchers conducting the interviews. The profile of the interviewees is shown in Table 3.

Table 3: Descriptions of the organisations involved in the semi-structured interviews and matching to Carter and Ellram (1998) framework

Interviewee	Task environment (TE) and role ¹		Position & experience (Individual* / Organisation)
	TE	Role	
A	Output	Buyer	Marketing manager (Established since 1993)
B	Competitive	Competitor	Managing director (*20 years' experience)
C	Regulatory	Interest aggregator	Executive manager (Operational since 2005)
D	Output	Buyer	CEO and owner (25 years in business)
E	Input	Suppliers	Executive manager (*15 years' experience)
F	Regulatory	Government agencies	Senior environment protection officer

Notes: ¹Reference to Carter and Ellram (1998) Framework; A = Organisation owning the largest salvage yard in Australia; B = Medium sized construction company active in projects for the South Australian (SA) government; C = Provider of legal services to SA construction companies; D = Leading salvaging organisation in South Australia; E = Largest recycling facility in South Australia particularly in recycling concrete and production of recycled aggregates; and F = South Australia's primary environmental regulator (Environmental Protection Authority (EPA)).

As can be seen from Table 3, the interviewees' represents the broader spectrum of the stakeholders identified within the seminal study of Carter and Ellram (1998).

SUVEY RESULTS AND DISCUSSION

Ranking of the practices

This sub section examines the ranking the practices according to their three sub classifications (industry, organisational and project-level). Table 4 summarizes the results of the analysis. The highly ranked practice was "*reducing the amount of waste generation as part of strategic objectives (mean score = 4.082, std dev. = 0.886)*". This finding was consistent with literature regarding the main objectives of RL (Addis, 2006; Hosseini *et al.* 2014). Interestingly, the findings of the fourth ranked practice, namely "*existing demand for salvaged and used building providers*" contradict previous (Addis 2006; Gorgolewski 2008; Hiete *et al.* 2011). For example, the study by Hiete *et al.* (2011) found that supply and demand in recovered building materials market does not necessarily match. Thus, it is necessary to buy desired reclaimed materials once they show up in the market (Gorgolewski, 2008). This might be very early in the project to ensure their availability in due course.

Table 4: Ranking of practices desirable for RL implementation

Practices	MS ¹	SD ²	R ³	OR ⁴
<i>Industry related</i>				
Availability of salvaged building products, components and materials	3.796	0.735	1	7
Availability of deconstruction and dismantling service providers	3.714	0.707	2	11
Existing demand for salvaged and used building products	3.571	0.890	4	13
Facilities to recover the used products after deconstruction	3.694	0.713	3	12
Regulatory and financial incentives in favour of deconstruction	2.792	1.031	6	17
Regulatory and financial incentives for promoting use of salvaged material	2.729	1.001	7	18
Quality control compliance for used products	2.857	0.913	5	16
<i>Organisational related</i>				
Clear understanding of the benefits of deconstructing buildings	4.061	0.827	1	2
Awareness of deconstructing procedures	3.750	0.887	4	10
Understanding of challenges associated with deconstruction	4.020	0.750	2	3
Understanding of different aspects of reusing buildings	3.898	0.848	3	4
<i>Project related</i>				
Deconstruction is implemented in our projects	3.510	0.893	6	14
Utilisation of salvaged materials in new buildings	3.204	1.060	7	15
Reducing the amount of waste generation as part of strategic objectives	4.082	0.886	1	1
Enhancing the green image as part of strategic objectives	3.837	0.746	2	5
Organisational support for using salvaged materials in new buildings	3.776	0.848	5	9
Organisational support for deconstructing buildings	3.776	0.743	4	8
Organisational support for designing buildings based on DfRL principles	3.796	0.676	3	6

Notes: MS¹ where the higher the mean, the more important the practice for RL; SD = Standard deviation; ³R = overall ranking based on full sample and within the individual grouping of the RL practices classification; ⁴OR = Overall ranking based on the full practices.

Similarly, Addis (2006) observed that one of the underlying problems associated with this practice is the aspect of spending money sooner than usual along with more problems associated with storage of products and materials. One of the probable reasons for the conflicting results is that, the market for recycling in South Australia is deemed mature with established facilities and strong players. The evidence for existing demand for salvaged and used building products (see Table 1: Industry Practice 3) is further provided by the Marketing Manager (Interviewee A) who commented: “*Number of customers is increasing. [...] Customers are people who do small alterations to their homes, house builders, architects, contractors etc..[...] Definitely, the domestic sector is very huge compared to the commercial sector, both as customers and providers of salvaged materials [...]*”. This observation was further reinforced by the supplier (Interviewee E) who acknowledged that market was booming, with more competitors making the supply harder to get. The industry level practice of “*quality control compliance for used products*” though ranked fifth (mean score = 2.857), was the least ranked (Rank=16th) based on the full practices. Studies such as Kibert (2012) and Nordby *et al.* (2009) have pointed to the lack of products or materials with a certificate or eco-label designated as preferable for builders.

However, some of the Interviewees have acknowledged this problem, and suggested some measures be put in place to improve this practice. While it is beyond the scope

of this paper to report on all of the interviewee's observation, in general some of the comments related to the testing of aggregates for asbestos (Interviewee D). With reference to the materials used on the construction of roads, Interviewee D further highlighted the problems associated with recycled and reused products as follows: "There is also a bit of quality issue with recycled products. For example, bitumen mixed with tiny wood particles can have a mushroom effect on the surface of a road.....Some tradesmen don't like concrete made out of re-cycled aggregate. ...It sets quickly and compacts better. Maybe it's because of cement in those aggregates". Despite the higher ranking of this practice, some of the interviewees expressed reservation with the storage of extracted material and highlighting the role played by the regulator. The executive manager (Interviewee C) observed that "storage of extracted materials from buildings is an issue since the EPA regards anything without immediate use as waste and asks to remove it from the site". These comments suggests that despite the efforts made at integrating and reusing recycled and salvaged products from the RL perspective, the issue of quality remains one of the main impediments to the adoption of RL. Furthermore, this appears not just to be confined to the South Australian construction industry context, but globally. For example, with the Brazilian context, a study conducted by Da Rocha and Sattler (2009 cited in Hosseini *et al.* 2014), aimed at identifying the major factors influencing the reuse of building components established that the variability or inconsistency of quality as a major constraint of their popularity.

Overall ranking of the barriers

This sub section examines the construction stakeholder's perception of the barriers inhibiting the implementation of RL (see Tables 5 and 6).

Table 5: Overall ratings of barriers to RL-Operational related

Barrier ¹	Mean score	Std. Dev	RAI ²	Rank ³	Overall ranking
OperBr1	3.286	0.935	0.657	1	=4
OperBr2	3.286	0.935	0.657	1	=4
OperBr3	2.592	0.956	0.518	7	16
OperBr4	2.776	0.771	0.555	5	13
OperBr5	2.837	0.746	0.567	4	12
OperBr6	2.776	0.771	0.555	5	13
OperBr7	3.000	0.875	0.600	3	10

Notes: ¹For detailed description of the operational barriers, see Table 2; ²RAI = Relative agreement index; and ³Rank based on the sub category grouping of the operational barriers

As can be seen from Tables 5 and 6, the organisation's reluctance to use salvaged materials due to the lack of design incorporation is ranked as the most important critical barrier within this category of "industrial barriers" as well based on all the sixteen barriers (Mean score = 3.563, RAI = 0.713; Std Dev = 0.848). Support of the high ranking of this critical barrier can be found in previous studies such as manufacturing related (Abdulrahman *et al.* 2014; Rogers and Tibben-Lembke, 1999); and a number of construction related studies (Hosseini *et al.*, 2014). Table 6 further shows that apart from the "Industrial barrier 3" and "Social barrier 1", the mean scores values for the remaining barriers were greater 3.000, thus implying some level of significance or importance.

Table 6: Overall ratings of barriers to RL-Industrial and social related

Barrier ¹	Mean score	Std. Dev	RAI ²	Rank	Overall ranking
IndsBr1	3.163	0.943	0.633	3	7
IndsBr2	3.563	0.848	0.713	1	1
IndsBr3	2.776	0.823	0.555	5	15
IndsBr4	3.122	0.881	0.625	4	8
IndsBr5	3.417	0.919	0.683	2	3
SocBr1	2.878	0.780	0.576	4	11
SocBr2	3.167	0.907	0.633	2	6
SocBr3	3.021	0.887	0.604	3	9
SocBr4	3.449	0.868	0.690	1	2

Notes: ¹For detailed description of the industrial and social barriers, see Table 2; ²RAI = Relative agreement index; and ³Rank based on the sub category grouping of the industrial and social barriers

LIMITATIONS

While the study makes several contributions to supply chain management (SCM) and RL theory and practice, some limitations should be noted. This first limitation relates to the cross-sectional nature of the quantitative study. Against that background, caution should be exercised in the interpretation and generalization of the results. Future studies should employ larger samples. The second limitation relates to the restrictions of the population sample to only South Australia and the construction industry, as such the generalization of the findings to other industries might not be possible. The third limitation relates to the small sample size (n=49) for the survey which restricted the need for employing rigorous and refined statistical analysis such as factors analysis and Structural Equation Modelling (SEM). These techniques would have enabled the empirical validation of the identified practices, and eliminated the problems of multicollinearity which obscures the relationship among the practices.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this paper is to explore and identify the prevailing practices and barriers to the implementation of reverse logistics (RL), and assess the readiness of South Australian construction organisations when implementing RL practices. The findings from the quantitative study demonstrated a good level of readiness on the project level practices, as well as the organisational level. There were mixed findings with regard to the readiness of the regulatory related industry practices. This study established that despite the advocated benefits of regulatory and legislations as drivers for implementing RL practices (Carter and Ellram, 1998), this was not the case in the South Australian construction industry. While the review of the literature (Hosseini *et al.* 2014) identified an array of major regulations supporting reducing waste and recovering the value of used materials in South Australia, it is clear from the empirical evidence and qualitative data that, the available regulations could be regarded as pushing organisations away, than towards implementing strategies with the same objectives as RL. It is further recommended that further research be carried out to explore the relationships between the identified practices and improved organisational performance. Future research would assist organisations in understanding the linkages between RL practices and performance, and help provide theoretical explanations as to why certain practices may work well in one context but not another.

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STAKEHOLDER-ASSOCIATED RISK NETWORKS IN GREEN BUILDINGS: CHINA VERSUS AUSTRALIA

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The aim of this research is to model stakeholder-associated risk networks and gain understanding of the differences and similarities of green building risks in China and Australia, given the different political, social-cultural and legal systems. This paper builds on the authors' previously published research (Yang and Zou 2014). Case studies of green star accredited recently constructed major office buildings were undertaken in both countries. Data were collected through desktop studies, focused workshops and face-to-face interviews with key project participants, and analysed by using Social Network Analysis (SNA) methods which aims to analyse the characteristics and interdependencies of risks-stakeholders relationships. The research finds that while reputation risks are important for project players in both countries, the ethical risk 'assessment experience and fairness' has been highlighted as crucial in the Chinese green practice due to potential corruption issues. In the Chinese case, relatively higher attention was paid on the quality / technical issues and the government plays more important role to develop rigorous policy systems, as well as improve societies' knowledge and awareness levels on green technology and energy saving. From stakeholder management perspective, communications between internal stakeholders can contribute to a smooth green building design and construction in both countries. The main contribution of this research is the development and application of an integrated method of SNA and stakeholder management in project risk assessment in green buildings in differing political, technical, social and cultural settings. The outcomes of this research have an implication in theoretical development and practical application for both green building risk management and international construction.

Keywords: green building, risk, stakeholder, social network analysis, Australia, China.

INTRODUCTION AND RESEARCH AIMS

With the rapid rates of economic development and urbanization, the property development and construction industry in China has become a pillar of its national economy, and they are proposing to develop 10 million affordable green buildings every year in the next 10 years (Guo and Su, 2011). All buildings in China, including new developments and existing buildings, are required to achieve a reduction of energy consumption of a minimum of 50% compared to the nineteen-eighties (MOHURD, 2011). This is a massive undertaking, particularly when it is

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acknowledged that China is still in its infancy in terms of experience in the adoption of 'green building' expertise (Wang, 2010).

The Australia in the Asian Century White Paper (Australian Government, 2011) has clearly emphasised the vital importance to identify the actions that Australia governments and business sectors should seize the opportunities and meet the challenges arising from China which is already unfolding. While opportunities may be attractive, there are many risks when working in different business environments where the institutional and economic developments, as well as the legal, political and sociocultural settings are quite different from the host countries (Kytile and Ruggie, 2005). Most of the risks are associated with various project or business stakeholders, from the government, to the building development lifecycle supply chain members, because of the different claims, interests, and culture backgrounds (Zhang, 2011). This requires an in-depth understanding of the Chinese construction market operation and management mechanism, their relevant policies, and market demand force together with the opportunities, stakeholders and associated risks for Australian governments and firms.

This study aims to understand the differences and similarities of the green building risks in different political, social and cultural settings, by using China and Australia as case examples to demystify complex stakeholder and risk networks. Two office buildings with one in each country were selected as case studies for comparison. A Social Network Analysis (SNA) model, improved based on the one proposed by the authors of this paper (refer to Yang and Zou (2014)) was chosen to assist the case study analysis process. This paper starts with an explanation of the theoretical background on use of the SNA model, which standardises the case study process. Then the results of the two case projects are explained, compared, and discussed to assist researchers' and industry practitioners' understanding of stakeholder associated risk networks and international green building practice.

THEORETICAL BACKGROUND

Yang and Zou (2014) developed a SNA-based 'green' risk & stakeholder analysis model by combining the classical risk management process and the generic SNA steps. Rather than focusing on risks'/stakeholders' attributes, the social network views characteristics and interdependencies of risks-stakeholders as arising out of the social structural environment in order to better understand the decision-making process. By identifying the directions of influence in the entire network, project managers can conduct systemic analysis, communicate with internal and external stakeholders about the influential risks, and develop risk response or mitigation strategies accordingly. In essence, the application of the social network perspective to stakeholder and risk analysis investigates the patterns of stakeholder-associated risk networks as well as the forces which shape these patterns, and unlocks risk interactions inside the whole relationship network. All of these are intended to provide a rationale for stakeholder communication and risk response strategies and facilitate the decision-making process in green buildings. There are five major steps in this model, listed as below:

4. Identification of stakeholders and their risks

The stakeholder and risk groups were proposed. Risk categories include: time (risks related to time management), cost (risks related to cost increase and return), quality and technical issues (risks related to the product quality, including technical barriers, material availability and work quality), organization and management (risks related to organizational structure, knowledge, and relationship

management), policy and standards (risks related to regulations and standards), safety (risks related to occupational health and safety), ethics and reputation (risks related to social and ethical issues), and environment (risks related to environment protection). The stakeholder groups include: client, consultant, contractor, subcontractor/supplier, end user, financial organization, government, environmental organization, professional association, media, public, labour union, assessor/certifier, researcher/educator, and others.

5. Determination of risk interrelations

This step defines the links in the risk network, which represent the impact between two nodes. The link is defined by the impact from one risk to the other, and the likelihood of the interaction between the risks.

6. Visualisation of risk network

In the network, different shapes of the nodes represent risks associated with different stakeholders, while different colours of the nodes represent different risk categories. The arrows with values in the network are the interrelations among the risks, of which the thicknesses indicate the degrees of influence degrees (i.e. impact * likelihoods) of the interrelations.

7. Decipherment of risk network

Three types of measures are useful for network analysis: Network measures, Node/link measures, and Partition measures.

8. Identification and simulation of risk mitigation actions

The critical risks and interrelations are identified based on the results in the last step. The critical risks will be removed from the network, and the network measures can be recalculated.

The SNA-based model presented by Yang and Zou (2014) has been demonstrated as a useful tool for assessing risk interactions and risk mitigation actions in green building projects. The case study analysis in this research will follow the steps in this SNA model. For detailed information about the model, please refer to their paper.

RESEARCH METHODS

Why Case Study Method

This research has adopted a case study approach. The research aims to obtain an in-depth understanding of the stakeholder-associated risks and their interactions in green buildings under different legal, political, social and cultural settings, namely China and Australia. The emphasis here is more on 'how' and 'why' than 'what'. Green building development is relatively new and still in its infancy stage. Such new development involves application of new technology and new sets of skills, which are not applied to general building design and construction. Furthermore the collection of the data that is required to develop the risk network requires interactive interactions with project team rather than a single round of 'tick and flip' exercise. As such it would not be feasible or suitable to use population-wide or sample-sized questionnaire surveys. Instead case study methods are more suitable. Case study analysis is a preferred technique when 'how' and 'why' questions are considered (Yin, 2009). This research addresses a 'how' type of question in order to understand how risks are connected in large-scale complex green building projects. Given the above mentioned reasons, the case selection was not random but based on theoretical/selective sampling. The case projects were chosen because they have high level project complexities, which make stakeholder and risk analysis more meaningful, due to the complex relationships in the projects, and the project managers had challenges

managing them. The data was collected by workshops and interviews, with more details in the following section.

Case Selection

The Chinese Case

The Chinese case selected for this research was a multi-storey office building located in Shenzhen city, the southern China. The building occupies 3000 m² of land, and has 14 storeys including 2 underground basement levels. The total indoor area is 18,114 m². The total cost is \$80+ millions Chinese Renminbi (RMB). It implements a design principle of 'localisation, low cost, low energy consumption, and scalability'. The total energy saving achieved the goal of 65.9%. It has achieved significant economical environmental and social benefits and exceeded the national saving targets set by the Chinese central government. The finance and occupancy of the building all belong to the same organisation, which is a research and design institute whose core business is undertaking research to improve building performance in terms of energy, water, indoor air, etc. To this end, it is like 'leading by example'. The building has been granted the US LEED golden prize and a number of the Chinese national green ratings and awards.

A workshop, which has 8 project team members attended including project managers, consultants, contractors and end users, was organised to identify the internal and external stakeholders and their associated risks in the project with reference to the stakeholder and risk categories specified by Yang and Zou's study (2014). The workshop participants also contributed to the development of risk interrelationship matrix in which the possibility and consequence of the impact between risks were determined with five-point values (5 meaning extremely high, 1 meaning extremely low). A number of interviews with the team members were conducted at a later stage to obtain further information and clarify any ambiguities. The researchers (i.e. the authors of this paper) also had a site visit to the built facility, to gain first hand impression and understanding of the technologies applied to the building and the built environment.

The Australian case

The Australian case project selected here was adopted from a previous study by the authors Yang and Zou (2014), for comparison purpose. While more details of the project can be referred to their paper, a brief summary of the project case is provided here. It is a three-storey office building, which has a contract sum of over \$10 million Australian dollars. It was constructed using a World Leading practices as required by the Green Building Council of Australia to target a 6 Stars rating in both "*As Design*" and "*As Built*". The case project presented considerable challenges and difficulties to the project management team, requiring the adoption of a relationship based collaborative approach to project management and project delivery. A number of new technologies have been designed and applied to this building.

The data was collected through surveys and interviews with key project participants together with desktop-studies on the project information provided by the design-and-construct head contractor. The stakeholder and risk information were collected in a first round survey, based on which the risk relationship matrix was developed in the second round surveys and interviews. The researchers (i.e. the authors) visited the building at its near-completion stage accompanied by the project director. For more details readers are referred to Yang and Zou (2014).

RESULTS AND ANALYSIS

Comparison of risk and stakeholder groups

In SNA, density and cohesion are two network measures: The higher the density, the more risk interrelations are there in the network; and the higher the cohesion, the more complexity of the risk network is. Figure 1 shows the risk networks in both projects. The network density and cohesion value are (0.338, 0.624) in the Chinese case and (0.37, 0.703) in the Australian case, which show that the networks in both projects are relatively dense and complex compared to networks in other studies such as Fang *et al.*'s work (2012).

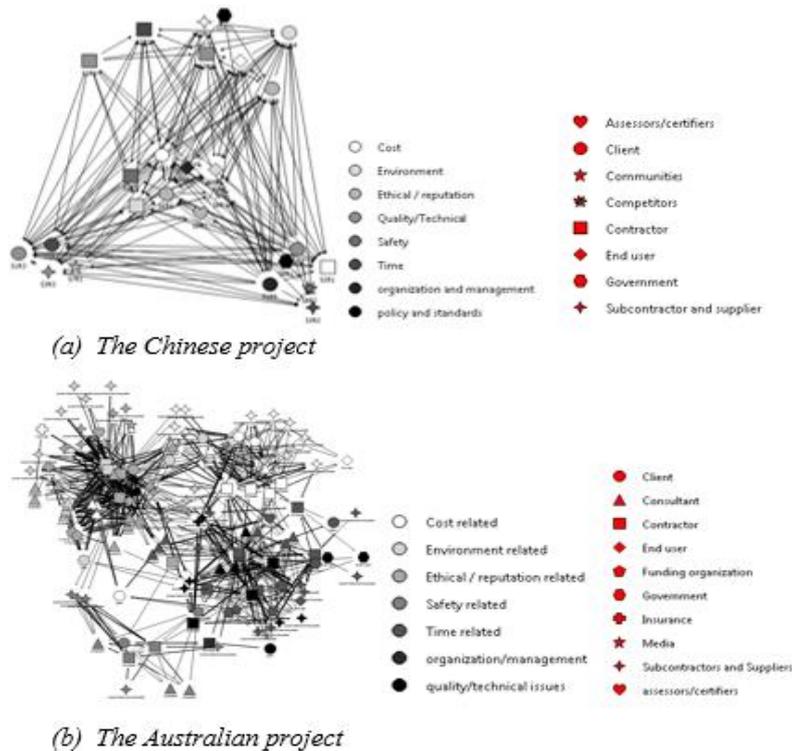


Figure 1 Stakeholder-associated green risk networks

In the Chinese case, in total, 9 stakeholders were identified with 26 ‘green related’ risks and 220 risk interactions (Table 1). Comparing with the Australian case which has 127 ‘green-related’ risks associated with 20 stakeholders, and 867 risk interactions, the numbers of stakeholders, risks and their interactions are much less. This can be explained from two perspectives:

- **Project contract types:** The Australian building is a Design-Build project, in which the head contractor subcontracts the design work to several consultants, and most construction activities to specialised subcontractors or trades; while the Chinese building is a combination of force account and traditional procurement type, in which the client has its own team for design, and only contracts the construction work to a major firm who may have its own workforce (including trades and labourers). Since the design work was completed by themselves staff, the Chinese client does not have a consultant stakeholder group, which reduced the project environment complexity significantly.
- **Construction practices:** There is a major difference between Australian and Chinese construction firms: Usually in Australia, the head contractors do not

have their own labours, so they have to subcontract most construction works to subcontractors. In contrast, most of the Chinese construction firms have permanent employees working on different trades on sites, and only subcontract sporadic works to external firms. This not only reduces the labour cost, but also minimises the coordination works, thereby mitigates risks. However, for international contractors in China, they have to be aware of the dispute risk with local construction labours (Zhang, 2011), as well as labour restrictions and cost to use sources of labour from inside/outside the host country (Ashley and Bonner, 1987).

Table 1: Summary of risks and stakeholder groups identified in the Chinese project

Stakeholder category	Stakeholder	Number of risks	Risk ID	Risk	Risk category
Client	IBR	8	S1R1	Cost risk if budget found to be inadequate	Cost
			S1R2	On time design, construction and occupation of building	Time
			S1R3	Failure of achieving green building standards targets	Quality/ Technical
			S1R4	Higher than expected energy use	Environment
			S1R5	Demonstration of social responsibilities	Ethical / reputation
			S1R6	Enterprise awards	Ethical / reputation
			S1R7	Experience on green building project management	Quality/ Technical
			S1R8	Tender selection mechanism to choose experienced green building contractor and suppliers	Organization and management
Contractor	FTJA	6	S2R1	Responsible to ensure project is delivered within budget	Cost
			S2R2	On time deliver the building	Time
			S2R3	Responsible to ensure project is delivered to green building quality standard	Quality/ Technical
			S2R4	Waste minimisation	Environment
			S2R5	Ensuring construction safety when working on some green features	Safety
			S2R6	Experience on green building construction	Quality/ Technical
Subcontractor and supplier	Subcontractor and supplier	3	S3R1	Responsible to ensure the building component is delivered within budget	Cost
			S3R2	On time deliver the building	Time
			S3R3	Green products and the final work satisfy green building quality standards	Quality/ Technical

Comparing with the Australian case, relatively higher attention was paid on the quality / technical issues (risks) in the Chinese case which mainly refer to the green building design, construction and assessment experiences in China. Although the Chinese government launched a series of green programme since 2004, there still is a shortage of green building skills in the Chinese construction industry (Andrews-speed, 2009). Two risks in the Chinese case are related to policy and standards; while policy risks were not proposed in the Australian project. This indicates the importance of Chinese government in green building development. Apart from the above mentioned differences, the Chinese industry also concerns more on the organisation and management issues, but less on the ethical/reputation, cost, and time risks. However, since the striking difference of risk numbers in the two projects, it is more meaningful to compare the critical risks instead of quantities.

Comparison of critical risks

The comparison of critical nodes and links are based on the calculation of out-degree, degree difference, and betweenness values.

The out-degree shows the direct impact from a risk to the others, and the higher the degree difference, the stronger impact of the risk to the others comparing to the impact received by the risk. Figure 2 shows the out-degree and degree difference in the Chinese case. S1R8 (Tender selection mechanism to choose experienced green building contractor and suppliers) has the highest out-degree of 283; S6R1 (Transparent green building assessment standards) has the highest degree difference of 270 with no direct impact from the others, followed by S1R7 (Experience on green building project management). These three risks basically have high direct impact on the others. Comparing with the Australian case in which the reputation related risks associated with contractors and consultants have higher direct impact, the Chinese practitioners viewed the management process (as S1R8), policy issue (as S6R1), and industry capacity (as S1R7) are critical in the current green building practice.

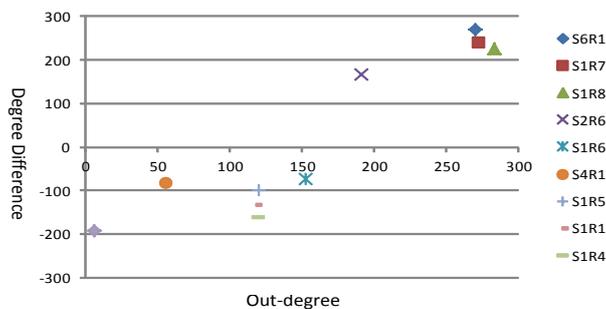


Figure 2 Distribution of risks with high degree values in the Chinese case

Betweenness centrality indicates the incidence with which a given node/link falls between two other nodes/links. A node/link with a high value of betweenness centrality has a high level of control over the impact passing through it, and the node is somehow taking the gatekeeper role. Table 2 displays the top ten ranked risks and the interrelations with the highest betweenness centrality in the Chinese project. Different from the Australian case in which most high betweenness centrality risks are associated with contractor, in the Chinese project client plays more connection 'hub' roles in a project environment. A risk related to end users within the 'organisation and management' risk category (S4R3 - Appropriate user behaviour) also has high betweenness centrality. This finding shows the important impact of user behaviour on energy consumption in occupation stage in China.

Table 2: The key risks and links according to the betweenness centrality

Rank	Risk ID	Node Betweenness Centrality	Link ID	Link Betweenness Centrality
1	S1R5	0.067	S1R7 → S1R8	40.00
2	S1R3	0.067	S1R6 → S4R3	12.55
3	S1R6	0.056	S1R5 → S4R3	11.29
4	S1R4	0.046	S9R1 → S1R3	8.177
5	S1R8	0.042	S4R3 → S1R4	7.78
6	S4R3	0.037	S1R3 → S1R5	7.61
7	S1R1	0.034	S1R3 → S4R2	7.38
8	S1R2	0.028	S4R1 → S1R4	7.38
9	S2R3	0.022	S5R1 → S1R8	7.20
10	S2R4	0.019	S9R1 → S1R6	6.39

All of the important links are related to the key risks in Table 2. As Yang and Zou (2014) stated, the source risks of the links in betweenness centrality results should be treated with caution because by controlling these risks, the links can be cut off. Comparing with the Australian project in which the contractor, consultants and subcontractors are the main sources of critical risk links, in the Chinese case, the client, assessor, end user and government are owners of key risk connections. This shows an interesting difference between the two countries. In a mature green building market such as Australia, the risk network is connected by the green ‘constructors’ who are responsible for the design and construction works; whereas in a developing market such as China, the risk network is mainly shaped up because of client and external stakeholders although most risks are caused by internal stakeholders. This means that risk network segmentation mainly relies on builders and consultants in Australia, while in China clients, government and end users take more responsibilities on the reduction of risk network complexity.

In Table 2, another risk worth mentioning is S9R1 (assessment experience and fairness) related to the assessors’ ethics, which is the sources of two important links. This shows that in China, the bidders view assessors’ experiences and fairness as a critical risk, due to the immature policy systems and corruption issues in China. Severe measures against bribery have been implemented nationally by the new Chinese government leading by President Xi Jinping since 2013. Nevertheless, international firms should understand the potential ethical risks in the construction industry.

Comparison of interfaces between stakeholders

Partition measures compute the interfaces between each pair of stakeholder groups. Table 3 shows the interfaces of stakeholder categories in the Chinese case. The important impacts are highlighted in bold. As shown in Table 3(a), S1 (Client) receives high impacts from the internal stakeholders (contractor, subcontractors and end users). This is similar with the Australian case with suggestions to increase communication activities between internal stakeholders. The Chinese also is impacted significantly by S6 who is the green building assessment government body. Considering the propagated consequences in Table 3(b), the communication between end users should be enhanced in the Chinese project mainly due to staff energy using behaviour affecting the building operation and maintenance cost significantly. This was not considered in the Australian project.

Table 3 Interfaces between stakeholders in the Chinese case

	S1	S2	S3	S4	S5	S6	S7	S8	S9
(a) Immediate interface									
S1	507	353	239	193	0	0	0	110	0
S2	369	317	0	37	0	0	0	0	0
S3	156	0	37	32	0	0	0	0	0
S4	126	0	0	54	0	0	0	14	0
S5	41	0	0	0	0	0	0	0	0
S6	97	0	0	0	0	0	0	24	16
S7	36	0	0	32	0	0	0	0	9
S8	18	0	0	0	0	0	0	25	0
S9	4	0	0	0	0	0	0	20	0
(b) Global interface									
S1	0.57	0.41	0.15	0.12	0.04	0.00	0.03	0.02	0.00
S2	0.39	0.32	0.04	0.03	0.01	0.02	0.01	0.00	0.00
S3	0.22	0.06	0.04	0.02	0.01	0.01	0.01	0.00	0.00
S4	0.19	0.08	0.04	0.05	0.00	0.01	0.02	0.00	0.00
S5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S6	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S8	0.01	0.03	0.01	0.02	0.00	0.02	0.00	0.02	0.01
S9	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00

CONCLUSIONS

In conclusion, this research has achieved its aim of providing an in-depth understanding of the risk-stakeholder interactions in green building in international markets, by undertaking two case studies. The results show a number of key differences between China and Australia due to the different political, social and cultural differences and the different level of technology and technique uptake and application in green building development process. While reputation risks are important for project players in both countries, the ethical risk ‘assessment experience and fairness’ has been highlighted as crucial in the Chinese green practice due to potential corruption issues. In the Chinese case, relatively higher attention was paid on the quality / technical issues and the government plays more important role to develop rigorous policy systems, as well as improve societies’ knowledge and awareness levels on green technology and energy saving. From stakeholder management perspective, communications between internal stakeholders can contribute to a smooth green building design and construction in both countries. It is anticipated that the risk analysis process and results presented in this research will be useful to researchers and practitioners, not only about risk in green building projects but also their interactions in an international construction arena. In future more cases should be studied to provide a more comprehensive understanding of the similarities and differences between the two countries. In short, risk–stakeholder interaction analysis is an

important area requires further research, and the use of SNA-based approach is an appropriate modelling method for such purpose.

ACKNOWLEDGEMENT

The authors appreciate industry participants' contribution to data collection. This study was supported by the National Natural Science Foundation of China (71272088).

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EXAMINING THE BARRIERS TO SUCCESSFUL ONSITE CONSTRUCTION ENVIRONMENTAL MANAGEMENT OPERATIONS

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With the introduction of ecologically sustainable development (ESD) and subsequent legislative regulations throughout Australia, effective environmental management across the construction sector should occur. In reality, construction operations continue to have detrimental environmental impacts. Within New South Wales the primary legislation governing development control, for the purpose of ESD, has produced a complex legislative system that its ability to achieve the objectives of environmental protection remains questionable. Large scale development projects may evoke need for associated environmental regulatory controls; however, such rules are generally not applicable to small and medium scale developments. Yet, these types of projects make up a significant amount of the development market and collectively a major contribution to detrimental environmental impacts. Given each construction project is unique, the application of complex regulatory controls may result in notably different levels of environmental protection between developments. Inconsistency may be seen with regulatory interpretation, implementation, monitoring and associated processes of enforcement. Using a systemic lens this research linked the efficacy of regulation, monitoring, and information flow to explain variability in the outcomes of onsite environmental management operations. The paper reports preliminary findings of a two stage qualitative study involving semi-structured interviews with key project stakeholders (e.g. government regulatory officers, construction managers) and case study examination of four medium scale development projects. Using a phenomenological coding approach, preliminary analysis identified a number of themes that impact effective onsite environmental management including: environmental interpretation and assessment, compliance and enforcement, external influences, collaboration and engagement.

Keywords: ecologically sustainable development, environmental planning, development planning, government regulation, qualitative analysis.

INTRODUCTION

Internationally, construction operations continue to be acknowledged as a significant cause of environmental degradation (Fuertes *et al.*, 2013; United Nations Environment Programme Division of Technology Industry and Economics, 2003; Walbaum & Buerkin, 2003). Adverse impacts that result from industry operations lead to the exhaustion of natural resources, and contribute to greenhouse gas emissions (Fuertes *et al.*, 2013). Other causes of environmental degradation from onsite operations include: construction and demolition waste generation; land contamination; surface and underground water contamination; and toxic atmospheric emissions (Chen, Li, &

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Wong, 2005; Gangolles *et al.*, 2009; Shen & Tam, 2002). Attempts to legislate the mitigation of these negative impacts were subsequently introduced in jurisdictions around the world, with varying levels of success. This research investigates the Australian experience, using a phenomenological lens to explore environmental preservation during construction operations as an emergent feature of the interaction between various regulatory systems designed to protect the environment. The underlying intent is to understand barriers and enablers of good policy practice.

UNDERSTANDING REGULATORY POLICY

Within the literature it has been stated that ‘most existing approaches to regulation, are seriously sub-optimal...they are not effective in delivering their purported policy goals, or efficient, in doing so at least cost, nor do they perform well in terms of other criteria such as equity or political acceptability’ (Gunningham & Sinclair, 1998, p. 1). Internationally, the Organization for Economic Co-operation and Development (Organization for Economic Co-operation and Development, 2010) explained that the changing financial and natural climates have strained emerging regulatory systems. During 2011, they advised of ‘evidence of serious regulatory failures’ given the current state of both economic and environmental climates (Organization for Economic Co-operation and Development, 2011, p. 3).

Today, governments worldwide are commissioned to solve extremely complex policy problems. The degree of complexity has evolved to a point where they have been considered highly resistant to resolution: often identified as ‘wicked’ problems (Australian Government & Australian Public Service Commission, 2007). Although there are many obstacles when tackling such problems (e.g. there may be no ability to test a policy apart from implementation) there are governing rules to assist good policy practice. Six areas of consideration that impact upon policy development and subsequently interpretation and implementation are now presented.

1. Academic information

Reliability of information within policy may be questioned where academic literature has not have underpinned its development (Holmes & Clark, 2008). There may be access restrictions, timeframe limitations, ignorance of its necessity, or it may be technically complex and not open for interpretation. A lack of understanding as to who is considered an expert on the subject topic or how to access technical professionals may further impact development. In addition, those responsible for formulation of policy may not have the academic knowledge to undertake appropriate methodological assessment (Holmes & Clark, 2008).

2. Science and statistics

Science may be viewed as a mechanism to justify policy and guide its development. Therefore, scientific professionals can assist with development of sound methodologies, provide informed scientific knowledge and facilitate mechanisms for assessment of policy effectiveness (Holmes & Clark, 2008). Literature has identified that science and methodology need to play more of a role within the policy system commencing with formulation (Ballinger & Stojanovic, 2010) and supported by statistical analysis to ensure appropriate development and outcome rationalisation (Srebotnjak, 2007). However, it is often sought at later stages (e.g. interpretation of results), which hinders accurate analysis (Srebotnjak, 2007).

3. Collaboration and stakeholder engagement

Ineffective intergovernmental collaboration may significantly impede the ability of an objective to be achieved (Burby & May, 1998). Without appropriate collaboration

high level policy objectives may not be adequately understood, accepted or given the appropriate degree of importance (Keijzers, 2000). Similarly, without stakeholder engagement, objectives may be viewed as rigid and lacking flexibility. Collaboration and engagement allow for consideration of respective economic and social interests in policy formulation which may encourage participation and commitment to implementation (Keijzers, 2000).

4. Interpretation and Ambiguity

There is often a degree of complexity surrounding policy problems that may render it difficult to clearly define a situation (Australian Government & Australian Public Service Commission, 2007). However, a well written policy has the potential to remove ambiguity (Keijzers, 2000), and with detailed definitions may assist to provide structure (Onate & Peco, 2005). Although the areas of development and regulation attempt to achieve a set outcome, clear and well defined policy is needed as interpretation and implementation can result in a misalignment between policy intention and policy outcomes (Clement & Amezaga, 2009).

5. External influences: politics and economics

Policy may be influenced by external variables such as politics and economics that contribute to policy complexity: development and interpretation (Srebotnjak, 2007). Complexity is exasperated by the multitude of stakeholders with differing agendas (Australian Government & Australian Public Service Commission, 2007). The desire for good environmental outcomes may not be the driver for change. Consumer demand and economic indicators may be the motivators for adoption of good environmental management practices, rather than a conscience effort towards improved environmental performance (Cary & Roberts, 2011).

6. Enforcement

Government administration of enforcement: command and control, has been identified as a strong mechanism to achieve compliance (Shi, Peng, Liu, & Zhong, 2008; Shimshack & Ward, 2007). Enforcement alters behaviour by identifying how stakeholders must perform (Organization for Economic Co-operation and Development, 2010). Enforcement methods are typically associated with penalties and these have been shown to result in significant environmental improvement. The threat associated with potential non-compliance, particularly if economic based, is often seen as the motivator for improved environmental performance (Shimshack & Ward, 2007).

NATIONAL REGULATORY POLICY

In 1992, a report entitled ‘Our Common Future’ (also known as the Brundtland Report) was tabled at the United Nation Conference on Environment and Development (United Nations, 1992), where principles of sustainable development were first ratified and incorporated into Agenda 21: ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ (World Commission on Environment and Development, 1987).

Subsequently Australia introduced an array of regulatory policy in an attempt to achieve the principles of Agenda 21. Ecologically Sustainable Development (ESD), was introduced to legislation and defined as ‘using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased’ (Australian Government Department of Environment, 1992).

ESD was incorporated into governing environmental legislation: *Environment Protection and Biodiversity Conservation Act* 1999. Within the Act, guidance was given on how to achieve ESD through adhering to specified principles, *inter alia*, precautionary principle, considering biological diversity and ecological integrity in decision making (Australian Government Department of Environment, 1999). Subsequently, ESD became entrenched in State and Territory Legislation such as the New South Wales (NSW) *Protection of the Environment Administration Act*, 1991 responsible for establishing the Environmental Protection Authority and providing environmental reports on the State of the Environment, and the *Environmental Planning and Assessment Act* (EP&A Act), 1979 the primary Act that governs development processes. ESD principles continued to filter through the government hierarchy to regional and local level authorities to be included regulatory and non-regulatory (e.g. development control plans) policy.

NEW SOUTH WALES REGULATORY POLICY

Within NSW introduction of ESD policy created a particularly complex and multifaceted legislative system. In 2005 a State government review of the EP&A Act identified a need to ‘...eliminate unnecessary and complicated red tape’ (NSW Government Department of Planning and Infrastructure, 2005a). The Act and its processes were described as ‘...a confusing web of conflicting plans and instruments’ (NSW Government Department of Planning and Infrastructure, 2005b). A governmental review during 2007 highlighted that policy, in particular the EP&A Act, ‘...remains lengthy, complex and confusing...’ (NSW Government Department of Planning and Infrastructure, 2007).

Change of State government in 2011 brought a strong focus upon transformation of the EP&A Act and the related development system. The Planning System Review Issues Paper identified the Act remained overly legalistic and complicated, making interpretation and application difficult (Moore & Dyer, 2011). However the State government’s system reforms have yet to be implemented, largely as a consequence of a lack of political will. Most observers acknowledge the Act has received little more than minor tweaking (e.g. the deletion of certain clauses). Nevertheless, some minor changes have evolved into a new part within the Act or established themselves as a new policy. Although ESD has established its place in State regulatory policy the system still remains largely ineffective and fraught with complexity which may be impacting upon its ability to achieve ESD principles.

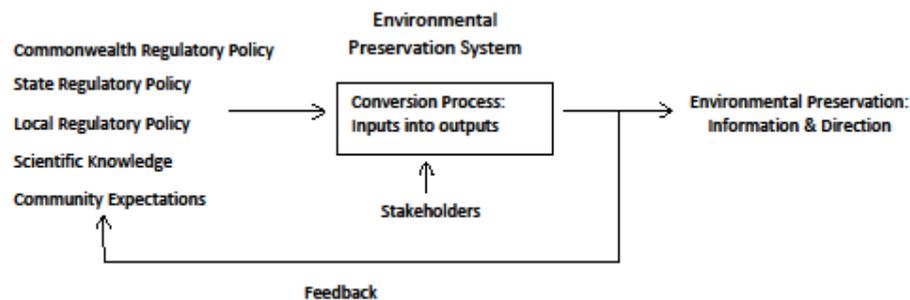
RESEARCH CONTEXT

The intent of the research is to examine regulatory policy – specifically the EP&A Act – to determine how it impacts upon onsite construction environmental management operations. Although it may be responsible for meeting ESD principles it does not operate in isolation. Inadequate information flows between stakeholders and processes within the construction management system can result in destructive onsite operations. Given their impact there is a pressing need to understand interrelationships to identify barriers and enablers of effective onsite environmental management operations.

The research context was conceived as a system encompassing an array of relationships, communications, information exchanges, collaborations that contributed to attaining environmental preservation during construction operations (FitzGerald, FitzGerald, & Stallings, 1981; Smith, 1982). It was believed that by

understanding the system and interactions within it, system efficacy itself could be explained (Mbiti, Blismas, Wakefield, & Lombardo, 2011). During design of the research, various inputs such as State and local policy were identified; however, it was recognised that environmental preservation occurred at the interface between these influences. To move beyond inputs and examine interactions within this system (refer Figure 1) stakeholders were identified since they contribute to outcomes associated with environmental preservation (Stewart & Ayres, 2001).

Figure 1: Interactions within the environmental preservation system (Maund & Brewer, 2012).



METHODS

The research employed a qualitative exploratory design where data collection involved two (2) stages. Stage 1 used interviews to enable exploration of stakeholder perspectives and understandings of regulatory policy and its impact upon onsite construction operations. Recruitment was conducted through third party organisations who met specific inclusion criteria. For example, Councils who approved the most number of development applications from the 2010-2011 period as identified in the NSW Department of Planning and Infrastructure 'Local Development Performance Monitoring 2010-2011' report. Participants were selected due to knowledge and experience of development processes (e.g. lodgement or assessment of applications) and/or construction operations (either onsite operations or certification). Twelve (12) interviews were conducted with key stakeholders including regulatory officers such as local government town planners and non-regulatory professionals such as developers and site supervisors.

Stage 2 employed a case study approach to further examine specific projects, looking at documentation, information flow, environmental and policy knowledge to assist in development of a framework of understanding onsite environmental management operations. To further determine whether consideration was given to environmental onsite impacts at the design/consent stage of the project and if so, whether they were implemented in accordance with the consent and/or whether additional environmental measures were administered.

Four (4) medium sized construction projects were elected based upon criteria including type of development. Specific documentation for each construction project was analysed (e.g. development consent) and assessed in terms of coverage of environmental issues. Interviews were also conducted with key stakeholders from each project (refer Table 1). Selection process followed that of Stage 1. Twenty four (24) interviews were conducted and recordings transcribed and analysed using qualitative methods. Analysis involved thematic exploration of data using a three (3) step coding process (Morse and Richards, 2002) to enable full use of the richness of data and increase robustness the analysis.

Table 1. Examples of Stage 2 questions.

What paperwork did you have onsite for this project and how would you assess it? (e.g. statement of environment effects, environmental management plan).
Who was responsible for onsite operations for this project and how did you ensure environmental measures were implemented? (e.g. construction/site manager/building certifier/engineer).
Did you have an internal or external auditor on this project?

RESULTS AND DISCUSSION

Stage 1 interviews explored the issues associated with environmental regulations influencing project environmentally sustainable outcomes. Using an open coding process, preliminary analysis of transcripts identified a number of environmental issues to be further explored in the context of actual construction projects during Stage 2. Table 2 provides an example of the coding structure for Stage 1.

Table 2. An example of the coding system structure for Stage 1.

Open Code	Axial Codes			
Environmental Theme	Pre-construction	Green building	Sedimentation	Government firms
	Post-construction	Energy efficiency	Erosion	Regulators
		Green star	Waste Mgt	Contractors
		BCA Section J	Water Mgt	Policy makers
			Tree Mgt	Construction Mgrs

Stage 2 documentation review revealed minimal inclusion of environmental conditions of consent. The focus being sedimentation and erosion control, with waste management plans occasionally noted. Themes including electricity usage and atmospheric emissions were not identified in documentation for any projects. Preliminary Stage 2 interview coding enabled examination of variables impacting upon onsite environmental management practices to better understand construction management operations: intent versus actual (refer Table 3). Preliminary analysis from Stage 2 data revealed a number of issues impacting upon policy practice. These are now discussed.

Table 3. An example of the Stage 2 coding system structure.

Open Code	Axial Codes			
Enforcement	Policy	Politics	Misdirection	Government
	Legislation	Economic impacts	Confusion	Developers
	Law	Penalties	Ambiguity	Policy makers
	Delegations	Environment	Clarity	Regulatory officer
	Regulations	Sustainability	Understanding	Construction firms

Environmental interpretation and assessment

Interpretation of an environmental issue was often skewed by what non-regulatory policies (e.g. development control plans) and the projects regulatory approval documentation (conditions of consent), stated. There was often an inability to look for environmental issues beyond those stated in this paperwork. Interpretation of the EP&A Act, by regulatory offices undertaking assessment of projects is an extremely subjective process. The need for professional expertise has been identified by Holmes and Clark (2008). This has impact throughout the policy cycle from formulation to implementation. Professional expertise of regulatory officers developing non-regulatory policy, conducting regulatory assessments and writing regulatory conditions of consent to achieve EP&A Act requirements, may be questioned (we note that no regulatory assessment officer had environmental qualifications: they came from town planning backgrounds). Without professional expertise and knowledge there may be an inability to understand full development implications and as described by Clement and Amezga (2009) interpretation impacts implementation and may result in misalignment between intention and outcomes.

Environmental themes

Stakeholders understanding of the term environmental management related to design and/or post-construction operations: manipulating design to achieve regulatory assessment and/or post construction compliance. For example, areas regulated such as energy efficiency, where there are negative impacts from non-compliance including project completion delays due to an inability to receive final regulatory project sign off. Atmospheric emissions from operation of heavy plant equipment, water and energy consumption during construction activities were not a consideration. In addition, three predominant environmental themes being sedimentation and erosion control, waste management and water management (e.g. in relation to mitigating contamination rather than water and energy usage) were highlighted as important to achieve environmental management. Without appropriate academic literature, science and clear structure supporting policy development, it may be flawed (Holmes & Clark, 2008; Keijzers, 2000) with officers make subjective decisions based upon their interpretation, without necessary consideration of policy intent (e.g. influenced by politics).

Compliance and enforcement

It was identified by regulatory officers that they believed the Act was formulated in a manner that prevented them from including conditions of consent related to many environmental areas. A number of regulatory officers identified that once development consent had been approved their ability for further regulatory control was limited, particularly if construction inspection processes went to a private building certifier, over their in-house professional, as it was no longer their site to monitor. With most projects, there were minimal regulatory inspections undertaken. When the building regulator attended the site for construction inspections, they were often the primary source of regulatory environmental monitoring. Otherwise, regulatory environmental inspections were generally a result of a major environmental incident or need to investigate a community complaint. Stronger regulatory enforcement procedures have been shown as beneficial (Shi *et al.*, 2008; Shimshack & Ward, 2007). Improved regulatory mechanisms and education on the importance of ESD may contribute to providing appropriately qualified and experienced inspection officers.

Collaboration and engagement

Internal regulatory assessment processes were identified as dysfunctional by many officers. Town planners were responsible for development application control, dictating whether internal specialists (i.e. environmental officers) were required to attend pre-lodgement meetings, along with when and if referrals to specialist regulatory officers were necessary. Suitability of town planners in making environmental determinations was often questioned. This was seen as problematic: input by appropriate environmental professionals at later stages may mean mitigation measures are missed or given the later stage of the project may be unable to be implemented. Srebotnjak (2007) identified a need to have appropriate professionals involved at the beginning of the process to avoid such issues and environmental management is no different. There is the inability of assessing officers to engage with fellow officers who have professional expertise with subject areas to appropriately identify issues and this highlights the importance of stakeholder collaboration identified by Burby and May (1998) and Keijzers (2000).

Significant transfer blockages were evident through the system. There was minimal interaction between policy makers, regulators and private specialists with those responsible for onsite operations. For the private sector, questioning development consent conditions was generally avoided due to involvement of many regulatory officers presenting different subjective opinions at various stages, possibly with new requirements. Similarly, local government seldom conversed with their state government counterparts, primarily as information was not readily offered. There was a belief that officers did not have sufficient knowledge and understanding to assist with inquiries, and information was not offered due to legal implications of providing advice. These issues again identify the importance of clear policy direction to establish parameters for stakeholders and the need for collaboration in development of policy (Keijzers, 2000).

External influences

Occupational health and safety (OH&S), quality assurance and environmental management were the three (3) themes identified as onsite priorities by construction teams. However, OH&S, followed by quality assurance, were given precedence over environmental management due to ramifications associated with non-compliance. In most cases, their environmental inspections were undertaken as part of the OH&S regime. Given the lack of regulatory inspections, this may contribute to emphasis being placed upon the other two areas. Stronger enforcement powers within the Act as described Srebotnjak (2007) may assist to promote more emphasis upon environmental issues.

CONCLUSION

Modifications to regulatory policy concerning ESD provide the context for effective environmental management. Presently, there is insufficient research linking onsite environmental construction management practices and environmental management to the effectiveness of regulatory policy enforcement and information flow. Examining these practices within a policy context has divulged a range of barriers impacting upon good environmental practice.

Given the limited guidance of the EP&A Act, local government has developed a range of guideline documents and checklists. These are relied upon as if regulatory in nature and encompass all salient environmental impacts, when ultimately they remain inadequate.

Government internal systems are problematic with town planners responsible for development applications and determination of internal referrals. In many cases environmental officers were not requested to review applications, nor invited to attend pre-development application meetings. Their input often came at later stages; whereby, new requirements were sometimes introduced. This brought into question, often inadequate knowledge and experience of assessment officers.

There remains a strong focus upon meeting government requirements to ensure approval is forthcoming. In turn this has led to a belief that government documentation considers all environmental impacts from development, where this is clearly not the case. There was a strong focus upon sedimentation and erosion control, waste management (to meet development assessment requirements), water management (in terms of contamination over usage) and post construction requirements (energy efficiency). There was a clear lack of consideration into all environmental impacts such as onsite water, energy usage and atmospheric emissions.

Minimal interaction was displayed between policy makers, regulators and private specialists with those responsible for onsite operations. The subjective nature of development assessment by regulatory officers was often questioned. Caution was displayed in contacting government for advice as the subjective nature of the process could introduce further constraints. There was often a communication blockage between government tiers due to the legalities associated with providing advice.

Although it was necessary to submit development applications with certain management plans (i.e. waste) there were rarely any regulatory consent conditions that addressed the need for monitoring or reporting. Minimal onsite regulatory inspections were undertaken, often left to professionals undertaking construction inspections.

The next phase of this research involves further development into a theoretical framework within which exploration into onsite construction activities and environmental management against the effectiveness of regulation, monitoring and information flow can be determined. Bridging the knowledge gap and learning about these processes can ultimately assist in achieving the objectives of ESD during construction operations.

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MATERIAL WASTE IN THE NORTHERN IRELAND CONSTRUCTION INDUSTRY: ON-SITE MANAGEMENT CAUSES AND METHODS OF PREVENTION

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The construction industry in Northern Ireland is one of the major contributors of construction waste to landfill each year. The aim of this research paper is to identify the core on-site management causes of material waste on construction sites in Northern Ireland and to illustrate various methods of prevention which can be adopted. The research begins with a detailed literature review and is complemented with the conduction of semi-structured interviews with 6 professionals who are experienced and active within the Northern Ireland construction industry. Following on from the literature review and interviews analysis, a questionnaire survey is developed to obtain further information in relation to the subject area. The questionnaire is based on the key findings of the previous stages to direct the research towards the most influential factors. The analysis of the survey responses reveals that the core causes of waste generation include a rushed program, poor handling and on-site damage of materials, while the principal methods of prevention emerge as the adequate storage, the reuse of material on-site and efficient material ordering. Furthermore, the role of the professional background in the shaping of perceptions relevant to waste management is also investigated and significant differences are identified. The findings of this research are beneficial for the industry as they enhance the understanding of construction waste generation causes and highlight the practices required to reduce waste on-site in the context of sustainable development.

Keywords: construction planning, design management, recycling, waste management.

INTRODUCTION

It is an unquestionable fact that the construction industry makes a valuable contribution to the competitiveness and prosperity of the country's economy accounting for 8% of Gross Domestic Product and providing employment for around 3 million workers (HM Government, 2008). However, the official UK government statistics reveal that the construction sector is also the largest contributing sector to the generation of waste, with more than 100 million tonnes per year. Construction waste is a mixture of inert and non-inert materials arising from various construction activities and could include materials such as soil and sand, brick and blocks, concrete and aggregate, wood, metal products, roofing materials, plastic materials and packaging of products (Begum *et al.* 2006).

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The influential report “*Rethinking Construction*” by Egan (1998) highlighted the fact that there is plenty of scope for improving efficiency and quality of UK construction simply by taking waste out of it. Furthermore, reducing waste is a high priority issue in the European and UK recent years' sustainability agenda. For example, in the 2008 Strategy for Sustainable Construction the Government included the target to halve construction, demolition and excavation waste going to landfill by 2012. Moreover, the European Union with its 2008/98/ EC Directive establishes the legal framework for the treatment of waste within the Community and defines prevention as the top of the waste hierarchy and the number one priority for waste management. It also identifies reuse and recycling as the next acceptable levels in the waste management hierarchy and urges all Member States to take measures for the appropriate treatment of their waste. In this context, construction is under increasing pressure to improve performance, reduce waste and increase recycling.

Specifically for Northern Ireland, landfilling has historically been the main disposal route for construction and demolition waste, often under the guise of agricultural land improvement at authorised sites which are exempt from licensing (DOENI 2013). The current estimate is that around 4 million tonnes of construction and demolition waste are produced annually, of which only 1.3 million tonnes (33%) is currently reused or recycled while up to 1.7 million tonnes (42.5%) per year is illegally dumped (DOENI 2010). In fact, in Northern Ireland there is a shortage of legal landfill space and this will become more severe in future years. It is therefore vital to minimise waste on construction sites (Dep. of Finance and Personnel 2010). The ambitious future target included in the 2006-2020 N. Ireland Waste Management Strategy is to achieve the 75% of construction and demolition waste being recycled or reused by 2020 which means that 3 million tonnes should be reused or recycled every year (DOENI, 2006).

The results of a survey on the waste management practices and perceptions of construction industry practitioners in Northern Ireland are presented in this paper, aiming to enlighten the major waste generation causes and highlight the most effective methods of waste prevention.

LITERATURE REVIEW

Waste is a major issue for the construction industry both from the perspective of efficiency and protection of the environment. Currently in the UK, slightly more than 100 million tonnes of construction and demolition waste ends up as landfill – of which 16% apparently is material delivered and then thrown away unused (Myers 2013).

Difficulties inherent in construction waste management process have been highlighted in the literature. Kwan *et al.* (2001) note that commonly on construction sites the responsibility for the waste generated on-site is not clear and cannot be allocated to one specific group of people therefore leaving it extremely hard to enforce. In addition, Teo *et al.* (2000) highlight the fact that the labour-intensive nature of construction activity suggests that behavioural impediments are likely to influence waste levels significantly. Teo and Loosemore (2001) provide relevant evidence exploring people's attitudes to waste and notice that a lack of managerial commitment and support for the issue of waste often, results in inadequate resources, manpower and time being devoted for waste management activities.

Many surveys and studies have been carried out in different countries to identify the causes of construction waste and assess the relevant minimisation practices in the industry. Al Hajj and Hamani (2011) focused on practices implemented in UAE

construction sites and concluded that the factors contributing the most to the generation of material waste are the workers' lack of awareness, poor design, rework requirements and lack of legal and contractual incentives. Furthermore, they highlighted the important role of adequate storage, staff training and Just-In-Time (JIT) delivery to the minimization of waste. The study by Formoso *et al.* (2002) encompassing 74 building sites in Brazil demonstrated that a large proportion of material waste occurs because of poor material delivery, transportation and handling as well as due to poor detailing and coordination in design and lack of site layout planning. Cha *et al.* (2009) investigated waste management practices in the Korean industry and highlighted the importance of factors like the contractor's commitment, the use of standardized materials and the appointment of labourers solely for waste disposal.

In the UK, the Department for Environment, Food and Rural Affairs sets the context of a resource efficient approach and suggests careful choice of materials and methods of construction during the design phase, proposes the incorporation of waste management targets into tender specifications, encourages the introduction of regular toolbox talks with workers and highlights the role of adequate ordering, delivery and storage of materials (DEFRA 2008).

The Site Waste Management Plans (SWMPs) are also considered as an important tool for construction companies and their clients, to improve their environmental performance and reduce costs of disposing of waste. A SWMP details the amount and type of waste that will be produced on a construction site and how it will be reused, recycled or disposed of. The plan is then updated during the construction process to record how the waste is managed and to confirm the disposal of any materials that cannot be reused or recycled at a legitimate site. The use of SWMP has been associated not only with environmental benefits, but also with economic benefits. A cost-benefit analysis conducted in the context of the UK-wide Waste and Resources Action Programme (WRAP) specified that the average saving for the 15 case studies (including housing, public and commercial projects) was about 0.8% of the construction value, which however can equate to a large saving. Furthermore, evidence from a detailed questionnaire survey suggested that using a SWMP has been beneficial to the majority of organisations and most achieved significant cost savings (WRAP 2009). SWMPs have been used in the construction industry for several years and in April 2008 they became a legal requirement for construction and demolition projects over £300,000 (exc VAT) in England. The implementation of a SWMP is not currently compulsory within N. Ireland.

INVESTIGATION OF WASTE MANAGEMENT PRACTICES IN N. IRELAND

Qualitative Research

Six semi-structured interviews were conducted with relevant professionals ranging from Project Managers and Site Managers to Trade Foremen with an average construction experience of 16.5 years. Each of them lasted about 20 minutes and was conducted in person. These interviews enabled first-hand knowledge to be obtained from people who are experienced and active within the Northern Ireland construction industry and deal with the situation of material waste on-site on a daily basis.

The first three interviewees were the sustainability manager, the assistant construction manager and a site foreman of a large company with a large number of employees and

sub –contractors, based in Enniskillen. When asked about the waste generation causes, the sustainability manager highlighted the rushed programme and the poor handling, the assistant construction manager emphasized on inadequate storage facilities and design related issues and the site foreman highlighted the role sub-trades in excessive construction waste generation along with over ordering of materials.

The same interviewees also highlighted a number of key methods of prevention of material waste. The sustainability manager suggested good planning and the use of segregated skips to deal with waste recycling on-site. He also mentioned the idea of designing out waste i.e. the designers analysing, controlling and reducing the waste implications of their solutions. The assistant construction manager detailed the reuse of materials as a prevention method along with the adherence to the SWMP which was considered a crucial element of the waste reduction process. The site foreman suggested JIT deliveries and good site management as key factors in SWMP adherence and the prevention of material waste. Furthermore, the use of segregated skips to ensure efficient recycling and tool box talks to increase awareness on site were also mentioned as efficient methods to reduce material waste.

The rest three people interviewed on-site were a Project manager, a site manager and a site foreman of a smaller scale construction company in Belfast.

The project Manager detailed that large skips caused increased amounts of waste to be disposed with the workforce just simply ignoring the reuse of materials. He also stated that providing adequate storage facilities helped prevent materials damage and also detailed that sufficient disposal facilities encourage effective recycling and therefore prevent waste on-site. The site manager additionally suggested ensuring adequate time is set aside for material waste management systems on-site while the site foreman highlighted the criticality of good crew coordination and having adequate space for segregation, especially on confined sites.

The summary of the key issues most commonly mentioned by the 6 interviewees with regards to the waste generation and prevention are presented in Table 1. These concepts along with other secondary ones which were also mentioned (e.g. tool box talks, the role of subtrades) were used to produce the questions included in the detailed questionnaire.

Table 1: Key findings of interviews

	1	2	3	4	5	6
Design related issues	✓	✓		✓	✓	✓
Materials handling, management and on-site storage	✓	✓	✓	✓	✓	
Reuse / recycle of materials and use of proper skips	✓	✓	✓	✓		✓
SWMP implementation		✓	✓			✓
Rushed program / Time management	✓				✓	

Quantitative Research

In order to further the topic of on-site management and material waste on construction sites within the Northern Ireland industry, a questionnaire survey incorporating the

key findings of the interview process detailed previously, was also undertaken. The questionnaires were sent out via email to a wide range of different people spanning over different professions to encourage a more widespread feedback from all perceptions.

The questionnaire consisted of 3 different sections. Section A included four general multiple-choice questions in relation to the particulars of the respondents (job title, years of experience in the industry, type and size of organization they work in). Sections B and C included a range of statements in relation to the causes of construction materials waste and the methods of prevention, respectively. The respondents were asked to indicate their level of agreement/disagreement with the statement, choosing a number from 1 to 5, according to the following scale:

- (1) Disagree
- (2) Slightly disagree
- (3) Neither agree nor disagree
- (4) Slightly Agree
- (5) Agree

Section C also allowed the people questioned to make additional comments relevant to the research in a separate column.

Results Analysis

Section A - Respondents particulars

70 questionnaires were sent out and 45 responses were received in total (response rate 64.3%). According to the details that the respondents provided regarding their job title, they can be broken down as follows; 6 Project Managers(13%), 10 Construction/Site Managers (22%), 7 Site Engineers (16%), 8 Quantity Surveyors 18%, 8 Architect/Designers (18%), 5 Health and Safety Officers (11%) and 1 Other (2%).

With regards to the type of their organisation, 23 respondents (51%) worked with main contractors, 16 (36%) with sub-contractors and 6 (13%) in a public body. The 45% of the organisations (20 in total) was medium-sized (25-75 people), 33% (15 organisations) of large size (>75 people) and 22% (10 organisations) of small size (<25 people).

With regards to the work experience of the respondents in the construction industry, 18 (40%) had less than 5 years of experience, 6 (14%) had experience between 6 and 10 years, 5 (11%) between 11 and 15 years, 10 (22%) between 16 and 20 years and 6 (13%) had experience greater than 20 years. The considerable percentage of respondents with little experience (0-5 years) may have been beneficial to the research, as the younger generation of construction workers, is probably more aware of the importance of incorporating material waste management systems into design and construction.

Section B- Construction waste causes

In this section the respondents were asked to indicate their level of agreement / disagreement with different statements directly connecting the waste generation with the following factors: Rushed program, Design issues, Damaged materials, Packaging waste, Sub trades, Poor handling, Odd sized components, Over ordering of materials, Lack of sufficient time for waste management and Poor scheduling of deliveries.

The weighted average values of the respondents' level of agreement (ALA) with each statement and the standard deviation (SD) were then calculated using the formulas (1) and (2),

$$ALA_i = \frac{\sum_{j=1}^n LA_j N_{ij}}{N} \quad (1)$$

$$SD_i = \sqrt{\frac{\sum_{j=1}^n (LA_j - ALA_i)^2}{N}} \quad (2)$$

where ALA_i is the average level of agreement for the factor i , LA_j the level of agreement chosen (1-5) for the factor i , N_{ij} the number of respondents who chose the j th level of agreement (LA_j) for the factor i , n the number of different available agreement levels, SD_i the standard deviation of the acceptance level for the factor i , N the total number of respondents.

According to Shen and Tam (2002) the commonly recognized weakness involved in using the weighted average as a ranking criterion is that it does not consider the degree of variation between individual responses. The typical technique used to mitigate this weakness is to apply the Coefficient of Variation (CV), obtained through dividing the weighted average by the standard deviation, as in formula (3).

$$CV_i = \frac{ALA_i}{SD_i} \quad (3)$$

Thus the different factors ranking should result from the Index Value for each factor IV_i , easily determined after considering both the weighted average and the coefficient of variation, according to the formula (4).

$$IV_i = ALA_i + CV_i \quad (4)$$

The views of the respondents in relation to the main causes of construction waste generation on site are presented in Table 2.

It can be seen that the average level of agreement for the 5 out of 10 statements is equal or greater than 4, which denotes wide acceptance of the rushed program, design issues, damaged materials, poor handling and odd-sizes components as waste generating causes. The statements correlating waste to poor scheduling, lack of time, over ordering of materials and packaging were also accepted by the respondents but at a lower average level of agreement. Finally, the statement linking waste with sub trades was rejected as the relevant ALA was below 3. Taking into account the standard deviation of the responses, the five factors with the greatest contribution to the generation of waste are: Poor handling, rushed program, damaged materials on-site, odd-sized components and design issues.

Table 2: Acceptance level and ranking of waste generation causes

Statement	ALA	SD	CV	IV	Rank
St. 1: Rushed program leads to increased material waste on-site	4.20	0.757	5.550	9.75	2
St. 2: Design issues are a major contributor to material waste on-site	4.18	1.134	3.686	7.87	5
St. 3: Damaged materials on-site lead to more waste disposed	4.36	0.908	4.799	9.16	3
St. 4: Packaging waste is a major issue within the industry	3.89	1.092	3.563	7.45	6
St. 5: Sub trades on-site are main contributors to waste	2.78	1.491	1.865	4.65	10
St. 6: Poor handling creates more waste on-site	4.02	0.543	7.402	11.42	1
St. 7: Odd sized components increase waste with off cuts etc.	4.24	1.069	3.965	8.21	4
St. 8: Over ordering of materials contributes to on-site waste	3.76	1.417	2.654	6.41	9
St. 9: There is not sufficient time allowed for material waste management on-site	3.84	1.476	2.601	6.44	8
St. 10: Poor scheduling of deliveries leads to increased volumes of waste on site	3.98	1.196	3.327	7.31	7

Section C- Construction waste methods of prevention

In this section the respondents were asked to state their level of agreement / disagreement with the consideration of the following factors as contributing factors to the waste generation minimisation: Site Waste Management Plans, Designing out waste, JIT deliveries, Adequate storage, waste targets for sub-trades, segregated skips, efficient ordering of materials, timescale of project, reuse of materials, tool-box talks.

The views of the respondents in relation to waste prevention methods on site were analysed as detailed in the previous sub-section and are presented in Table 3.

Table 3: Acceptance level and ranking of waste prevention methods

Statement	ALA	SD	CV	IV	Rank
St.1: The use of a Site Waste Management Plan (SWMP) is important	4.42	0.753	5.866	10.29	4
St. 2: Designing out waste reduces material management issues on-site	4.24	1.069	3.965	8.21	8
St. 3: Just In Time (JIT) deliveries ensure less material waste	4.22	0.951	4.438	8.66	5
St. 4: Adequate storage lessens the amount of damaged material on-site	4.29	0.626	6.853	11.14	1
St. 5: Targets set for sub trades in terms of waste ensure less wastage	4.18	0.936	4.464	8.64	6
St.6: Segregated skips on site ensure effective recycling	4.09	0.900	4.544	8.63	7
St. 7: Efficient ordering of materials reduces waste	4.51	0.758	5.954	10.46	3
St. 8: Timescale of project can ensure effective waste reduction on-site	3.80	1.375	2.763	6.56	10
St.9: Maximizing the reuse of materials lessens the impact of waste	4.42	0.723	6.116	10.54	2
St.10: Tool box talks on-site raise awareness	4.02	0.965	4.166	8.19	9

It can be seen that the average level of agreement for the 9 out of 10 factors reviewed is equal or greater than 4, which denotes wide acceptance of the factor as waste prevention method. The last factor, which is the project's timescale can also be considered acceptable as its ALA is 3.8. Taking into account the standard deviation of the responses, the five more widely accepted factors as waste prevention methods are the adequate storage of materials, the reuse of materials, the efficient ordering of materials, the use of SWMP and JIT deliveries of materials.

DISCUSSION

The results of the survey were further analysed in correlation with the job role of the respondents to allow for different perceptions resulting from different professional backgrounds to be revealed. For this purpose the respondents were grouped in three different groups: Group1: designers/architects, Group2: construction /project managers and Group3: site-related post holders (site managers and engineers, quantity surveyors, health and safety officers). As presented in Table 4, all the three groups rank the statements 3,4,5 and 9 referring to the role of damaged materials, packaging, sub trades and time at the same or similar (up to two places higher or lower) position. The ranking for statement 7 referring to the role of odd-sized components is significantly different across the different groups: although odd-sized components are considered the most important factor by the group of Managers, site-related post holders give this factor the fourth place while designers consider it even less important than the majority of the factors reviewed, ranking it at the eighth place. Furthermore, the views of designers (Group1) and site-related post holders (Group3) broadly coincide with regards to the statements 1, 2, 6 and 10 referring to rushed program, design issues, poor handling and poor scheduling of materials for which the group of managers seems to have different views. Especially for the statement referring to the role of poor handling in waste generation (st.6) it is worth noting that both groups 1 and 3 have ranked it first while the group of managers (Group2) has ranked it fifth. Finally, the role of materials' over ordering (st.8) seems to be much more appreciated by designers and managers than by the site-related post holders who rank it at the bottom of the list (group 3).

Table 4: Ranking of waste generation causes per group of professionals

	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10
Group1	3	5	4	7	9	1	8	2	10	6
Group2	6	8	3	7	10	5	1	3	9	2
Group3	2	5	3	7	10	1	4	9	8	6

With regards to the various waste prevention methods, the respective group analysis of the responses (Table 5) reveals that there is significant diversity of views across the different groups.

Table 5: Ranking of waste prevention methods per group of professionals

	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10
Group1	1	9	7	4	6	8	1	10	1	5
Group2	3	1	4	6	5	2	8	10	7	9
Group3	4	6	5	2	9	7	1	8	3	10

The most noteworthy difference concerns the role of efficient ordering of materials which is ranked first by designers and site related job holders while the group of managers only give it the eighth place. On the other hand, managers' list has at the first place the factor of designing out waste, which quite unexpectedly is given the ninth place by the "responsible" group of designers. Finally, it is also apparent that the use of SWMPs is widely acceptable across the different disciplines as all the three groups have ranked it highly.

CONCLUSIONS

The construction sector is the UK largest contributing sector to the generation of waste, with more than 100 million tonnes per year. Therefore, the effective management and reduction of construction's enormous quantity of waste is a goal as well as a major challenge for the industry. This research investigated the perceptions of construction practitioners in Northern Ireland with regards to the causes of construction waste generation and the methods of prevention. Key factors in waste management as identified by the semi-structured interviews are the project's design, the proper materials handling, management and on-site storage, the reuse/ recycle of materials and use of proper skips, the implementation of the SWMP and the adequate time management of construction processes. To supplement the viewpoint of the interviewees, a questionnaire survey was undertaken to capture the views of a greater number of professionals. The 45 survey respondents confirmed that waste generation is attributed to both design inefficiencies like odd-sized components as well as on-site related factors like poor handling and on-site damage of materials. Additionally, it emerged that the reuse of materials is a key factor for the successful waste prevention and this is the case for the SWMPs as well, although their use is currently not compulsory in Northern Ireland. Other factors widely accepted by the respondents as preventing waste generation are the efficient ordering of materials, their delivery JIT and the adequate storage facilities. Furthermore, the results of the survey were analysed in correlation with the job role of the respondents (designers, managers, on-site positions) to allow for different perceptions resulting from different professional backgrounds to be revealed. This analysis highlighted significant differences in the relative importance attached to factors like the poor handling of materials, the over-ordering of materials and design related issues. This research enhances the understanding of construction waste generation and prevention and highlights the practices which can significantly contribute to the target of construction waste minimisation in the immediate future.

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OVERCOMING THE BARRIERS OF GREEN INNOVATION IN CONSTRUCTION PROJECTS THROUGH ITS SUCCESSFUL MANAGEMENT

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The construction industry has a significant opportunity to mitigate the harmful effects construction has on the natural environment. However, green innovations are far from becoming customary in construction as the industry is recognised as slow to adopt innovation. Consequently, to overcome barriers to the adoption of green innovation, it is important to understand how green innovation is defined and what are the obstacles, drivers and influences that affect how it is successfully managed. Through this research, involving a literature review, the collation and analysis of four semi-structured interviews and 60 questionnaire responses, green innovation can be defined as: a process that aims to maximise performance, while minimising environmental degradation, triggered by the need for a new outcome. The research indicates firstly that green innovation barriers consist of organisational, stakeholder and contractual obstacles and that to overcome these barriers and to increase demand, the industry needs more green innovation information available in order to define the ownership and balance cost and quality. Secondly, green innovation management and its adoption are also affected by the attitude, demographic and cognitive characteristics of the manager concerned. The research also shows that successful management of green innovation can be promoted by a culture that involves the whole project team and the evaluation of the project's management in order to document the success factors. Finally, the formation of a new green contract, or the amendment of the design build procurement path to outline the ownership of risk and the alignment of the construction aims and objectives, will promote green innovation adoption.

Keywords: green, innovation, environment, procurement.

INTRODUCTION

The construction industry is resource intensive and a major environmental pollutant generator (Zhang and Wen, 2008). This has raised global concern on how to adopt and implement greener construction practices (Cole, 1999) as the industry has the greatest opportunity to mitigate the harmful effects it is having on the natural environment (Addis and Talbot, 2001). Even with negative coverage in the media, green practices are far from becoming an industry standard (Matar *et al.* 2008), “*the construction industry is infamous for the barriers it places in the way of innovation*” (CERF, 1998). Zairi (1994) and Jones and Saad (2003) both argue that construction is failing to innovate compared to other industries.

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The barriers to green innovation in construction are seen as ‘general barriers’ and ‘technical barriers’. ‘General barriers’ are factors such as ‘Cost’ and ‘Demand’ (Matar, 2007), while the ‘technical barriers’ include managerial barriers (Hambrick and Mason, 1984). Successful innovation management is therefore integral to the adoption of innovation in the construction industry (McQuater *et al.*, 1998).

Little research has been carried out into the barriers of green innovation and specifically, overcoming these barriers through successful green innovation management. Hoffman and Henn (2008) propose that the construction industry would benefit from a study focusing on overcoming the barriers against the adoption of green innovations. This study therefore aims to fill this gap within green building literature by providing information for both the industry and academia in the UK and Ireland.

The following research questions therefore formed the basis of this investigation:

RQ1. What effect do the relationships between the barriers of green innovation have on the adoption of green innovation in construction?

RQ2. What effect do the relationships between the characteristics of a manager have on the adoption of green innovation in construction?

RQ3. What is the definition of the term “*green innovation*”?

RQ4. What effect do the relationships of the factors contributing to overcoming green innovation barriers have on the adoption of green innovation in construction?

RQ5. What effect do the relationships of the factors contributing to successfully managing green innovation have on the adoption of green innovation in construction?

Hypothesis: At the outset the authors hypothesised that: Successful innovation management mitigates the barriers of green innovation in construction projects.

LITERATURE REVIEW

Green Innovation Management

Innovation: This can be defined as the implementation of a new process, system or product aimed at enhancing competitive advantage, project feasibility, safety and/or quality, while decreasing the cost and time of a project (Slaughter, 1998; and Jones and Saad, 2003). What makes innovation adoption difficult is lack of clarity on whether innovation is a process or an outcome (Zairi, 1994). Slaughter (1998) suggests that an innovation does not need to be new, it may exist elsewhere, but be new to a particular industry. Nevertheless, Jones and Saad (2003) argue that construction is slow and failing to innovate compared to other industries.

Green construction: Hoffman and Henn (2008) suggest that green construction encompasses “*strategies, techniques, and construction products that are less resource intensive or pollution producing than in regular construction*”. Jones and Saad (2003) say that green construction involves all of these strategies and includes the responsible management of a buildings demolition waste at the end of its life cycle. ISO (2008) states that green construction practices are an attempt to achieve maximum performance with minimal impact to the environment.

Green innovation management: Benmansour and Hogg (2002) propose that successful innovation management is a managerial responsibility that should balance the empowerment and accountability of an organisation. Hambrick and Mason (1984) and Gambatese & Hallowell (2011) argue that the characteristics of an innovation

manager are one of the most significant factors in successful innovation. Equally, Sharma (2000) offers that the scope for the adoption of green innovation is significant, however, its interpretation is largely down to a manager's characteristics.

Competitive advantage is the "*ability to innovate and learn*" (Teece *et al.*, 1997) and according to Slaughter (1998) innovation is the catalyst for competitive advantage.

Pervaiz (1998) and Dulaimi *et al.* (2002a) propose that organisations with successful green innovation management have corporate structures that allow flexible team sizes to prioritise projects with more innovations; the adoption of a 'no blame' culture; and the use of incentives to promote green innovation. Quinn (1985) says innovation champions are key to innovation success in small organisations; and that top management isolation in larger firms can lead to intolerance of innovation champions.

Kuczmariski (1990) argues that innovation managers have trouble shifting to new technologies, decision making and learning from past experiences. Gambatese and Hallowell (2011) say that the key to successful innovation management is awareness of the innovation process and its barriers. Another problem to be overcome is the risk that the aims and objectives of different stakeholders in co-innovation will not align. Accordingly, Dulaimi *et al.* (2002b) say that successful co-innovation relies on the effective management of the firm initiating the innovation and other stakeholders.

Barriers to Green Innovation

Clients' Needs: Overcoming 'the client' as a barrier to green innovation is important, as construction has many different types of clients (Jones and Saad, 2003). Gambatese & Hallowell (2011) state that one of the biggest barriers to green innovations is the failure of organisations to extend innovations from one project to the next. Laborde and Sanvido (1994) suggest that the client plays a more significant role in green innovation adoption compared to project team members with technical knowledge.

Construction aims and objectives: Organisations in a construction project are independent of each other, with their own aims, objectives and cultures, yet they are inter-dependent in the success of the project (Jones and Saad, 2003). Similarly, Rothwell and Dodgson (1991) propose that the aims and objectives of different organisations involved in co-innovation projects must be aligned if they are to successfully implement green innovation into their construction projects.

Contracts and Procurement: The success of a green innovation is proportional to the type of contract used within a project (Tagaza and Wilson, 2004). For example, lump sum contracting leads to adversarial relationships (Jones and Saad, 2003); Dulaimi *et al.* (2002a) say design-build procurement can lead to a rise in green innovation. The incentive for firms to innovate is lost when tendering for new projects as previous relationships and managerial styles cannot be continued (Wood, 1975). Bowley (1960) says the two biggest barriers to innovation adoption are the type of contract and the inability to measure innovation success. However, academics suggest that innovation success can be measured by maintaining a client relationship.

Cost: Williams and Dair (2007) argue that anything other than traditional practices will lead to significant cost increases. However, Robichaud and Anantatmula (2011) argue that the cost premium on green projects is in the region of 0-10%. Comparably, BRECSU (1999) suggests that construction over-estimates the cost of a green innovation and under-estimates the potential savings attributed to it.

Demand: Williams and Dair (2007) suggest this is because the present economic climate has resulted in little demand for green construction, with cheaper construction technologies being favoured by industry stakeholders. Jones and Saad (2003) argue that a further barrier to demand is that slumps and booms are more common in the construction industry than in other sector of the economy.

Employee Knowledge: Qi *et al.* (2010) propose that employees are the single most important resource in an organisation. This is because the technological competence of employees is one of the most significant factors of successful green innovation management (Nam and Tatum, 1997). Laborde and Sanvido (1994) suggest that successful innovation management can be attributed to a project team's competency.

Location: The effectiveness and efficiency of an innovation is, in part, due to the source of an innovation and the market's opportunities (Tidd, 2001). Furthermore, McQuarter *et al.* (1998) argue that an organisation's geographical location is directly proportional to their ability to successfully manage innovations.

Risk: In the UK, construction companies are reluctant to change due to the litigious nature of the industry (Jones and Saad, 2003). Similarly, Benmansour and Hogg (2002) say organisations are unwilling to take the risks and uncertainties associated with green innovation adoption. Nevertheless, the OECD (1982) argues that larger firms can best absorb the risks of innovation failure.

Social and psychological: Hoffman and Henn (2008) argue that barriers to green innovation in construction can now include social and psychological effects.

Time: A significant weakness in construction is the unparalleled emphasis by the client on the schedule and cost (Jones and Saad, 2003). Ling (2003) says that short project schedules and tight budgets impede green innovation adoption in construction.

RESEARCH METHOD

A sequential analytic method was applied whereby the qualitative analysis was used to inform the quantitative analysis. It was decided that four interviews would be conducted. Eleven questions were developed using the information documented in the literature reviews. The interview form adopted was an open-ended, structured format and was chosen as it ensured the same eleven questions are asked to each interviewee. The next step was to interpret the interviews by performing a Central, Domain and Cluster analysis using Decision Explorer. Consequently, the results of this analysis were used to build a questionnaire in order to collect sufficient quantitative data.

The questionnaire was constructed around questions in five sections:

Section A: Demographic information.

Section B: Barriers of green innovation adoption in construction.

Section C: Most influential characteristic of a project manager.

Section D: Defining green innovation.

Section E: Overcoming green innovation barriers.

Section F: Managing green innovation:

The data collection followed two paths. First, the questionnaires link was sent to over 600 construction professionals throughout the UK and Ireland and second, using LinkedIn, the link was posted on a number of construction groups. After receiving 60

responses to the study's questionnaire, the raw quantitative data was analysed using SPSS to perform a Factor analysis and a Linear Regression analysis.

RESULTS AND ANALYSIS

Quantitative results and analysis:

Section A collected the demographic information of the 60 respondents (a response rate of less than 10%). The average respondent was a male aged between 20-39 working as either an architect or engineer with 0-9 year's construction industry experience in both the public and private sectors in Great Britain with an average project value of less than £500,000.

From Section B Factor analysis, it was observed that 'Building Regulations' are not a barrier to green innovation, they are a benchmark to improve upon and that the 'Cost' of a green innovation is not more expensive than the use of traditional practices.

From the Factor analysis of Section C - a surprise result was the exclusion of 'Seniority in organisation' and the inclusion of 'Age' and 'Long held position' in this component, as the assumption could have been made that older construction professionals will have held their position for a long time meaning that they will most likely be in senior positions within a organisation.

Section D proposed a series of statements to each respondent to try to get a definition of the term 'Green Innovation'. On the basis of mean score analysis green innovation can be defined as an innovation that aims to maximise performance, while minimising environmental degradation. This can be achieved by stepping away from normal conventions in order to substitute less polluting products. Green innovation is triggered by the need for a new outcome and may adopt an innovation from another industry. Green innovation is a process and not an outcome, therefore requiring constant review.

In section E, the Factor analysis demonstrated that the sample was still statistically significant. To further aid the discussion, a new name was assigned to each component identified to interpret the variance observed in the data. The four components include; 'More information', 'Stakeholders risk', 'Increased demand' and finally, 'Balancing cost and quality'.

In section F, the Factor analysis also demonstrated that the sample was still statistically significant and to further aid the discussion, a new name was assigned to each component identified to explore the variance observed in the data. The four components include; 'Management culture' 'Management evaluation', 'Manager evaluation' and finally, 'Team effort'.

Linear Regression analysis suggests that the four biggest barriers to green innovation are; the slowness of the construction industry to adopt green innovation, the lack of accurate information with regard to the savings, the length of time a manager has held their position and the fact that contractors are not willing to absorb the risk of green innovation failure. Furthermore, it also provides that 'green' means maximising performance, while minimising environmental degradation.

Qualitative results and analysis:

Table 1 details the first five results for the Central and Domain analysis performed on the group Decision Explorer cognitive map.

Table 1 - Group model - Central and Domain analysis

Central analysis - Group	Domain analysis - Group
Cost (50 from 101 concepts)	Cost (15 links around)
Proven track record (40 from 84 concepts)	Risk (11 links around)
Risk (39 from 81 concepts)	Proven track record (10 links around)
Marketing tool (33 from 70 concepts)	Marketing tool (9 links around)
Impedes (32 from 70)	Impedes (9 links around)

‘Cost’ ranked first in the Central and Domain analysis as each interviewee said it was one of the most significant barriers. ‘Proven track record’ ranked second in Central and third in Domain analysis as each interviewee thought more information on green innovations and a proven track record of implementing them correctly would increase demand and reduce risk. ‘Risk’ was second in Domain and third in Central analysis because two of the four interviewees suggested that risk of green innovation failure is a large barrier that must be overcome. ‘Marketing tool’ ranked fourth in Central and joint fourth in Domain analysis, as there is a need for more information on the benefits of innovations in order to drive green innovation adoption. Finally, ‘Impedes’ ranked fifth in the Central and joint fourth in the Domain analysis, as the interviewees believed that public sector tendering impedes the adoption of green innovation.

A Cluster analysis was also performed on the combined cognitive map. This showed seven significant Clusters indicating that there are many underlying relationships. Table 2 documents the underlying relationships observed in the clusters.

Table 2 - Underlying relationships identified in clusters

Cluster	Underlying relationships
1	Green innovation can create competitive advantage
2	Green innovation is a process and needs constant testing
3	There is a strong correlation between risk and a proven track record
4	The age and location of an organisation are barriers to green innovation.
5	The characteristics of a manager act as a barrier to green innovation
6	There is a strong correlation between management and employee knowledge
7	Green innovation relies on aligned aims and object of the stakeholders

DISCUSSION

Section A: Demographic information: Having previously described the average respondent, the results achieved can be attributed to younger professionals having a greater empathy to help out other young professionals. From further analysis of the proportion of males to females in construction, the percentage of females responding to this survey was much higher than the expected percentage of just 2.4%, they contributing 15%. Thus, these results may suggest that female construction professionals occupy more sustainable construction roles than their male counterparts.

Section B: Barriers of green innovation adoption in construction: ‘Organisational barriers’ suggested that the organisation itself could act as a large barrier or driver to green innovation as its location may demand more innovation, while its size could allow it to absorb more risk. This result endorses the views of the OECD (1982) who argue that larger firms can best absorb innovation risk and Tidd (2001) who proposed that innovation success is related to its geographical location. The component ‘Green contractual barriers’ confirms the opinions of Tagaza and Wilson (2004) who stated that the success of a green innovation is proportional to the type of contract used in its

adoption. This study suggests that there is a need for a new green contract. Likewise, 'Stakeholder barriers' mirror the views of Jones and Saad (2003) who argue that, although organisations are independent of each other, they are inter-dependent in the success of the project. Thus, green innovation will only be successful if the aims and objectives of different project stakeholders are aligned. The implication to practice is that the amendment of the design–build contract to align the aims and objectives of different project stakeholders will further encourage green innovation adoption.

Section C: Most influential characteristic of a project manager: 'Demographic characteristics' coupled the trivial demographics of a manager including 'Age' and 'Gender'. Consequently, the demographic characteristics of a manager can influence a manager's ability to adopt green innovations. Furthermore, the component 'cognitive characteristics' suggests that time can influence how a manager deals with problems/managerial issues. Sharma (2000) says that the interpretation of an innovation is largely down to a manager's characteristics. Comparably, 'Attitude characteristics' reason that a manager will suppress his/her views in order to fit in with an organisation's culture. Quinn (1985) proposes this is because top management isolation in larger firms can lead to an intolerance of innovation champions. The implication for practice from this result is that construction professionals are barrier driven, not wanting to do anything that could hamper chances of future promotion.

Section D: Defining green innovation: The definition of green innovation provided in section D and the Linear Regression analysis is similar to the definition provide by ISO (2008) who state that green construction practices are an attempt to achieve maximum performance with minimal impact. Consequently, any new green construction practice, technology or material can be classified as a green innovation. Its trigger is the need for a new outcome, as the construction industry is slow to innovate. Equally, Jones and Saad (2003) and the Linear Regression analysis argue that the construction industry is slow and failing to innovate. Finally, green innovation is a process and not an outcome. Consequently, the implication for practice is that green innovation success is dependent on constant review.

Section E: Overcoming green innovation barriers: 'More information' offers that past green innovation successes can be used to create a competitive advantage. Similarly, Slaughter (1998) proposed that innovation is the catalyst to an organisation's competitive advantage. The component 'Stakeholder risk' suggests that a further amendment needed to the design-build contract is the confirmation of green innovation risk ownership. This is because the Factor and Regression analysis stated that consultants, contractors and clients are not willing to absorb the risk of innovation failure. Likewise, Jones and Saad (2003) suggested that the litigious nature of the construction industry has resulted in an industry intolerant of risk. Moreover, the component 'Increased demand' reiterates the results of the Regression analysis proposing that an increase in demand for green innovation projects would drive its research, producing more accurate data of the savings involved. Lastly, 'Balancing cost and quality' argues that the need to balance cost and quality has occurred due to the boom and bust cycles, which the construction industry endures. Jones and Saad (2003) argue that slumps and booms are more common in the construction industry than in other sectors of the economy. The implication for practice is that more information on the savings of green innovation will increase demand and reduce risk.

Section F: Managing green innovation: The first component 'Management culture' suggests that the culture of an organisation has a large influence on a manager's

ability to adopt green innovations. Similarly, Pervaiz, (1998) offers that corporate culture has a huge effect on an organisation's/manager's ability to adopt new management techniques. The second and third components 'Management evaluation' and 'Manager evaluation' linked statements that could be used as management evaluation techniques to reduce the risk of innovation failure. Gambatese and Hallowell (2011) offer that understanding the innovation process and its success factors is key to successful innovation management. The implications to practice of this result is that organisations can evaluate management/managers by asking questions such as; where the aims and objectives of different stakeholders aligned and did the managers learn from his/her mistakes on the project? A further recommendation would be the use of the Serve-Qual/Serve-Perf models in order to measure the 'actual or perceived gaps between client expectations and perceptions of the service' (Shahin, 2004). Finally, 'Team Effort' offers that successful innovation management does not just involve the management of one organisation, but the successful management of all stakeholders in the project. Dulaimi *et al.* (2002b) proposes that successful co-innovation management relies on the effective management of the firm initiating the innovation and the other project stakeholders.

CONCLUSIONS AND RECOMMENDATIONS

The conclusion derived from RQ1 is that larger organisations should be encouraged to adopt more green innovation in their projects as they can best absorb the risks. The responses aligned with RQ2 suggest that younger, green innovation champions will encourage the adoption of green innovation in an organisation.

RQ3 defines green innovation as an innovation that aims to maximise performance, while minimising environmental degradation. It is triggered by the need for a new outcome and finally, is a process and not an outcome. RQ4 responses suggest that demand can be increased by organisations evaluating past green innovations in order to document their success. In turn, this will give more accurate information and create a competitive advantage by educating clients and staff of the innovations' benefits.

Finally, responses for RQ5 suggest that organisations wanting to implement green innovation should appoint green innovation managers to manage not only the green innovations within that organisation, but all of the stakeholders' organisations.

Hypothesis:

The researchers' hypothesis that successful innovation management mitigates the barriers of green innovation in construction projects is supported. The research has shown that the appointment of green innovation managers/champions can overcome the barriers of green innovation by evaluating the management/managers' techniques and clients' perception of the perceived service in order to assess the success factors.

Research Limitations:

The findings from this study intended to inform the UK and Ireland's construction industry and academic literature. However, around 1 in 8 of the responses declared their location as either EU or International. Nevertheless, as most countries face similar management failures it has been assumed that these responses have only aided this study by providing further quantitative data.

Further research:

This study recommends further research into the formation of a green construction contract, this should look at ways of promoting green innovation, allocation of risk and the alignment of the aims and objectives of the contracted parties. Until the

details of this green contract are finalised, a further area of study would be the effect of the amendment of the design-build procurement path to include these matters.

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A PROTOCOL TO EVALUATE SCHOOL BUILDINGS' ENERGY CONSUMPTION

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Buildings contribute 20 to 40% of the world's energy consumption, making the need to regulate and minimize their energy use a priority. A standard protocol was developed by the University of Manitoba Construction Engineering and Management Group to evaluate energy consumption across a sample of Manitoba schools in collaboration with the Manitoba Public School Finance Board. The protocol aims to evaluate school buildings' overall historical energy consumption and real-time electricity consumption at the space level. An extensive literature review was carried out to identify relevant parameters, methods and instruments to evaluate buildings' energy use. The protocol identifies school data parameters as well as historical energy data and real-time electricity data parameters to be collected, related methods and recommended values for these parameters. The protocol is currently being validated through its practical application to the sample of Manitoban schools identified. This protocol is expected to be useful to future researchers looking to evaluate other school buildings in other locations and enable buildings operators and managers to track their buildings' energy performance.

Keywords: electricity consumption, energy consumption, evaluation protocol, school.

INTRODUCTION

The rapid increase in energy use around the world raises concerns about the depletion of finite natural resources (Perez-Lombard *et al.* 2007) and thus the need to regulate this use across various industries, the building industry being the most important of all. This is because the building industry currently accounts for 20-40% of energy use worldwide (Issa *et al.* 2011), representing therefore an excellent opportunity to achieve large scale energy reductions, especially with the development of the green building industry (Azar and Menasa 2012). Green buildings can on average be 25-30% more energy efficient than conventional ones (Kats *et al.* 2003). This is despite a number of research studies showing different results (e.g. Thiers and Peuportier 2012, Kats *et al.* 2003, Torcellini *et al.* 2006, Issa *et al.* 2011), with ones surprisingly showing how green buildings can use more energy than conventional ones (e.g. Scofield 2002, Menassa *et al.* 2011). These results reinforce the need to close the gap between new buildings' actual and expected performance and their performance in comparison with older buildings (Hancock and Stevenson 2009).

The goal of this paper is to present a comprehensive protocol for evaluating historical and real-time energy consumption, focusing on school buildings in particular. It is part of a study conducted by the Construction Engineering and Management Group at the

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University of Manitoba in collaboration with the Manitoba Public School Finance Board to evaluate energy consumption in relation to building usage and occupancy in Manitoba schools in Canada. As the study is still in progress and the protocol is currently being deployed, the paper will only focus on presenting the protocol, with no validation of it. The study and protocol will aim to 1) evaluate buildings' overall energy consumption in a sample of old, middle-aged and new green schools and 2) evaluate space-level electricity consumption across a smaller sample. This is to investigate the effects of energy efficiency measures and green certification on building and space-level energy consumption.

PROBLEM OVERVIEW

Developing this protocol entailed identifying relevant research using several databases such as Scopus and Science Direct and reviewing a total of thirty research studies specifically investigating energy consumption in green buildings. Other studies evaluating energy consumption in buildings in general were also identified, the aim being to review the protocols and standards used in them. The vast majority of identified studies collected energy consumption data for whole buildings either using utility bills (e.g. Oates and Sullivan 2012, Diamond *et al.* 2011) or by installing metering systems for overall buildings' energy consumption (e.g. Zhu *et al.* 2009, Li *et al.* 2006). However, only one of the identified studies sub-metered specific building spaces (Jain *et al.* 2013), revealing the lack of research focusing on specific building spaces' energy consumption, possibly due to the large amount of resources this requires. In this study, apartments were sub metered from the main distribution panel highlighting the large discrepancies between their electricity consumption although they are in the same buildings. For space-level energy consumption, a different study by Menezes *et al.* (2011) relied on other detailed measurement techniques. This study entailed compiling electricity consumption data from plug monitors providing half-hour usage profiles for equipment inside the spaces such as computers and printers. It revealed a strong correlation between occupants behaviour and plug-loads electricity consumption in building spaces. The wide variety of methods and techniques used in previous studies raises challenges in replicating and validating these studies in different contexts. Therefore, this protocol aims to address this limitation in the literature by evaluating overall building energy consumption for a group of schools using utility bills. It provides a simple method to demonstrate trends in the whole buildings' energy consumption which can be replicated in different contexts. An additional optional part of the protocol involves evaluating space-level energy consumption for only few representative buildings using power meters. This is because of the cost involved in installing advanced sub-meters in all buildings and the limited resources availability.

Current literature also shows how most studies focused on commercial and institutional buildings (e.g. Adalberth *et al.* 2001, Turner and Frankel 2008), possibly due to the size of the investments made in these two building sectors. Some of the identified studies investigated energy consumption in academic buildings, mostly on university campuses (e.g. Scofield 2009, Martani *et al.* 2012). However, only a small number of studies investigated energy consumption in school buildings (e.g. Issa *et al.* 2012, Robertson and Higgins 2012). In a study by Issa *et al.* (2012), new green schools in Toronto were found to consume 37% more electricity than older and energy retrofitted schools, but 41 to 56% less gas than them, resulting in a 28% decrease in overall energy costs. In contrast, new schools in Albuquerque, New Mexico were found to consume considerably more energy and electricity than older schools, raising

concerns about the energy efficient technologies used in these new schools (Robertson and Higgins 2012). These findings highlight the need for more studies on school buildings in order to validate previous studies on them and the need for an in-depth investigation of energy consumed within specific spaces in these schools: needs that this new protocol aims to address.

In addition, current research methods reported in the literature reveal the lack of a standardized approach to evaluating building energy consumption. For instance, the frequency of energy data collection varied depending on the data collection method used. Ten of the thirty studies reviewed on green buildings collected data on a monthly basis using utility bills (e.g. Diamond *et al.* 2006, Menassa *et al.* 2011). However, other studies collected energy consumption data on a minutely basis using advanced metering systems (e.g. Li *et al.* 2006), or during site visits occurring on quarter-annual basis (e.g. Byrd 2012). In a study by Lenoir *et al.* (2012), metering systems installed in the studied building were configured to compile energy consumption data on an hourly-basis. These examples reveal the need to establish comparable methodologies to evaluate buildings' energy consumption data. Therefore, this protocol entails collecting historical energy data on a monthly basis, since this frequency of data collection can be easily replicated in other studies especially if utility bills are used as a source.

Half of the identified studies on green buildings' energy consumption (e.g. Torcellini *et al.* 2006, Brunklaus *et al.* 2010) investigated less than five buildings using a case-study research approach. Although these case studies provided useful evidence about buildings' energy performance, the small sample sizes in many made it difficult to generalize the results to the larger building population. To address this limitation, this study aims to evaluate overall schools' energy consumption in a sample of thirty-one schools selected using Neyman's allocation method to represent all schools in four Manitoba school divisions. The four additional in-depth case studies as part of this study will provide detailed information about schools energy consumption at the space-level.

PROTOCOL DEVELOPMENT

In addition to reviewing previous studies, developing this protocol involved reviewing existing building performance evaluation standards such as the American Society for Testing and Materials (ASTM E2797) and the United States National Renewable Energy Lab (NREL/TP-550-38601, Barley *et al.* 2005). The procedures outlined in these standards were used collectively with the methods reported in the literature to develop a standardized protocol for evaluating historical and real-time energy consumption in schools at the building and space-level respectively.

DATA COLLECTION

Four school divisions are participating in this research study, providing a total population of 129 schools in Manitoba. The study involved using stratified random sampling and Neyman proportional allocation process to select the sample of thirty-one schools to be analysed based on their age and size. This is to create three categories with fourteen schools representing old schools built on or before 1959, thirteen middle-aged schools built between 1960 and 1989, and four new schools built on or after 1990. The cut-off dates used for these schools are similar to the ones used by the United States Commercial Buildings Energy Consumption Survey (CBECS) thus building on previous categorizations of old, middle-aged, and new buildings

(CBECS 2003). The stratified random sampling process used also aims to ensure the inclusion of schools of different sizes, with the size of the schools in the sample varying between 10,000 and 100,000 sq.ft. One school from each age category will be selected for space-level analysis of real-time electricity consumption. A fourth school, the only certified to the Canadian Leadership in Energy and Environmental Design (LEED) Rating System in Manitoba will be subjected to the same space-level analysis to highlight the effect of LEED certification on schools' real-time electricity consumption. The study will focus on evaluating space-level electricity consumption in these four schools because of the limited resources, cost and manpower required to install advanced power meters in each of the thirty-one school.

This protocol aims to investigate current trends in schools' energy performance in Manitoba by implementing a case-study approach on a representative sample of Manitoba schools. It will involve evaluating: 1) detailed school data capturing the most important parameters that may affect energy consumption, to be administered to all schools within the sample 2) historical energy consumption data at the building level, to be administered to all schools within the sample and 3) real-time electricity consumption data at the space-level, to be administered only to the four case-study schools where advanced power metering systems will be installed.

The evaluation of detailed school data will include documenting parameters believed to influence buildings' energy consumption such as the building shape and footprint, the Heating, Ventilation and Air Conditioning (HVAC) equipment used in there and the green and other energy-related retrofits implemented. This information will be collected for every school building to investigate the effect of these parameters on energy consumption.

The evaluation of historical energy consumption data at the building level will involve reviewing existing standards and codes for energy consumption (e.g. CBECS 2003, NECB 2011, ASHRAE 90.1 2004). Recommended values for each energy parameter will be collected based on green certification programs such as PassivHaus or Building Research Establishment Environmental Assessment Methodology (BREEAM). The average historical energy consumption data provided by the CBECS dataset will be used for benchmarking purposes to evaluate the historical performance of schools against industry standards and average values for similar buildings. A thorough literature review was conducted to identify these standards and values.

The space-level electricity consumption evaluation protocol will involve documenting electricity consumption in a number of predetermined spaces (e.g. classrooms and gymnasiums) within each of the four schools analysed in real-time, and the type of equipment and devices used to collect such data. This protocol will only focus on space-level electricity consumption for lighting, as well as, plug load consumption for equipment. This is because of the significance of these two-use categories, which combined can represent 40% of space-level electricity consumption in schools (CBECS 2003). Moreover, other end-use applications such as space heating utilize other energy sources in some schools (e.g. gas or geothermal energy), raising challenges for comparing their consumption between different schools.

School data

The first data collection form compiles a comprehensive list of all energy-related parameters which may affect schools' energy consumption. Table 1 provides a list of these parameters with an explanation of each when needed.

Table 1: School data collection parameters

School information	Comments/ explanation
School name	N/A
School address	N/A
School key site manager contact name and information	N/A
Number of floors	N/A
Year built	N/A
Number of classrooms	N/A
Number of offices	N/A
Number of other-use spaces	e.g. labs, gym, library
Completion date of last major renovation (if applicable)	N/A
Weekly school operating hours	N/A
Heating source(s)	Type of fuel used for heating
Renewable energy use	(Yes/No)
School footprint	Select from checklist with different possible building shapes
School surroundings	Select from checklist with different possible building attachments
Number of electric meters serving school	N/A
Availability of sub-meters	Indicate number of sub-meters if applicable
On-site renewable energy sources	Select from checklist listing different possible on-site renewable energy sources
Building interior lighting information	Select from checklist listing different possible fixture types
Building exterior lighting information	Select from checklist listing different possible fixture types
Building environmental stewardship information	Select from checklist listing different possible sustainability plans and policies (e.g. sustainable purchasing)
Building HVAC equipment ENERGY STAR rated?	(Yes/No)
Building Hot Water equipment ENERGY STAR rated?	(Yes/No)
Building equipment	List number of computers, copiers and other equipment available in school
Building water efficiency plan in place?	(Yes/No)
Backup Power Supply	e.g. diesel, gas, not available

Historical energy data at the building level

The second data collection form documents historical energy consumption data for all schools. Table 2 lists the performance metrics collected as part of this form and the methods used to collect them. Another table not included in this paper also identifies all recommended values for each performance metric based on several sources identified from the literature review such as PassivHaus, CBECS, and BREEAM.

Table 2: Historical energy data collection parameters and methods

Item	Performance metric	Necessary data	Point of measurement/ data source	Frequency	Measurement equipment
1	Functional area	Floor area	Architectural drawings	One time	N/A
2	Total building fuel use (gas)	Fuel consumption	Utility bills/ records	Monthly	Utility meter
3	Building fuel use intensity (gas)	Items 1 and 2	Items 1 and 2	Monthly	N/A
4	Building fuel use cost intensity (gas)	Fuel cost	Utility bills/ records	Monthly	Utility meter
5	Total building electricity use	Electricity consumption	Utility bills/ records	Monthly	Utility meter
6	Building electricity use intensity	Items 1 and 5	Items 1 and 5	Monthly	N/A
7	Building electricity use cost intensity	Electricity costs	Utility bills/ records	Monthly	Utility meter
8	Total building electricity Production	Renewable electricity generation	Wire between PV panel and main panel	Monthly	Utility meter
9	Total building energy use	Items 2 and 5	Items 2 and 5	Monthly	N/A
10	Total building energy use intensity	Items 1 and 9	Items 1 and 9	Monthly	N/A
11	Total building energy cost intensity	Items 4 and 7	Items 4 and 7	Monthly	N/A

Real-time energy data at the space level

The third data collection form compiles real-time energy use data at the space level. Table 3 lists the performance metrics collected using this form, as well as the methods used to collect it. Another table that is not included in this paper also lists all recommended values for each metric in the literature where applicable based on identified standards such as European Standard (CEN/TC 169 N 0618. 2006), American Society for Heating Refrigerating and Air Conditioning Engineers (ASHRAE 90.1 2004), and the National Energy Code for Buildings in Canada (NECB 2011)

Table 3: Space-level energy data collection parameters and methods

Item	Performance metric	Necessary data	Point of measurement/ data source	Frequency	Measurement equipment
1	Gross interior space area	Floor area	Architectural drawings	One time	N/A
2	Installed lighting energy use	Controlled lighting circuits	Distribution panel	Time-series	DENT® power meters
3	Installed lighting energy use intensity	Items 1 and 2	Items 1 and 2	Monthly	N/A
4	Plug-in lighting energy use	Numbers, power ratings and their consumption	Visual inspection/ interviews/ line voltage	time-series	Plug monitors by KillAWatt®
5	Plug-in lighting energy use intensity	Items 1 and 4	Items 1 and 4	Monthly	N/A
6	Total building lighting energy use	Controlled lighting circuits	Distribution panel	Time-series	DENT® power meters
7	Total building lighting energy use intensity	Items 1 and 6	Items 1 and 6	Monthly	N/A
8	Plug loads energy use	Energy consumed in plugs or plug load circuits	Distribution panels/ individual plugs	Time-series	DENT® power meters or plug monitors by KillAWatt®
9	Plug loads energy use intensity	Items 1 and 8	items 1 and 8	Monthly	N/A
10	Installed lighting power density	Number of light fixtures, power ratings, and floor areas	Visual inspection/ interviews	One time	N/A

DATA ANALYSIS

This research will entail comparing historical energy consumption data across old, middle-aged and new schools. The average energy consumption data for each category of schools will be further compared against recommended values compiled from different sources identified in the literature review. The analysis will also highlight historical trends in energy consumption for schools in each of the three categories.

The analysis will involve correlating historical energy consumption data to specific parameters and school attributes shown in Table 1 collected through the school information form. This will aim to highlight the effect of certain parameters and energy-efficiency retrofits on buildings' overall energy consumption.

At the space level, the research involves comparing average space-level electricity consumption data between the selected schools against recommended values shown in table 5. It also entails comparing electricity-use data in rooms of similar types in different schools. The analysis will also correlate average room electricity consumption for lighting and equipment to specific parameters and school attributes collected using the school information form, thus identifying the parameters with the most impact on space level electricity consumption.

CONCLUSION AND FUTURE WORK

The collected energy consumption data for the overall sample of schools and for specific spaces in four detailed case-study schools will be correlated to occupancy patterns and usage data from the same schools. This essential part of the research aims to demonstrate the relationship between occupancy, usage and buildings' energy consumption; a topic seldom investigated in the literature.

The standardized protocol for evaluating energy consumption in schools is an essential tool for future research since it can be applied in other locations and for other school buildings. The protocol also provides a set of measurable performance indicators that can be used by buildings operators and managers to track their buildings' performance. The protocol also identifies recommended values for these indicators, thus enabling the benchmarking of buildings' energy performance against set standards.

One of the limitations of this protocol is that it doesn't capture all end-use electricity consumption at the space-level. However, the two items reported in this protocol (i.e. lighting and plug loads) collectively represent approximately 40% of total electricity consumption and can be easily compared and benchmarked against other schools.

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RENEWABLE ENERGY TECHNOLOGY MEANS OF PROVIDING SUSTAINABLE ELECTRICITY IN NIGERIAN RURAL AREAS - A REVIEW

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Following the failure of the Power Holding Company of Nigeria (PHCN) and fossil fuel source applications for the provision of electricity in Nigeria, the country has been experiencing power energy shortages for over three decades now. More than 65% of the population lack commercial electricity, particularly in the rural areas. This has caused socio-economic problems involving relocation of manufacturing companies to neighbouring countries, unemployment, and endemic rural-urban migration. The research that underpins this paper aims to investigate the potential of Renewable Energy Technologies (RETs) in the provision of sustainable electricity in Nigeria's rural areas. This has been motivated by the strategic value of RETs in identifying when and where electricity is actually required thereby eliminating/reducing the high cost of gridline network and offering a more sustainable alternative to fossil fuels. A systematic review method has been used to examine various RETs regarding their viability and applicability in Nigeria. The sustainability of various RETs is then evaluated using SWOT analysis to screen the technologies to be used in an energy supply mix in Nigeria's rural areas. Biomass, hydro and solar sources are appropriate for use in Nigeria rural areas. The utilisation level of RETs in Nigeria is extremely low except for hydropower source. The major problems of RETs implementation are lack of implementable energy policy, government apathy towards development of RETs and the low purchasing power of majority of citizens. Further work includes the application of whole life costing (WLC) to assess and optimise the economic performance of the identified RETs.

Keywords: Nigeria, renewable energy technology, sustainable electricity, sustainability indicators, SWOT

INTRODUCTION

Due to the failure of the utility company Power Holding Company of Nigeria (PHCN) and fossil fuel system application for the provision of electricity in Nigeria, the country has been experiencing power energy shortage for over three decades, thus creating an unfavourable environment for both multi-national and local investors.

Nigeria is blessed with abundant conventional and renewable energy resources (see (ECN 2005) for details), but despite this, it is still unable to meet electricity needs of its citizens. Nigeria's power generation installed capacity was approximately 6500 MW in 2005 but 3959 MW was the only capacity available (Ibitoye and Adenikinju 2007) and this situation is yet to change. Furthermore, in the same period only 34% of Nigeria's total population had access to electricity; this includes around 10% of rural

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communities; which constitute over 60% of total population (Ikeme and Ebohon 2005; Bugaje 2006).

The most disturbing situation is in the rural areas, where the power problems have subdued the local economy and prevented the development of cottage industries and businesses (Ikeme and Ebohon 2005). Although electricity access is not directly related to socio-economic growth but it is an impetus for development. The declining electricity access in the rural areas needs attention, namely through provision of sustainable electricity, otherwise the negative effects will continue to affect the inhabitants: increasing poverty level, endemic rural-urban migration, unemployment, health deterioration and depletion of forest biomass in the country.

According to Sambo (2009), fuel wood and charcoal (FWC) usage constitutes between 32%-40% of Nigeria's total primary energy consumption, with approximate annual consumption of 50 million metric tons of fuel wood alone. In addition, self-electricity generation is generally common in the country, and is projected to be between 4,000-8,000 MW, though this capacity may exceed the gridline source (Eberhard and Gratwick 2012). The reasons for this inconceivable condition of Nigeria power industry can be classified into technical factors (e.g. power generation stagnation, dilapidated power plants) or human factors (e.g. insufficient funding, leadership changes, electricity theft from ghost customers, non-payment of electricity bills by customers, corruption) (Adenikinju 2003; Sambo 2009).

Several government energy policies in Nigeria have targeted rural inhabitants in order to improve their energy access by subsidizing refined petroleum products at a cost of more than US\$20 billion over the last three years. Unfortunately these policies didn't attain their goals due to topography of some rural areas, diversion of the products by selfish marketers and poor road network. Furthermore, considering the cost of maintaining the grid network as a result of vandalism, alternative sources of power have to be sought with little or no transmission and distribution network as investors may not be willing to invest where there is low consumption and low income earners (Sambo 2009; Ikeme and Ebohon 2005; Kaundiya, et.al. 2009).

Nigeria electricity's sector problems, particularly in the rural areas may be mitigated through the adoption of alternative sources of electricity, such as renewable energy system (decentralized). This is because Nigeria rural communities' electricity demands are usually low. In addition, most RETs do not require gridline networks or transmission lines as electricity are generated close to the demand site. Hence, the aim of this research work is to investigate the potential of various RETs in the provision of sustainable electricity to Nigeria rural areas.

In the next section, RETs and rural electricity in Nigeria are discussed. This is followed by a critical review of various RETs in Nigeria with emphasis on their potential, utilization levels and constraints. Then, a SWOT analysis of major RETs is performed and presented. Finally, conclusions are drawn and further research work is introduced.

RET AND RURAL ELECTRIFICATION IN NIGERIA

The Majority of rural dwellers in Nigeria are low energy consumers and living below the poverty line of US\$ 1.25/day (UNICEF 2011) with electricity requirements below 1MW and around 10% electricity accessibility; those who fit this description constitute over 60% of total population of the country. In line with economy and strategy reasons, both government and Independent Power Providers are finding it

difficult to provide sustainable electricity to these communities. Although the government, through several energy policies, has expressed interest in providing electricity to these communities, reality suggests that it is unrealistic to do so considering the country's centralised energy system (dependent on fossil fuel sources) which will require gridline extensions to provide this electricity. Therefore, authorities have sought alternative and sustainable energy sources for rural areas in order to minimise rural-urban migration, which has put pressure on the cities' infrastructures, and encourage the development of cottage industries, thereby minimising current security and unemployment problems in the country.

RETs may be the one and only energy source that can provide sustainable electricity to Nigeria's rural areas considering the number of the villages, the distance between generation and demand centres, the economy of the gridline network and the energy insecurities as a result of unrest in the Niger Delta region. RETs present the strategic value of identifying when and where electricity is actually required, thereby eliminating/reducing gridline networks because of the closeness of generation to demand centres; they also can operate on smaller power scales and are more sustainable than fossil fuels. Capital costs may be high, but in the long term they are cheaper than fossil fuel sources. Furthermore, some RETs have laudable characteristics, such as zero fuel costs (e.g., wind and solar sources), benign environmental impact with little waste or pollutants, and no urban smog. However, there are several barriers to their utilisation, such as a lack of investments and expertise, inadequate policy framework (particularly in developing countries), high capital costs, intermittency of resources (mostly solar and wind sources), and the fact that they may lead to food crises, particularly if biomass sources are unregulated (Shunmugam 2009; Kaundiya *et al.* 2009).

RET RESOURCES UTILIZATION IN NIGERIA

Nigeria has abundant RET sources; however, only two sources are currently being used: hydropower and traditional biomass (Akinbami 2001). The following section will examine major RETs in Nigeria with a view to filter them for distributed application in rural areas.

Wind Energy in Nigeria

Wind energy technology has experienced significant global growth in the last decade, with its installed capacity doubling every three years (WWEA 2012). Unfortunately, this is not the case in Nigeria. The country is categorised under a poor-moderate wind regime, so, consequently, wind energy cannot be applied on a bigger scale except for irrigation and village electrification.

According to Ajayi (2007), wind energy resources are very poor in the southwest and south-south onshore regions of the country, but offshore areas of the same zones bound by the Atlantic Ocean have excellent wind energy resources. However, a lot of authors recommend its application for specific locations (Ojosu and Salawu 1990; Ohunakin *et al.* 2011; Ngala *et al.* 2007; Fagbenle *et al.* 2011).

Currently there is not an official record of significant wind energy application in Nigeria. According to Sopian *et al.* (2011) 2.2MW of electricity has been generated by wind energy in Nigeria, but reality suggests that it has been abandoned due to the lack of maintenance and technical knowhow.

Other obstacles facing sustainable wind energy utilisation in Nigeria include the lack of a corresponding market, general apathy towards the development of wind technology, and poor budgetary allocation (Ajayi and Ajayi 2013 and Oyedepo 2012)

Solar Energy in Nigeria

Nigeria solar energy has capacity of producing 4.2 X 10⁵ GWh of electricity/annum (Akinbami 2001). The solar potential is 27 times greater than that of the nation's fossil fuel sources (Augustine and Nnabuchi 2009).

Nigeria has commenced solar panel manufacturing with an annual capacity of around 7.5 MW. This will resolve the lack of technical knowhow and the high cost of imported solar panels previously witnessed in the country. According to Adeoti *et al.* (2001), it is possible to use solar energy to generate enough electricity to meet the needs of people throughout the year in all locations throughout the country.

Currently, solar energy systems are used in Nigeria for small- and medium-sized power applications including street lighting, domestic/office powering, water pumping, rural electrification, rural health centres (e.g., refrigeration of vaccines), powering of telecommunication booster stations and ATM machines. For the appropriate development of solar energy technology, the following problems must be addressed: creating a reliable policy framework, reducing the costs of components, stopping the use of sub-standard components, strengthening the poor maintenance culture, and improving the lack of statistical data and capacity utilisation (Shaaban and Petinrin 2014; Mohammed *et al.* 2013; Oyedepo 2012).

Hydropower Energy in Nigeria

Nigeria has hydropower potential of approximately 14,735 MW, with waterways in excess of 3,000 KM. However, only 1,960 MW have so far been exploited, representing 14% of the total capacity (i.e., 1930 MW (Large hydro) and 30 MW (Small hydropower)) (Sambo 2009; ECN 2005). Currently, 150 MW of small- and medium-sized hydropower projects are on-going in the country, but more needs to be developed considering the potential.

Hydropower technology has been developed and used in Nigeria since the 1960s. In addition, no transformers, high tension lines, or reservoirs are needed for distribution if small hydropower is used. The displacement of inhabitants, however, is a major side effect. This can be mitigated through informed consent from local communities along with economic compensation.

Biomass Energy in Nigeria

Nigeria's biomass resources include agricultural residues, forest biomass, municipal solid waste (MSW) and animal dung. The country's vegetation arrangement dictates the availability of these resources. The major forms of vegetation in Nigeria are savannahs and forests, with the former occupying approximately 80% of Nigeria's total area (Sambo 2009; Akinbami *et al.* 2003). Substantial land areas are cultivatable in the northern part of the country where agricultural products, animal dung and modest quantities of fuel wood are produced, while large quantities of wooden biomass are produced in the south. Traditional biomass has proven to be an alternative source of energy to the scarce petroleum products despite the fact that Nigeria is a major producer of crude oil. The rate of consumption, particularly of FWC, is alarming, and there is a pressing need for modernising the use of this energy source to prevent depletion of the resources.

Nigeria biomass resources can generate electricity up to 68,000 GWh/year at 30% availability. However, biomass-effective supply chains and overall affordability will ultimately decide its viability for electrical generation. This is mainly because biomass resources have to be procured. In addition, residues, particularly forest biomass, have low density and low value, where transportation costs are high/energy units (Evans *et al.* 2010).

Geothermal Energy in Nigeria

There are two locations of geothermal energy that exist in Nigeria: Ikogosi warm spring and Wikki warm spring in Ondo state and Bauchi state, respectively. Similarly, the tendencies of high geothermal gradient are identified in the Lagos sub-basin, Auchi-Agbede, Okitipupa ridge and also the Abakaliki anticlinorium (ECN 2005).

The problems of this energy source include the lack of discovering of commercial proportion in the country and perhaps the lack of records. However, the situation may change if commercial quantities from this source are established, which may eventually allow it to be enlisted among the energy supply mix in the country (ECN 2005).

Ocean Energy in Nigeria

Nigeria is bordered by the Atlantic Ocean in the southern part of the country, with the coastline extending from Bakassi to Badagry with a distance exceeding 850 km. This gives Nigeria the opportunity to produce electricity using ocean energy technologies if the availability of the resources is confirmed.

The wave energy potential of the West African coast (including Nigeria) has the poorest resources in Africa, with an energy regime of 10 KW/m. According to ECN (2005), “*Nigeria does not seem to have significant tidal energy resources*”. However, OPEC (2004) estimated that Nigeria has 150,000 TJ/annum of wave and tidal energy resources.

Furthermore, even if Nigeria has adequate resources from this energy source, the technology is still developing, along with high capital costs, long gestation periods and low load factors. Hence, it is not commercially viable at the moment even at the global level, *let alone* in a developing nation like Nigeria

ASSESSMENT OF RET USING SWOT ANALYSIS

Based on the data collected from the systematic review and the results of a pilot study, a SWOT analysis has been carried out to assess the potential of various RETs (see Table 1). This was followed by ranking various technologies according to various sustainability criteria to identify the best options for utilisation in rural communities. This is summarised in Table 2. Sustainability criteria included sustainable development objectives and resource criteria. This is because RET may not be sustainable if resources (e.g., water, materials, land) are constrained (Manish *et al.* 2006).

In ranking each technology, a scale of 1-3 is used to rate individual RETs in relation to each sustainability criterion used, with 3 and 1 being the highest and lowest marks, respectively. For example, where the RET resource is continuously available, it scores 3, while partly available is 2 and intermittently available is 1. As shown in Table 2, the total score of each RET was achieved by adding up these individual ratings (shown in brackets). These total scores are then used to rank various RETs

Table (1): SWOT analysis of RET

WIND ENERGY			
STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Reduces GHG emission by ~98% when compared with coal	-Experience intermittency and idleness	-High tum over-US \$ 75 billion in 2012 as against US \$ 3.9 billion in 2000	-Landscape distortion
Major source of RET after hydro source	-Good resource location restriction	-Uses of flown turbines (Kites) as wind speed at jet stream are high	-Bird deaths and displacement
Cost competitive with fossil fuel source	-Many experience high transmission line cost because good resources are located far from energy demand centres	-Use of Aluminium conducting secure anchored in space generating wind power	-Noise
Zero fuel utilisation	-Low energy efficiency (24-54%)	Installed capacity doubling every 3 years	-Growth decline in the last 3 years
Generally available	-Low capacity factor (21%)		-Installation error
Contributing over 3% of global power energy	-Cannot produce base load		
Use in about 100 countries			
SOLAR ENERGY			
-Reduces GHG emission by ~95% when compared with coal	-Experience intermittency and idleness	-Experience unit cost priced reduction (between 20-30%) in 2012 alone	-Removal of incentives in 2008 in some European countries such as Spain
-Extremely modular	-Most expensive among RET sources	-Proposed advance application of satellite and ground solar farm (such as satellite power system, DeserteC)	-General policies uncertainties
-Require little/no maintenance cost	-Low energy efficiency (<22%)		-Saturation of local grids particularly in Europe
-Zero fuel utilisation	-Low capacity factor (19%)		-Market saturation
-Contribute around 100GW of global electricity energy in 2012	-Cannot produce base load		-Fierce competition (over 100 organisations closed up between 2011-2013)
-Generally available	-Deployment is quite small considering global potential		-A lot of Companies went bankrupt
-Highest global energy potential capacity (170,000 TWh/year)			
HYDROPOWER ENERGY			
-Reduces GHG emission by ~96% when compared with coal	-Partially intermittent especially tropical and Amazonian reservoirs	-Can be started and stopped at any time and are modular in nature	-Declining hydro dam construction because of resistance from habitats and pressure
-Largest source of RET (contributing over 16% of global total electricity generated in 2012)	-May be responsible for earthquake	-More new electricity generation from BRICS and other developing countries as witness in 2012	-Effect on biodiversity
-Cheapest form of RET/unit of electricity	-Location specific		-Effect on water quality and hydrological regimes
-Zero fuel utilisation	-Displacement of populations		-Climate change effect
-Most available, reliable and flexible form of RET	-Declining fisheries		
-Can provide base load and peak load	-Low energy efficiency (24-54%)		
-Most energy efficiency among RET (>90%)	-Partially Low capacity factor (20-70%)		
GEOTHERMAL ENERGY			
-Continuous available energy source	-Resource tapping is unsustainable	-Electricity generation is expected to rise because of improved technology (Enhanced Geothermal System) by 2015	-Rivers and lake pollution
-Has the highest capacity factor (>90%)	-Lowest energy efficiency among RET (10-20%)		-Cause land subsidence
-Cost competitive with fossil fuel sources	-Growing capacity is low		-Operation can induce micro seismic
-Can provide base load and peak load	-Lowest global potential among RET		
-Can provide 17% of global electricity needs	-Location specific		
	-Low potential for further expansion—using convention geothermal technology		
	-Highest source of GHG emission among RET (6 times that of wind energy)		
BIOMASS ENERGY			
-Generally available	-Deforestation (as result of land-used expansion)	-And land plantation can increase soil carbon	-Could worsen global climate change
-Carbon neutral (Reduces GHG emission by ~95% when compared with coal)	-Application causes food price increase—Huge water utilization/KWh electricity (around 150-260 kg/KWh)	-Develop international policy mechanism for sustainable land use	-It is not naturally available (majority of the resources have to be sought)
-Good capacity factor (60-70%)	-Food usage for energy generation	-High priority to none/less land bioenergy	-Continuous expansion leads to displacement of communities
-Cost competitive with fossil fuel source	-Highest land utilization among RET	-Strengthen sustainability requirements and certification schemes	-Water scarcity
-Continuous source of energy			
-Generate more employment than fossil fuel energy source/TJ energy	-Low return on investment when biomass is used for energy production		
-Good energy efficiency particularly if its gasification techniques (60-70%)			
OCEAN ENERGY			
-Generally available	-Location specific	-Enjoying policy support particularly in Europe	-Experiencing pressure from environmental campaigns
-Energy potential more than humans' needs	-Low capacity factor (23%)	-Has no significant impact on environment	-Ecological concern
-Highly dependable and predictable	-Lowest total installed capacity among RET (only 0.53 GW in 2012)		-Effect on ocean wild life
-Continuous energy source	-Most expensive after solar energy form of RET/unit of electricity		
-Reduces GHG emission by ~95% when compared with coal			
-Good energy efficiency particularly if its gasification techniques (60-70%)	-Faces Engineering challenges		

Table 2. Sustainability Indicators of RET in Nigeria Rural Areas

CRITERIA	Wind	Solar	Hydro	Geothermal	Biomass	Ocean (Tidal)
ENVIRONMENT						
Green house emission (g/kwh)	25 (3)	90 (2)	41 (3)	170 (1)	70 (2)	41 (3)
ECONOMY						
Price -cost/kwh (US\$)	0.07 (3)	0.24 (1)	0.05 (3)	0.07 (3)	0.06-0.08 (3)	0.12 (2)
Energy Efficiency (%)	24-54 (2)	4-22 (1)	>90 (3)	10-20 (1)	60-70 (2)	55-75 (2)
SOCIAL						
Visual, displacement, Noise, Pollution, Seismic etc	Visual, Noise & Bird strike (3)	Toxins & Visual (3)	Displacement health, Agric & Earthquake (1)	Seismic, Noise, pollution, odour (1)	Food shortage, biodiversity loss, more labour used (2)	Effect on marine life, visual (2)
RE SOURCES						
Water consumption(Kg/KWh)	1 (3)	10 (3)	36 (2)	12-300 (1)	150-260 (1)	28-40 (2)
Land use/TWh	72Km ² (2)	28-64Km ² (3)	73-750Km ² (1)	18-72Km ² (3)	462Km ² (1)	73-750Km ² (1)
Continuity of resources	Intermittent (1)	Intermittent (1)	Partly Intermittent (2)	Continuous (3)	Continuous (3)	Continuous (3)
Resources availability type	Location specific (1)	General (3)	Partly Location specific (2)	Location specific (1)	General (3)	Location specific (1)
OTHERS						
Nigeria potential (TWh/year)	1 (1)	17,702 (3)	58 (3)	NER (1)	225 (3)	41.7 (1)
Capacity factor (%)	21 (1)	19 (1)	20-70 (2)	>70 (3)	60-70 (3)	23 (1)
Total Score	20	21	22	18	23	18
Rank	4	3	2	5	1	5

Legend - Numbers in the brackets represent (scores), other numbers/statements are raw data;
 Coal -GHG emission = 850-900g/kwh, Cost \$0.042; NER-No Existing Record

Biomass energy has been ranked first with the highest total score of 23 followed by hydropower, solar, and wind sources with total scores of 22, 21 and 20 respectively. The lowest technologies are geothermal and ocean energy with a total score of 18 each.

These findings are in agreement with previous research (e.g., Shaaban and Petinrin 2014; Mohammed et. al. 2013; Sambo 2009) that RETs have the potential of providing sustainable electricity to Nigeria rural areas. Biomass is the way forward for providing sustainable electricity for rural communities in Nigeria without supply chain problems. This research will be the first to optimise subset of RETs in Nigeria with a view to be affordable to rural communities.

CONCLUSIONS AND THE WAY FORWARD

Nigerians are experiencing a dearth of electricity that is affecting their socio-economic standing, particularly in the rural areas. Causes of Nigeria's electricity problems include power generation limitations, investment pattern limitations, and the economics of gridline networks and infrastructures. Decentralized RET is recognized to be the solution because of its strategic benefits in identifying when and where electricity is actually required. Various RETs have been critically reviewed with a focus on their availability and level of utilisation in Nigeria. Nigeria has abundant renewable energy resources, particularly biomass, hydro and solar energy sources, with good potential for providing sustainable energy to rural areas in the country. The level of RETs utilisation in the country is low. The main causes are a lack of implementable policy framework, government apathy towards RETs development, and the low purchasing power of the majority of citizens. In line with sustainability assessment of RETs in Nigeria rural areas, the following energy sources should be adopted by order of priority for sustainable electricity: Biomass, hydro and solar sources; this should be supported with robust and consistent policy framework for implementation. Also, there is the need to correct the government's preference for fossil fuels over RETs as a source for generating electricity.

Further work includes the application of whole life costing (WLC) to optimize the economic performance of biomass RET within its whole life cycle rather than during the construction phase only. This will be reported in a future paper

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PERSPECTIVES ON THE SPECIFICATION OF BUILDING INTEGRATED PHOTOVOLTAIC (BIPV) TECHNOLOGY IN CONSTRUCTION PROJECTS

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Innovative, low carbon technologies are already available for use in the construction of buildings, but the impact of their specification on construction projects is unclear. This exploratory research identifies issues which arise following the specification of BIPV in non-residential construction projects. Rather than treating the inclusion of a new technology as a technical problem, the research explores the issue from a socio-technical perspective to understand the accommodations which the project team makes and their effect on the building and the technology. The paper is part of a larger research project which uses a Social Construction of Technology Approach (SCOT) to explore the accommodations made to working practices and design when Building Integrated PhotoVoltaic (BIPV) technology is introduced. The approach explores how the requirements of the technology from different groups of actors (Relevant Social Groups or RSG's) give rise to problems and create solutions. As such it rejects the notion of a rational linear view of innovation diffusion; instead it suggests that the variety and composition of the Relevant Social Groups set the agenda for problem solving and solutions as the project progresses. The research explores the experiences of three people who have extensive histories of involvement with BIPV in construction, looks at how SCOT can inform our understanding of the issues involved and identifies themes and issues in the specification of BIPV on construction projects. A key finding concerns the alignment of inflection points at which interviewees have found themselves changing from one RSG to another as new problems and solutions are identified. The points at which they change RSG often occurred at points which mirror conventional construction categories (in terms of project specification, tender, design and construction).

Keywords: BIPV, innovation, social groups, social construction of technology.

INTRODUCTION

Innovative, low carbon technologies are used in buildings, but the impact of their specification on construction processes is unclear. Often characterised as conservative, slow moving and resistant to change, the construction sector has been shown to be highly specialised, complex and full of innovative practice (Larsen, 2011). A key challenge for the sector is to improve innovation diffusion² so meeting the challenges of construction sector reform (Egan, 1998; Wolstenholme, 2009) and carbon reduction targets (Dept for Communities and Local Government, 2013).

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² Although the terms innovation, diffusion and uptake have separate literatures, this research considers the process of incorporation of an innovative technology on projects and the implications of this. The term innovation diffusion is used to describe that process.

Many organisational and technical factors influence innovation diffusion (such as: policies, organisational structures and operationalization of technology), but this research focuses on the effect of innovation on the construction process. More specifically, the research explores the implications on building design and the project actors as Building Integrated PhotoVoltaics are specified and included on non-residential builds.

The research adopts a socio-technical approach and uses the Social Construction of Technology as a lens to explore diffusion of BIPV. This approach identifies groups of actors who have a shared interpretation and requirement from a technology and then explores how the requirements of different groups and of the technology itself give rise to problems and generate solutions. SCOT thus provides a basis to explore the tensions and negotiations which occur around the specification of new technology and their impact on both the design and project actors

LITERATURE REVIEW

Studies of innovation diffusion span a number of interconnected literatures. The discussion which follows draws attention to the issues of innovation diffusion within the construction sector, the need to explore of the effect of innovation diffusion on actors and the opportunity for using a SCOT approach to examine these issues.

Innovation diffusion studies

Models of innovation diffusion have been developed from simple linear S curve models (Ryan and Gross, 1943) to more complex 5th generation models (Rothwell, 1994) with iterative feed-back loops and concepts of integration. To explain the wide variations in innovation diffusion, there has been move away from these positivist stage models towards a more interpretivist view of understanding what occurs within these stages. Rogers (2004)- an innovator and proponent of innovation diffusion models, latterly stressed the emerging importance of networks and the effects of sociological interactions.

An understanding that innovation diffusion depends on a range of "*softer*" issues rather than being a linear series of events, has led to exploration of its characteristics, effects and specificity. Many studies focus on the effect of issues (like leadership, organisation and strategies) external to the technology (Dainty *et al.*, 2002; Strang and Meyer, 2012), but few look at the effect of the innovation on the actors involved.

Although these areas of research draw attention to how more interpretivist issues may play a role in understanding innovation diffusion, they do not explore variations in the impact of an innovation on project actors across several firms. The project specific nature of work involving multiple firms within the construction sector suggests that the context of innovation diffusion is important.

Innovation diffusion within the construction sector

The construction sector has a very specific context involving temporary multi-disciplinary, multi-firm projects. Additionally different firms and different actors in a project may have different priorities and sensitivities (Pavitt, 1984; Malerba 2002). This makes the study of innovation diffusion in the sector particularly challenging. When considering the incorporation of BIPV within a building, the actors involved include manufacturers of panels, façade manufacturers and installers, mechanical and electrical engineers and commissioning teams. Each of these groups or individuals may be affected differently by the technology and may have different

priorities in accommodating it (Dubois and Gadde, 2002). This is particularly relevant to the specification of BIPV on a project, where benefit to the client in terms of running costs or design aesthetics may represent negative impacts of unfamiliar processes and technology on the designers

Little is known about how innovation diffusion affects different project actors within a complex building project. In the incorporation of BIPV within a project, exploration of the accommodations made by inter-dependent project actors over the course of the project is complex – eg the efficiency of BIPV will be affected both by landscaping around the building (shading) and length of cable runs (losses), and architects and engineers will have to adapt their ways of working to take these into account.

In summary, the construction of a building relies on interactions between many project actors with complex relationships and dependencies. The inclusion of innovative technologies will require different accommodations in the project team and to explore how project actors accommodate the inclusion of BIPV within a project, a clear understanding of their inter-relationships and interactions is necessary.

Socio technical view of diffusion studies

Socio technical studies provide a way to understand the interdependencies and interactions between project actors and the technology on a construction project. This approach can be used to study the development of an artefact (or in the case of the incorporation of BIPV within a building project, the BIPV assemblage within the building) and interactions between groups of project actors. It has been used in the study of the construction sector: the networks involved in the design and construction of complex buildings (Valente, 2012), the tension between innovation and project efficiency (Jacobsson and Linderöth, 2010) and how differences are narrowed between project actors through interaction strategies (Dewulf and Bouwen, 2012). Soudain *et al.* (2009) explore accommodations made between project marketing and project management at the start of a project, but focus their work on a comparison of limited groups or negotiations at a particular point in a project rather than considering the project as a whole.

This research is concerned with actors, the way they interact with a new technology, how the new technology is shaped by these interactions and how that interaction impacts working practices. The approach chosen for this research is that of Social Construction of technology which looks at groups of project actors, the problems that they find with the technology and the development of solutions to accommodate these issues.

SCOT

Social Construction of Technology (SCOT) is an approach which privileges neither structure nor actors. Analysis involves interpreting the interactions between social actors and the technology under consideration. The approach has been applied to a wide range of research topics, ranging from the historic technological development of the bicycle (Bijker, 2009) to understanding decision making processes in the acquisition of IT software packages (Howcroft and Light, 2010). As a lens through which to view the incorporation of BIPV, it allows for consideration of the technical issues which the introduction of the technology raises, the relevance of those issues to the project actors, the solutions which were proposed and selected and the impact of these on both the technology and the build process. For example, when planning

demands require particular generation levels, the design solutions can impact both the aesthetic layout of panels and the space required within the building for invertors.

In an early exemplar of SCOT Pinch and Bijker (1984) used the approach to identify Relevant Social Groups (RSG's) of actors who were involved in working through conflicting issues of bicycle design. Although subsequent criticism of the subjective nature of the identification of RSGs (Klein and Kleinman, 2002) showed limitations in the analysis, the approach has been strengthened through more rigorous consideration of the composition of these groups and power structures (Aibar and Bijker, 1997). Research underlines how RSGs are not made up by formal job titles and positions, but can be shared between actors from different firms and backgrounds.

Key concepts to carry forward from this review are: the notion that RSGs are composed of project actors who share a view of the technology rather than those who occupy common positions or roles, the fact that project actors do not necessarily remain in one RSG throughout the project, and that solutions develop from closing down the tensions and negotiations that occur as the project develops. These concepts inform the research which will examine the interdependencies and interactions between project actors and the technology on a construction projects.

RESEARCH DESIGN

BIPV as an artefact

BIPV technology is not fixed in format and is typically bespoke in design. It consists of several components: the photovoltaic cells which are laminated into the façade/louvre glass, connectors and wiring which take the DC generated electricity from the cell to the invertors, invertors which convert the electricity to AC and an export system which exports surplus generated electricity to the grid. Each of these components have implications for the design of the BIPV and similarly the design of the building will dictate the number of cells used, their configuration, length and location of wiring, position of invertors etc. By considering BIPV as a whole set of components, it can be considered as a technological assemblage which interfaces with the rest of the building design and so lends itself to a SCOT analysis of the issues, conflicts and resolutions which occur as the technology is accommodated within the design. When considering issues and tensions during the project, the assemblage is broken down into its several sub-artefacts eg: inverter equipment, façade configuration (brise-soleil/rainscreen), generating characteristic etc.

Interviewees, Project Actors and RSGs

For the purposes of this research three concepts must be made clear:

- *"Interviewees"* - the people interviewed for the research. They are used as initial informants to scope out the issues for a subsequent detailed analysis.
- *"Project Actors"* - project personnel mentioned by the actors during interviews and who fulfil traditional project roles. In this research it refers to generic project actors (project manager, client, design engineer etc).
- *"RSG"* - groups of projects actors who view the technology through a common frame. One project actor may belong to more than one RSG and may find themselves in a different RSG as particular issues arise.

From interviews the research identifies groups of project actors who have a shared interpretation and requirement from the technology (Relevant Social Groups). These

RSGs are distinct from the traditional project actor roles of client, supplier, project manager, QS, M&E designer etc., and are drawn up around shared frames through which they relate to the technology.

Interviewees

The three interviewees had very different perspectives and experiences of the inclusion of BIPV in projects. Their long term involvement with BIPV allowed them to comment on over 30 projects and gave insights into the accommodations made on projects when BIPV is specified. Table 1 summarises their historical involvement with BIPV and the role that they currently fill.

Table 1: Characterisation of Project Actors

	Interviewee 1	Interviewee 2	Interviewee 3
Years associated with BIPV	15	30	10
Historical roles undertaken	Façade Engineer Façade Sales Manager BIPV Sales Manager	M&E Engineer Head of PV Business Development BIPV consultant BIPV Advisor to government	Head of Sustainability Initiatives Manger Engagement and project Manager
No of projects identified during interview	10	15	5-10 discrete projects 100+ related projects
Involvement with BIPV research and development	Yes	Yes	Yes
Current main project role	Supplier	Consultant	Client

Data collection

Data collection used semi-structured interviews to focus on projects that incorporated BIPV with which the interviewees had been involved and their range of experiences over those projects. The interviewees experience of BIPV over many years, in different roles within and outside their respective firms. Each interview covered the interviewee's background, involvement with BIPV and experiences on construction projects.

The purpose of the set of interviews is to identify the range of issues and decisions which might be expected to emerge in the course of a project as these inter-relationships play out amongst the project actors. Project actors mentioned during the interviews were included in subsequent analysis. Interviewees 1 and 2 (see Table 1) cross referenced each other during the interviews. The nature of interviews (and responses) allowed membership and changes of RSG's by project actors to be followed throughout the course of each interview

Data analysis

Interview transcripts were coded against an initial set of nodes using NVivo 10 software. The analytic framework for the coding was derived from a Social Construction of Technology approach.

Interviews were analysed for different interests and concerns of project actors, issues arising from the specification of BIPV on the build (both in terms of technical detail and other project actors) and the effect that these issues had on project progress. The latter included the progress of the build, and also the effect the issues had on other project actors and solutions implemented.

The interviews were used to establish an informed understanding of what is involved in the specification of BIPV on a project and how it is specified, accommodated, and actualised within construction.

FINDINGS

The use of SCOT allowed two issues to be examined: the identification of types of RSGs likely to emerge on a construction project specifying BIPV and their associated interests and the type of tensions and negotiations that occur as the RSGs accommodate the technology into the project.

One particular theme which emerged from this concerned the importance of inflection points: this refers to the reconfiguration of RSGs as the phases of the project progress.

Relevant social groups

Although not exhaustive, six RSGs associated with projects were consistently identified by the interviewees. These groups have been named as part of this research and these, together with their main interest are summarised in Table 2.

Table 2: *Relevant Social Groups and their interests*

RSG	Main interest of RSG
Design Aesthetes	BIPV is part of the building which is a flagship architectural design
Green Guardians	BIPV reduces carbon emissions of the building and meets planning requirements
Design Optimisers	The process of design is efficient
Generation Maximisers	The PV system generates to its maximum potential
Cost Watchers	Project costs are kept to a minimum and financial case is maintained
Users	The building is fit for purpose and the generation reduces running costs

Although all three interviewees agree that explicit understandings of the requirements and needs of different RSGs is an important determinant of successful inclusion of BIPV, a striking feature of the interviews was that they all see this as a problem. A comparison of statements by the project actors interviewed Table 3 illustrates this agreement.

Tensions and Negotiations

As projects proceed from conception to construction, tensions develop around the inclusion of BIPV. Scot analysis illustrates how these tensions, potential solutions and the resulting negotiations can shape the design and occasionally influence the technology. Three tensions are illustrated below (figures 1, 2 and 3) and the preceding extracts from interviews illustrate how RSGs identify problems with the assemblage or design and how their proposed solutions can conflict with the interests of other RSGs which results in tension and negotiation of the solution between groups. The diagrams have been simplified to highlight the dynamics of one chosen solution.

Table 3: Explicit understanding of the interests of Relevant Social Groups

	Summary	Statement
Actor 1	Establishing the requirements from the technology is key to the successful resolution of design issues.	"...do you just want to produce decentralised power, or do you want something that's part of the building fabric? ...If you want just power and you've got an area of roof, stick the panels on the roof..."
Actor 2	Lack of clarity of requirements resulted in planning issues and increased costs	" it was supposed to go in as glazed roof [but] the client ran out of money so they changed it to a tin roof with some solar on. About a year later they rang up to say "the whole purpose of this building was that the roof powers the borehole, which heats and cools the building, and [now], we haven't complied with the original planning requirements. "
Actor 3	Understanding the impact of client requirements will ensure that the feature is incorporated even when it causes tension	" last year we sold three sustainable stores that had almost all singing all dancing stuff so there's definitely a market out there - a lot of pension funds, [who are] saying, "we've clients that want sustainable green portfolios "

Unanticipated Shading:

".. Football stadia roofs are ideal ... the thing is that you put all this PV in there, and it's giving you a nice bit of shading and it's giving you light, but ...certain times of the year ...it's also shading the grass, so the grass won't grow evenly, so they've had to alter the spacing of the panels to make sure that there is the same level of light [on the grass] ... "Interviewee 1

Figure 1 illustrates how the impact of unintended shading of the grass under the roofing area potentially impacts the shading performance of the façade configuration (part of the aesthetic appeal for using the panels) and its visual impact.

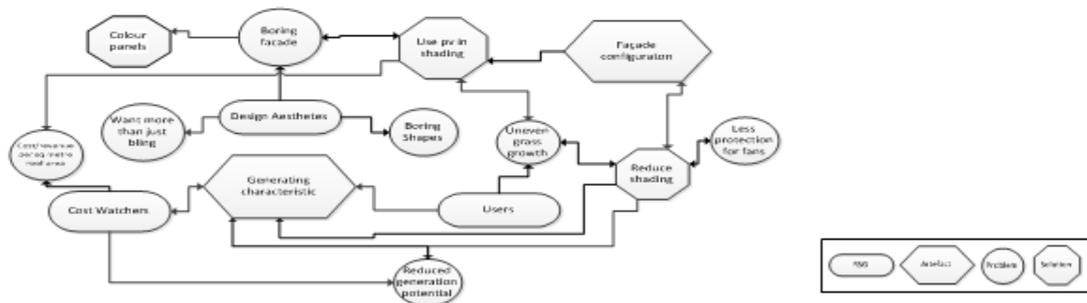


Figure 1: SCOT diagram of unanticipated shading

Three RSGs are shown, together with the problems they identify and the potential solutions. Arrows indicate how these solutions impact on the RSGs and result in tensions. The solution to reduce shading density by reducing the density of PV cells decreased the generation potential and affected project payback, but also impacted the design aesthetes. It is the ensuing negotiations that result in the ultimate solution.

Lack of familiarity with technology

"...so - where are you putting your wiring? Oh, we didn't think about the wiring. Where are you putting your inverters? Oh, do we need inverters? Really basic sort of [issues which came up] - as they were ordering stuff. The order was stopped for six weeks ... " Interviewee 2

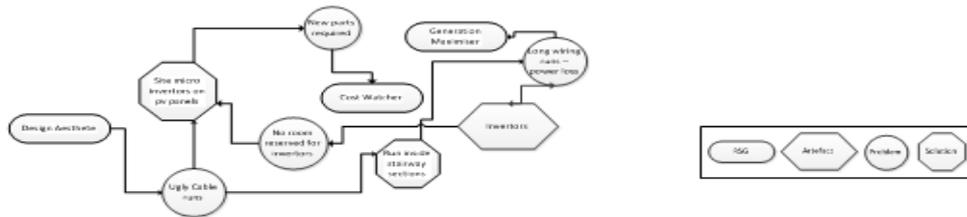


Figure 2: SCOT diagram of lack of familiarity

In this example, mapping the issues of "invertor siting" and "hiding wiring runs" (Figure 2) shows that the solution of using micro-invertors produced tensions between the cost watcher and Design Aesthetes RSGs. The lack of familiarity of problems associated with long cable runs added to the situation.

Project Sanction delays

"...So the feed in tariff changes every three months and...is it going in before the peak months or is it going in the middle of the winter when I get a kicking for saying, why didn't you do it during the summer?..." Interviewee 3

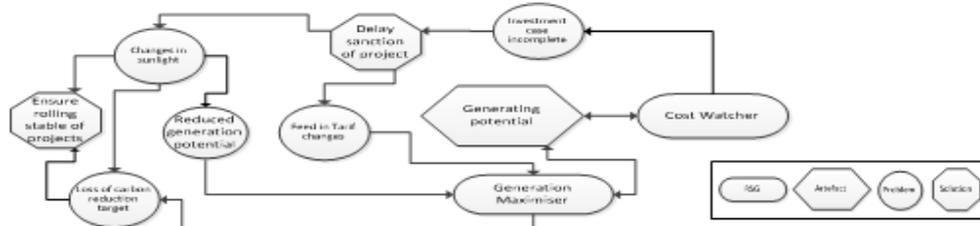


Figure 3: SCOT diagram of project sanction delays

Lack of understanding by Cost Watcher RSG has led to substantial loss of generating revenue potential through delayed project sanction. Tensions between The Generation Maximisation and Cost Watcher RSGs have brought about a solution which uses a rolling stable of projects to accommodate likely delays (Figure 3)

Inflection points

One emerging theme is that although all three interviewees find that their concerns shift as the building and technology develop (shift from concern with aesthetic to concern with costs), the points at which these concerns change often occur at stages which mirror conventional construction categories (in terms of project specification, tender, design and construction). The use of SCOT highlights how project actors change RSGs over a project's span and some of these inflection points correspond with changing phases of the project. These changes are illustrated in Figure 4 below.

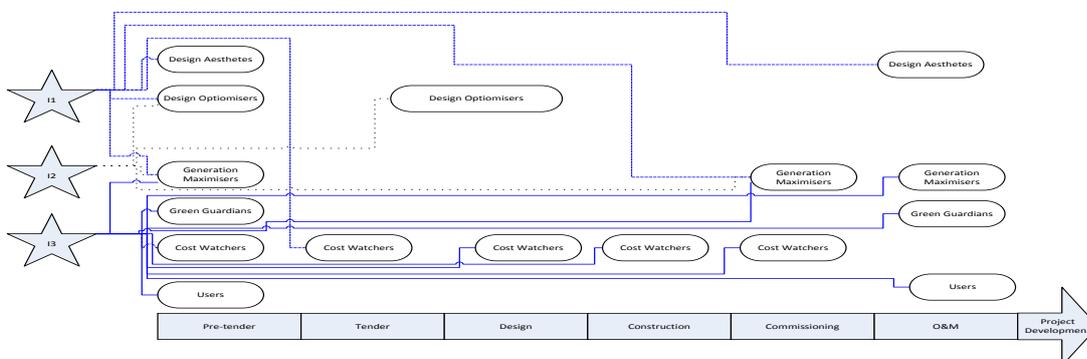


Figure 4: Inflection points of RSG composition

DISCUSSION AND CONCLUSIONS:

Rather than treating the inclusion of a new technology as a technical problem, the research explores the issue from a socio-technical standpoint to understand the accommodations which the project team makes and their effect on the building, the project actors and the technology. In doing so it identifies some of the common issues which the three interviewees have found following the specification of BIPV. Over the course of interviews, they spoke about three common types of experience:

- Accommodations forced on the design at late stages in the project due to unanticipated effects of the technology on build (shading from the configuration of the PV panels affected grass growth on the pitch and resulted in a reduction in panel spacing which negatively impacted generation).
- The unanticipated consequences of a design (the requirement to hide cables resulted in long wiring runs to the invertors, which resulted in generation loss, a new design for micro-invertors which resulted in more parts being required).
- The effect of standard firm procedures in delaying new projects which include BIPV (the standard procedure of hard negotiation of capital items resulted in delays to project sanction and loss in generation potential as the seasons changed and hours of daylight reduced).

Particular advantages of using SCOT have been to show that it is the way the project actor views the technology rather than their formal project role which brings problems into focus. This allows understanding of how RSGs become conscious of issues, how these caused tensions between the groups, and how the solutions have effects on the build, the actors and the technology.

- It has identified six RSGs which seem common to BIPV projects.
- It has shown that the composition of RSGs change over the span of the project and that this brings about changing tensions and negotiations with other members of the greater project team.
- It has been sufficiently flexible to unpack some of the issues surrounding conflicting solutions and effects on the build.

A key finding is that as groups of actors who have a shared interpretation and requirement from the technology (Relevant Social Groups) develop better understandings of the requirements of other RSG's, they begin to generate sophisticated solutions to the problems arising from the inclusion of new technology.

Further research will develop detailed analysis of specific projects to understand the accommodations made to projects, process and technology during the inclusion of BIPV, the process by which RSG membership changes, how tensions are negotiated and closed and the effect of the power hierarchy in construction projects.

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ESTABLISHING ABATEMENT ALTERNATIVES IN CONSTRUCTION

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Construction operations consume energy and due to the associated emission of greenhouse gases (GHG), leave negative environmental impacts. Many construction contractors look on emission mitigation efforts as being counter to profit and of secondary priority. However, due to increased social pressure, contractors are being obliged to reduce energy consumption and mitigate emissions. This paper focuses on emissions during construction. The aim of this research is to provide construction contractors with an understanding of the effectiveness and cost of available abatement alternatives and aid them in making profitable decisions while minimizing project emissions. Based on data from a road construction project, required material quantities, available suppliers, delivery vehicles and the NONROAD model, the cost and emissions of each possible procurement alternative are compared. The abatement curves are used to present the results. It is shown that by simply considering emissions in decision making, changing material supplier can help mitigate emissions. It demonstrates that for contractors who intend to make environmental friendly decisions, there exist affordable alternatives.

Keywords: construction operations, abatement curves, greenhouse gases, emissions, energy consumption.

INTRODUCTION

The push to examine carbon emissions is driven by obligatory and voluntarily regulations aimed at reducing greenhouse gases (GHG) set in response to global concerns over climate change issues. Minimizing carbon footprint is seen as a global priority and an important step towards sustainability (Piratla *et al.*, 2012).

Construction industry not only consumes energy, but also emits GHG which lead to climate change and global warming (Guggemos and Hovarth, 2005; Dixit *et al.*, 2010). Although compared with other industries, each individual construction project may not contribute to a large quantity of GHGs but the aggregate GHG product of the large number of construction projects is significant. For example, the construction industry is responsible for 40% of the primary energy use, and 36% of the energy related CO₂ emissions in industrialized countries (Blengini and Di Carlo 2010). In addition, in the United States, the construction industry ranks third after cement and steel production industries which supply construction projects with required material for its CO₂ emissions per unit of energy used as input (Avaetisyan *et al.* 2012).

However, when it comes to mitigation efforts, construction contractors, look at environmental issues generally as being counter to profit and secondary priority

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(Carmichael and Balatbat, 2009). With the increasing global scrutiny on environmental issues, contractors are being obliged to adopt carbon abatement efforts.

Contractors might see some competitive advantage through managing their GHG emissions during construction. They can start from activities producing greater emissions. The uniqueness of each construction project and the variety of construction activities makes it difficult to say which activity has the biggest contribution to GHG emissions. Previous research affirms that because of their dependence on fossil fuel for energy, transport of material to and from the site is among the top GHG emissions contributors in construction projects (Ren *et al.*, 2012). Thus including emissions as an emerging criterion in construction related decision-making makes it possible to reduce project emissions through thoughtful supplier selection. This can be accomplished with little or no increase in project costs.

Contractors require both the cost and efficiency of any abatement alternative to make win-win decisions for themselves and the environment. Such information can be presented in many ways including the form of cost curves known as the marginal abatement cost (MAC) curves.

The overall aim of this paper is to provide construction contractors with an understanding of the effectiveness and cost of available abatement alternatives. It seeks to aid construction contractors in making profitable decisions regarding supplier selection at the same time minimizing project emissions. The problem of optimal selection of material supplier for a project subject to simultaneously minimize emissions and project cost given different types and quantities of material, different distances and delivery vehicle emission rates is formulated as a bi-objective optimization problem. The application and benefits of using abatement curves is demonstrated on a case study involving an infrastructure project known as Project M. The cost and carbon footprint associated with supplying material from different quarries are compared using abatement curves. The paper shows that there exist abatement alternatives that do not incur cost on the contractor. This approach will be of interest to contractors seeking affordable ways of making environmental friendly decisions.

This paper first discusses the process of identifying abatement alternatives by measuring emissions in construction. The emergence of emissions as a criterion in construction decision-making is addressed. The paper then investigates abatement alternatives by presenting a case study. MAC curves are then derived for identified alternatives demonstrating the cost effectiveness and potential abatement of each alternative. Conclusions follow.

What remains a major challenge for making environmental friendly emissions in construction is the demonstration of the cost effectiveness of abatement alternatives. Contractors require both the cost and efficiency of abatement alternatives to make win-win decisions for themselves and the industry. Such information can be presented in many ways including the form of cost curves known as the marginal abatement cost (MAC) curves.

BACKGROUND

Identifying abatement alternatives

Measuring emissions is the prerequisite of managing emissions. Contractors are responsible for emissions from owned or controlled machinery and equipment, through activities such as transportation of materials, products, wastes and employees.

These activities represent scope 1 and 2 emissions based on the GHG Protocol Corporate Standard (Ranganathan *et al.*, 2004) which is one of many emissions reporting standards.

To help measure GHG emissions in construction several approaches have been made. Park *et al.* (2003) estimates emissions by multiplying total fuel consumption by fuel to emissions conversion coefficient. The conversion coefficients in this model are not equipment specific. Focusing on seven different types of equipment, Lewis (2009) proposed a model that provides detailed emission factors for ten engine modes. By using the fuel-to-emissions rates of each engine mode the fuel use rate is then converted to an emission factor. In a more comprehensive and general approach, the NONROAD model (EPA, 2008) developed by the U.S. Environmental Protection Agency (EPA) provides specific emission rates for each type of off-road equipment based on their power and year of make. The emissions are estimated using: (1) the emission factor which is the average emissions rate for a given pollutant and (2) the load factor which accounts for idle, partial load and transient operating conditions. The NONROAD model (EPA, 2008) is used for measuring emissions in this paper.

By measuring and reporting emissions, abatement opportunities are identified. Abatement is basically achieved by output cuts from polluting sources, by technical change or through cleaning up pollutants in the environment (Beaumont and Tinch, 2004). Every field has different abatement alternatives. In the transportation sector, they can include less expensive hybrid vehicles and bio-diesel while for climate change, its carbon capture and sequestration (Baker *et al.*, 2008).

Contractors can achieve abatement by focusing on main polluting sources. In construction, primary sources of GHG emissions are off-site transportation of material and equipment to/from the site and the operation of on-site equipment (Cole, 1998; Ahn *et al.*, 2010; Ren *et al.*, 2012). For a profit driven contractor reducing transport distance, equipment idle time and power usage are “*low hanging fruits*” which achieve abatement at least cost. Using well-maintained or new equipment with improved emissions controls are examples of technical changes in construction equipment, which aids emissions reduction at jobsites. For example, upgrading the diesel equipment fleet by 8 years reduces CO, NO₂, and HC emissions by 30–68% (Guggemos and Hovarth, 2005). However, changes in technology by upgrading the equipment fleet, requires investments and are expensive.

Adopting abatement alternatives

Construction contractors traditionally deal with problems such as optimal equipment selection, selecting among multiple sources of material that can serve a project, the route selection and the issue of replacing current fleet with new machines focusing on minimizing cost and maximizing productivity (Oglesby *et al.*, 1989). Classic decision-making problems in construction are no longer merely a cost and time minimization problem for contractors.

The objective function of these problems is now reducing emissions while minimizing the effect on cost. This approach has gained popularity in the construction industry and efforts have been made to solve construction problems with emissions in mind: construction method selection in tunneling (Ahn *et al.*, 2010), solving the equipment selection problem (Avetisyan *et al.*, 2012) and path selection model for construction material delivery (Koo and park, 2012).

As a common element in all decision-making problems, the contractor needs to know whether an abatement alternative is worth the cost. An abatement alternative merits performance if and only if a contractor deduces it would be better off adopting it. This is the heart of marginal decision-making.

Therefore achieving a win-win position for the contractor and the environment requires an understanding of available GHG abatement alternatives along with its associated costs and benefits. One of the ways to provide such information is the MAC curve.

CASE STUDY

An 11.5 kilometre road infrastructure project in the Australian Capital Territory (ACT), known as Project M is selected as the case study to measure the impact of supplier selection on cost and emissions. The contractor requires different quantities of material delivered to the site.

The contractor provided the bill of quantities, suppliers' descriptions (cost, location and supply capacity) and delivery vehicle descriptions. Four quarries can supply the required material. Bogie and trailers (15 m³) are used as delivery vehicles to haul the material from the quarry to the site. The two-way travel time from each quarry to the site and back is calculated based on the loaded travel speed (50 km/h) and the empty travel speed (60 km/h) of the delivery vehicle (**Error! Reference source not found.**).

Table 1: Two way travel time calculations from quarries to the site

Quarry code	Distance from site (km)	Travel time (h)		Total two way travel time (h)
		loaded	empty	
A	33.1	0.66	0.55	1.21
B	17.8	0.36	0.3	0.65
C	20.3	0.41	0.34	0.74
D	14.9	0.3	0.25	0.55

Based on the total quantity of different types of material required for the project and the capacity of the delivery vehicle used to haul the material, the number of two way trips required to transport the total quantities of material from the quarry to site and back is calculated (**Error! Reference source not found.**).

Table 2. Number of trips required to deliver required material to site

Material code	Material description	Quantity (tonne)	Number of two way trips
Type I	Surge rock 150mm size	110000	3667
Type II	Drainage blanket ballast 63mm	14500	483
Type III	Bedding material	25000	833
Type IV	Aggregate material (20mm granite)	15000	500

To calculate emissions produced through the transport of material from the quarry to the site the NONROAD model (EPA, 2008) is used. The model calculates the emission factors of equipment based on their horsepower (hp) and the year of make. The emission factors related to the delivery vehicle used in this case study are presented in **Error! Reference source not found.**

Table 3. Emission factors for the equipment used to haul the material to site

Item	HP	Year	Emission factors (kg per hour)					
			CO ₂	SO ₂	HC	CO	NO _x	PM
Bogie and trailer	425	2003	227.7	0.35	0.08	0.65	1.79	0.1

In a process called characterization, the global warming potential (GWP), is used to convert the emissions to one single carbon dioxide equivalent (CO₂-e) value. CO₂-e is the standard unit for measuring carbon footprint.

The GWP for carbon dioxide and methane are respectively 1 and 23 and there is no GWP associated to CO, NO_x, and SO₂ (IPCC, 2007). Hence, a CO₂-e value of 229.5 kg per hour use is considered for the bogie and trailer.

For every quarry, the cost of material delivery is calculated based on the unit cost of material delivered to site and the total quantities of required material. The total time required to deliver the required material to the site (delivery time) is obtained by multiplying the total two way travel time in **Error! Reference source not found.** by the number of two way trips required in **Error! Reference source not found.**. Total carbon footprint associated with supplying material from each quarry is then calculated by multiplying the delivery time of material by the CO₂-e value.

RESULTS AND DISCUSSIONS

The results from the case study are outlined below. They compare the cost and carbon footprint associated with supplying material from different quarries. Quarry selection is associated with a cost and a carbon footprint.

As traditionally contractors seek minimized cost, the contractor's choice is quarry A. This decision in return is associated with the highest emissions (Figure 5). It is eminent that the closest quarry to the site (D) produces the lowest emissions which in this case is incurs the highest cost for the contractor.

An estimate of 1500 tonnes of CO₂-e produced from material transport to the site in Project M over the construction period is made on the basis of the required quantities of material, quarry distance from the site and capacity and emission rate per delivery vehicle.

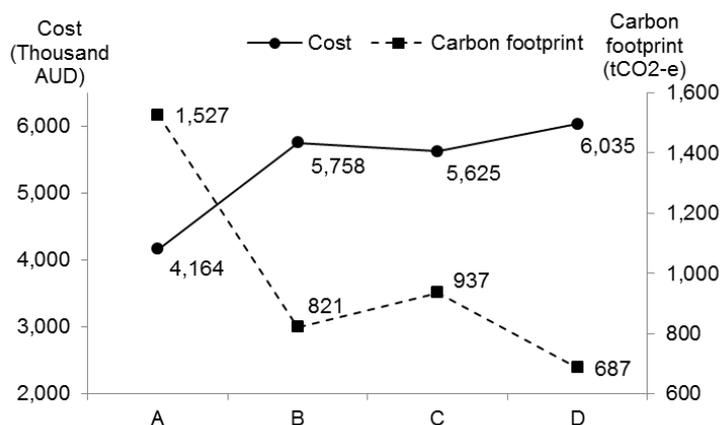


Figure 5. Cost and carbon footprint trade-off for material procurement from different quarries

Let's now consider the objective function of reducing carbon footprint while minimizing the cost. For this, quarries B, C and D are considered as abatement alternatives for quarry A. The abated amount of CO₂-e with the associate costs of supplying material from an alternative quarry is then calculated. The comparison results are summarized in table 4. The abatement cost is simply the cost divided by the total amount of abated CO₂-e and negative costs indicate cost savings. The results are presented using abatement curves.

Table 4- Summary of the cost and CO₂-e comparison between alternative quarries with the initial contractor's choice

Material Types	Quarry B				Quarry C				Quarry D			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Cost (1000 AUD)	1580	-249	353	-90	1786	-222	49	-152	2002	-193	276	-213
Abated CO ₂ -e (t)	472	62	107	64	394	52	89	53	561	74	127	85
Abatement Cost	3.3	-4	3.3	-1.4	4.5	-4.3	0.6	-2.8	3.6	-2.6	2.2	-2.5

For each alternative quarry, an abatement curve is derived to evaluate its abatement potential. Each abatement curve (figures 2, 3 and 4) compares the cost and carbon footprint associated with supplying the material from one of the alternative quarries (B, C and D) with quarry A.

Abatement curve

A marginal abatement cost curve is an intuitive way to represent the relationship between the cost-effectiveness of different alternatives and the total amount of GHG abated. Abatement curves have been used since the 1970s oil price shock. Under different names (for example saving curve and conservation supply curve) they are widely used concepts in environmental engineering. Despite being frequently used to examine climate change mitigation measures in various industries and sectors in different countries (Hasanbeigi *et al.*, 2010) the construction industry has not yet utilized the advantages of these curves.

MAC curves transparently communicate available abatement alternatives and provide an estimate of cost for the contractor to reach an abatement target. This type of cost curves also help contractors select the most affordable abatement alternative (Beaumont and Tinch, 2004). Describing the costs and benefits of any abatement alternative in the format of an abatement cost curve persuades the construction industry (contractors in particular) to make environmentally preferable decisions.

As the MAC curves depict, moving along the curve from left to right the cost-effectiveness of each measure worsens. It means, as the total level of abatement increases, each tonne of abated carbon dioxide equivalent (tCO₂-e) becomes more expensive (Figure 6, Figure 7 and Figure 8).

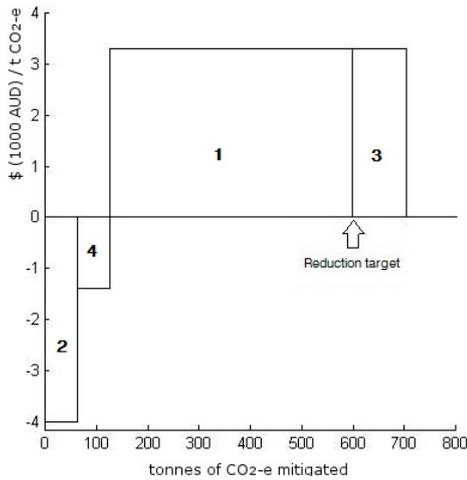


Figure 6. MAC curve for quarry B as an alternative material supplier.

Within each MAC curve, the cost benefit and abatement potential of each measure is demonstrated. In this paper, each measure represents the outcome of supplying a type of material from the alternative quarry instead of quarry A. For example measure 1 in Figure 2 represents supplying material type I from quarry B instead of A.

Measures below the horizontal axis are beneficial also in terms of cost reduction. In all three MAC curves, measures 2 and 4 which represent supplying type II and IV materials from any of the alternative quarries have both cost and carbon footprint savings for the contractor. On the other hand, measures 3 and 1 while reduce more emissions but incur a positive cost.

By supplying type II and IV materials from any supplier other than quarry A (adopting measures 2 and 4), 105 tonnes of CO₂-e mitigation is achieved. This achievement as the MAC curve clearly shows provides cost saving for the contractor.

Based on a reduction target, one or more of the measures have to be implemented. The reduction target is the amount of abatement a contractor is seeking to achieve. It can be set due to regulations or internally by the firm.

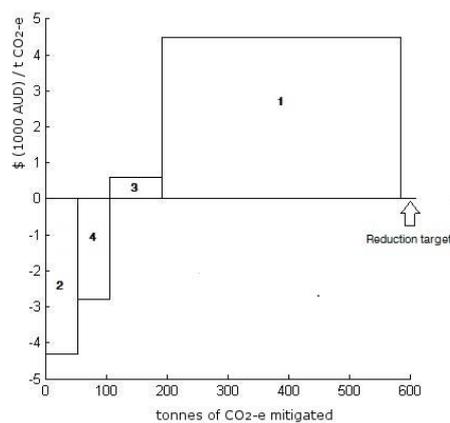


Figure 7. MAC curve for quarry C as an alternative material supplier.

For example if the reduction target is set to 600 tonnes of CO₂-e, by implementing measures 1, 2 and 4 (supplying material types II, IV and I) from quarry B the target is achieved (Figure 6). While the contractor can only achieve 588 tonnes of CO₂-e abatement by selecting quarry C (Figure 7). Therefore, it is clear that based on this reduction target, quarry C is not a suitable alternative for the contractor.

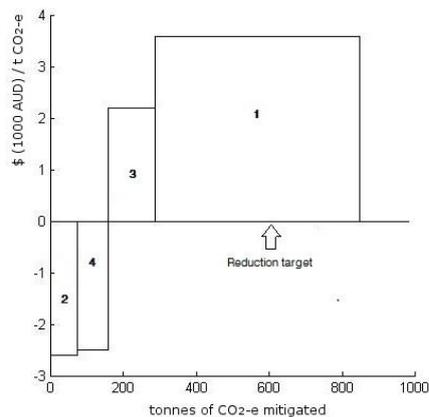


Figure 8. MAC curve for quarry D as an alternative material supplier.

On the other hand, if the reduction target were equal or less than 50 tonnes of CO₂-e, the abatement target would be achieved only by implementing measure 2 from any of the alternatives. This shows by simply changing the supplier of material type II, not only the reduction target is achieved but the contractor also benefits money saving. Finally it should be noted that the MAC curves show that the maximum amount of abatement achievable through changing the material supplier is 847 tonnes of CO₂-e. For greater reduction targets, the contractor has to think of other alternatives.

Previous research affirms that machinery and material transportation to and from the site are a major energy contributor in the construction phase (Cole, 2000; Guggamos and Horvath, 2005; Ahn, 2010 and Ren *et al.*, 2012). Consumption of fossil fuels during the previously mentioned activities produces emissions thus supplier selection is an important management issue in reducing carbon emissions in the construction industry. Emissions are an emerging criterion in the supplier selection problem. Supplier selection based on the lowest prices is not efficient sourcing any more. Other criteria in the literature include supply variety, quality and delivery (Ng, 2008). The case study results clearly support the related literature findings (Peng and Pheng, 2011) which demonstrate how local supply of material compared to international supply can significantly reduce carbon emissions.

CONCLUSION

This paper incorporates emissions as a decision-making criterion in a supplier selection problem. In a case study it evaluates alternative suppliers, in terms of their impact on both cost and emissions. Marginal abatement cost curves are used to present the results. It is shown that simply changing the supplier of material types II and IV, at least 105 tonnes of CO₂-e is mitigated. As the abatement curves clearly show, this achievement not only imposes any cost on the contractor but also saves money. Contractors benefit from the abatement curve as a tool to make cost effective environmental decisions. It is demonstrated that for contractors who intend to make environmental friendly decisions, there exists affordable alternatives.

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DESIGN

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DESIGNERS' PERSPECTIVES ON THE USE OF IMMERSIVE VIRTUAL REALITY TECHNOLOGY IN PRACTICE

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The role of emerging virtual reality (VR)/ BIM enabled technologies on the construction design process is examined in this paper from an angle of understanding the contextual use of technology in practice. Drawing attention to the dynamics of interrelating the social, perceptual and material/ technical mechanisms involved, the study takes an interest in issues of understanding and reflecting on the effect of immersive technologies on construction design activities as used in concrete 'real – life' settings and as perceived by practitioners. The case study is an on-going construction project for a new hospital in the UK, where an immersive VR environment (IVRE) was used performing design review sessions during the bid preparation stage. It is about understanding practitioners' reflection hence the study augments previous insights based on direct observation and audio-video recordings of multiple design meetings with interviewing the design participants. The focus is on designers' perception of the events, their reflection back on their actions, their conceptual understanding of using IVRE in the process, and their view on the possible connection with broader practices of design. A particular strategy was applied in conducting retrospective discussions with the participants in a data review session format, consisting in both playing back video-clips (thematically selected from the video data set), and revealing the researcher's interpretation around what was happening during the design sessions. This was aimed to allow the participants' reflection on how they experienced particular episodes and to engage them with the research questions, for asking them to describe their understanding and reasoning behind the events. Early analysis suggests that the interview data is particularly informing with regard to participants' perspective on how using IVRE in the design review connects with other VR/ BIM enabled ways of performing the process and exposes their insight on the potential impact on the broader construction context.

Keywords: construction design practice, designers' reflection-on-action, immersive virtual reality environment (IVRE).

INTRODUCTION

Although the potential of IVRE technologies (immersive virtual reality environments) has been widely addressed from a number of approaches (Kahkonen 2003, Whyte 2002), more research adopting sociological perspectives on the use of immersive technologies in the real life design practice is still needed. This study addresses this through examining the practicalities of the technology in an on-going construction project. The empirical material is drawn around the early design of a new hospital project wherein design and contractor teams used a CAVE (Cave Automatic Virtual

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Environment) set up in the University of Reading to demonstrate particular design requirements to the client and to perform design review meetings. This paper builds on a previous stage of research based on observing and video recording several design meetings held within the CAVE. The current study draws on retrospective discussions with the participants which had been involved in the CAVE design meetings. Mobilising Schon's (1983) idea of design as 'reflective practice', the paper focusses on the designers' retrospective reflection on their experience of performing design in this particular technological setting.

LITERATURE REVIEW

The broad argument of the paper is around Schon's (1983) theory of design as 'reflective practice', which considers design as a process of both reflecting and acting, or 'thinking' and 'doing' that are inseparable and bound up in the situations of practice. Schon positions design as situated activity, across different individuals and materials (design representations and technology). It stresses the context dependant character of the process, accomplished through locally constructing and collaboratively sharing meanings to iteratively shape the design. It is a process of making sense in situ, an interactive mechanism of both defining and addressing, creating as well as discovering the situation. Design as 'reflective practice' is not a uniform process, but dependent on how it becomes configured in the unique, complex and messy situations of practice. It involves mobilising existing repertoires of knowledge, prior understandings, media, procedures etc. which the participants draw on to collectively make sense of and address particular situations through conversation and action.

Distinguished in two states as reflection –in and –on action, the first refers to thinking about actions while performing, and the second is a form of thinking back to action previously accomplished outside of the situation, as a process of connecting with the understandings developed during action (1992). The process of addressing a design situation affects and reshapes appreciations and existing repertoires, therefore informing both the local episode and broader practice. Schon's idea of 'reflection-on-action' is the participants' reflecting back to enhance understanding and enrich repertoires of experience, applicable to subsequent situations of practice.

The approach adopted in this paper builds on Schon's position as well as on more recent studies that demonstrate the potential of mobilising ideas of reflective practice as a means to understand and analyse design work. Some draw on Schon's concern with examining and evaluating existing approaches to studying design (e.g. Dorst and Dijkhuis 1995; Stumpf 2001). Other studies mobilise more explicitly ideas and concepts of Schon to investigate aspects of the design process in empirical situations (e.g. Valkenburg and Dorst 1998; Stumpf and Mc Donnell 2002). Others build on Schon's position to develop models or frameworks for describing the design process and to develop methodological approaches to support the actual performance of design. Among these, McDonnell *et al* (2004) use Schon's reflection-on-action to propose a new approach for design practice. This combines video recordings and the story-telling techniques in an experimental study where the participants video a design event, and subsequently produce a story of the design episode. This is mobilised as research strategy for examining collaborative reflection on their experience, and for focussing on the cognitive mechanisms and social interaction involved. A particular focus is on the designers' critical assessment of their experiences, with envisaged implications for refining their practice. Their study restates the relevance of reflection

in design, and presents an interesting demonstration of how mobilising this idea supports accessing insights around the team design processes.

METHODOLOGY

The focus of the paper is on the idea of design as 'reflective practice' and the aim is to access insights around the participants' retrospective reflection-on-action. This is addressed through examining the participants' reflection on the use of technology and on their practice. This was achieved through discussions with the participants in a format resembling a data workshop reviewing and describing the design processes previously performed in the IVRE. The process consists of showing them the video-recordings of the design sessions in which they participated. The method choice draws partly on Schon's argument on the role of reflection-on-action outside of the situation as retrospective thinking on the previously performed actions through observing and describing. Also, the methodology resonates with what the ethnography refers to as 'closing the loop', as a way of checking the researcher's interpretation through engaging the participants with the research questions by allowing them to reflect back on the events. It is partly about the design participants' retrospective reflection-on-action which they performed during the design meetings in the CAVE, but also about their reflection on the researcher's sense making of the events.

The case study is based on an on-going project for designing a new hospital in the UK. One of the requirements is that all patient accommodation is in single rooms, rather than traditional wards. Single room only accommodation is rare in the UK, and so a key issue for the client was ensuring that the rooms were of sufficient size. At the time of the research, the project was still in bid preparation stage. The project team opted to augment the traditional design and client engagement procedure with the use of a CAVE (a type of IVRE) at the University of Reading. This was to be used to demonstrate to the client that the rooms were of an appropriate size.

As particular type of IVRE, the CAVE (Cave Automatic Virtual Environment) is an immersive, multi-person, room-sized, high resolution multi-display 3D video and audio environment, in which graphics are projected stereo onto the walls and the floor. It offers the user (equipped with 3D stereo glasses and a head mounted tracking device with location sensor) an active stereo and real-time interaction with a life sized 3D model. One user's movement in the space of the CAVE is being tracked and, consequently, perspective rendering is displayed responsively. CAVE participants see their arms and bodies and can easily interact between themselves during the simulation (DeFanti et.al. 2011). The CAVE at the University of Reading has three vertical projection screens (3m by 2.2 m) and a floor projection screen (3m by 3m).

The previous set of data consists of recordings and direct observation of a series of six sessions held within the CAVE) (Maftai and Harty 2012). For the current study, interviews were set out around showing the participants short clips and asking them questions drawing on the analytical themes generated through the initial stage of research. These follow up discussions were set out as semi-structured interviews in the format of individual data review sessions of 30- 60 minutes (December 2013). The retrospective discussions were supported by video fragments selected to illustrate themes drawn from the previous study for allowing the participants to reflect back on the events and on how they had perceived and experienced particular episodes. This consisted in playing back the video clips, introducing the participants to the researcher's interpretation, and asking them to describe their understanding and reasoning behind the events. The discussions were conducted individually in four

sessions with participants having various roles in the design team: visualizer (REVIT modeller), project director, head of health care (lead of interior design) and lead medical planner. Conducting the research followed the University's ethical procedures regarding the participants' consent and the confidentiality and data protection.

The analysis section below unpacks insights around: the participants' recognition of the analytical themes generated by the previous study of the video data; their reflection-on being in the CAVE (reflection-on the design review process and -on the use of the medium); and the participants' reflection on how the technology fits in the broader practice using other type of materials and less immersive technology.

ANALYSIS

Theme I: Reflecting on the researcher's interpretation of the events

Focussing on the participants' recognition of the themes drawn on studying the video data, this first analytical theme examines broadly how the design team members involved in the IVRE review sessions orient to the technology, and they first configure an understanding of the architectural model in the CAVE. Then the analysis unpacks insights on how the perception of the IVRE as non-familiar design medium provokes ruptures in the routine performance of the process, issue addressed through the designers' sense making and reflection-on the medium and on its use in the ongoing cycle of reflecting and doing, discovering and shaping the design .

Orienting to the technology

This theme of the video-based study focussed on how the participants organize the design review in the CAVE to address the technical specificities of the particular setting, in terms of issues such as orientation, navigation, perspective. Examining how the participants orient to the technology, the study of the video data noted that the designers perceived the ways of interacting with the IVRE as unexpected and needing a prior familiarisation with the CAVE. Among other instances to illustrate aspects of gradually making sense of the technology, episodes of stepping into walls are an example on the designers' initial stage of confusion when they were first getting immersed in the IVRE. This was found as subsequently addressed through processes of familiarising with the elements of surprise and making sense of the environment by learning to orient to the two types of spaces- the virtual space of the 3D model, and the more restrained physical space of the 3m squared CAVE. Reflecting on their experience of first encountering the CAVE technology, the participants commented:

"(...) it threw me a little bit that I just envisaged it would be enclosed and in my mind that would have been better. And looking at the video there, it just brought back some memories in the context of just the initial orientation. So you've got the goggles on and your field of vision, clearly looking at this, is quite narrow. Then you have a cable slightly in the way so I suppose you're a little hindered by the physical and the practicality of the technology that you're working with. And I recall someone else actually walking into the wall but that to me is a fantastic indication of how realistic it is... but I recall in a single room there that I stepped right up at one point to a wash hand basin and all the taps were modelled so you can literally put your hands out and see where that basin is. So for me I was blown away with it, I thought it was a fantastic way in which we can use technology to really convey a sense of space."

(Project Director)

Similarly, the Lead Medical Planner' reflection on the experience in the CAVE points firstly the perception of the environment as surprising in terms of not conforming with

the usual ways of interacting within a design sessions: *“it’s hard to understand what was happening when you first go in”*; *“it was exciting but it was a bit daunting as well because it’s something new and you’re kind of, have an expectation”*. Orienting to the ‘new’ technology involved noticing constraints—such as the goggles, the limited field of view, the cable attached to the head tracker device, or issues of feeling unsafe, but also making sense of the advantages brought by the CAVE. Among the perceived advantages, the designers mention the usefulness of enabling immersion in the designed spaces, providing a sense of being in the model and a compelling real like perception of the virtual design. Secondly, discussing retrospectively with the participants reveals insights into their processes of addressing the unexpectedness of the situation, responding to the surprise brought by the new technology different from their routine procedures through reflecting-in-action, which is of making sense of and familiarising with the IVRE, learning how to use it in order to perform the review sessions: *“(…) walking into the screens (…) I managed not to be able to do that. I think I realised quite quickly where the boundaries were”* (Lead Medical Planner).

The participants’ retrospective insights reveal their recognition of the analytical theme and expose their reflection on the use of the CAVE and on their processes of responding to the particularities of the technology, familiarising with it through their reflection-in-action in the situation of reviewing the design in the IVRE. Moreover, as inferred from the designers’ comments, showing them video clips from the CAVE sessions helped refreshing their memory of the previously accomplished processes and supported their retrospective reflection on the events (e.g. *“looking at the video there, it just brought back some memories”*; *“I recall”*; *“you’ve reminded me now”*).

Orienting to the design and representing out

Checking the participants’ recognition of the video data based theme concerned with how designers were moving from their understanding and sense making of the model to thinking about representing it out for showing the design to the client, the designers were shown a 20seconds recording when they were reviewing the operating theatre in the virtual design of the hospital. Their reflection on the use of the CAVE and on how the design review in the IVRE impacted on the process of representing the design for the client notes that the CAVE experience generated changes to the representation, oriented to address the concern with the client’s perception of the design.

“It was hugely beneficial because it allowed us to be able to make changes to it. When a client looks at something, that was incredibly cluttered that room, it had a lot of stuff in it. We had shown everything in there and we didn’t need to show everything and that was a mistake. (…) So it was to sell the size of the room to the end users.”

The designer’s reflection on the use of the CAVE for representing out the design indicates a role of the IVRE as commercial tool through mediating decisions regarding the way of presenting the model for the client from the concern of ‘selling the size of the rooms’. This points the advantage of the CAVE simulation by mediating the designers to evaluate the consequences of previous design intentions, appreciated as unsatisfactory- *“it was a mistake”*-leading to reconsidering the situation. The excerpt from the retrospective discussion with the participant reveals a sample of the designer’s reflection back on the thinking and doing involved in the processes within the CAVE through indicating the way in which her sense making of the design and the process of shaping it (intention, representation, evaluation, and re-appreciation) entangled in the CAVE experience. Also, beyond the representational level, the designer’s retrospective reflection suggests the effect of using the CAVE in the review

on deciding changes to the design, by supporting the design and contractor teams together with the client to reconsider the equipment needed in the operating theatre. The designer's insights indicate the role of the CAVE to mediate collaboratively reshaping the design decisions through engaging with client in the IVRE.

“So we had the benefit of being able to convince them that the space was acceptable. We would have had that meeting anyway regardless of whether we'd been in the CAVE. But what the CAVE allowed us to do was actually say, there is too much stuff in here for you to move around. How do you even work in this space? [an operating theatre]... So it was good for us to be able to say to them, we think there's a problem with the size of this room even though it's massive that you've got too much equipment in here.” (Lead Medical Planner)

The designer's reflection on experiencing the simulation of the operating theatre in the CAVE revealed first that although the design of the room was of big size, it seemed overcrowded when bringing all the equipment; and second, it allowed the designers to reflect on the need of equipment in the actual use of the theatre and to question and discuss it with the client. Consequently, reflecting on the requirement, the client confirmed that not all the equipment will be actually needed in the room at the same time and hence the size of the room was considered as satisfactory.

Summing, the participants recognized the research themes drawn on the video study. The designers' retrospective insights are a sample of their reflection -on their experience in the immersive environment and -on the particular medium, and point the use of the CAVE as a convincing representation, as well as supporting discussing and negotiating the design requirements with the client.

Theme II: Reflecting on the CAVE experience and on the use of the medium

This theme focusses on the participants' reflection-on their past accomplished process of reviewing the design in the CAVE and -on the use of the immersive technology for performing design activities. The designers' retrospective thinking about the CAVE experience infers an overall usefulness of the technology through enhancing the spatial understanding, either by confirming expectations or enabling noticing clashing issues and driving changes to the design, or by mediating discussions with the client:

“I think it was very beneficial. It made me realise, you always worry that the space is not big enough, that's the first issue you sometimes have, because we had a real pressure on area for the whole project, and some of the rooms were slightly squeezed down in size but it made me recognise that in fact the rooms were good. They were a good size, they were a good layout, so from that point of view it just reinforced, it validated. It confirmed that we had done the right thing.” (Lead Medical Planner)

The retrospective discussions with the designers around their reflection on the CAVE sessions and on the use of the medium triggered also the reflection on how the immersive experience compares with their existing repertoires of procedures and technologies involved in their mundane practice. As the Project Director comments: *“Where I thought the CAVE came into its own and was really very compelling was in the operating theatre, because you've got a lot of equipment in that space, (...) and the dynamic, three dimensional dynamic of that space changes quite dramatically. And there were certain elements that, even though we'd gone through it really, really very carefully, certain elements just weren't right, and it was only when we were in that environment that we noted they were not right. Could we have done it by other means? Probably. Would it have been as effective? Probably not. Would we have got*

the same kind of feedback from our users? I doubt it.” The Project Director’s reflection on being in the CAVE points how the immersive environment enabled noticing clashing issues regarding the arms of the equipment in the operating theatre of the designed hospital, which could not be perceived using other types of representations and technology. Similarly, reflecting-on what the CAVE brings in the process in addition to other representational ways and technologies, a Visualizer points the enhanced understanding of the relationships between elements, the awareness of the scale of space, and the potential to inform decisions regarding what to emphasise in the representation of the project:

“(...) the CAVE made me aware of what we needed to do. The spaces that you kind of didn’t think about developing actually needed to be developed a bit more in order to understand certain direction points and certain pathways. I think that actually physically being in the space helps you to understand the scale which is important especially when we’re designing. And understanding the scale is something you don’t get from a Revit model. So that was the most important thing in the CAVE for me, it made me understand the hierarchy of the space better.”

Referencing the use of the CAVE as design medium in relation to other less immersive technology (the repertoire of mediums used in the designer’s daily practice) points the influential role of the IVRE to inform and guide further designing. Reflecting back on their experience in the CAVE, the designers identify how reviewing the 3D model in the IVRE contributed to developing the project by enabling noticing issues about the design which had not been perceived using other mediums, fact that consequently lead to changes of the scheme:

“I think it definitely did influence it. How much? We made changes as a result of having experienced the CAVE and that’s perhaps something that wouldn’t have happened had we not had the benefit of being in the CAVE. So my corridor that was a little bit too low and narrow would have stayed a little bit too low and narrow and we wouldn’t have necessarily known.” (Lead Medical Planner)

The designer’s insights note that the CAVE experience brought about changes to the design, drawn on the experience of simulating and reviewing the model in the IVRE, which enabled the designers to ‘see’ issues about the design which had not been previously perceived, such as revealing the unsatisfactory appearance of the *“too low and too narrow corridor”*. With a similar perception around the CAVE experience, another participant’s reflection on the use of the technology points the potential of the immersive medium to enable seeing the things in new ways, reframing the understanding of the model through drawing awareness on different issues, informing the thinking and leading to re-evaluating the design: *“I guess it just gives you a different perspective. So when you have a different perspective on something you think of things in a different way.”* (Visualizer)

The designer’s reflection-on the use of the medium indicates benefits brought by the CAVE in the process in addition to the other representations of the design mediated through non-immersive technologies (on screen or on paper, Revit, 2D or 3D). The participants’ insights refer to perceived advantages of the CAVE such as confirming design expectations, or enabling a different way of making sense of the design by supporting noticing issues not perceived through using other, less immersive mediums, and by stimulating attention to other aspects (e.g. spatial awareness). The participants’ reflection-on their practice in the CAVE is about reflecting retrospectively on the doing and thinking involved in the CAVE, but also about

reflecting on the repertoire of experiences and of mediums, and comparing the design review in the CAVE with doing design routinely, using other types of representations and technology. As the Lead Medical Planner commented:

“It was just much more exciting because you were actually in, you feel like you’re in the space. You can immerse yourself in it much more. Generally, we would look at the 3D perspective and say, yes, that does, we think that does what, you’re never quite sure with a 3D image on paper or on a screen that it’s not slightly exaggerated or that the technology used to spit an image out of the model hasn’t done something to just distort what you think it should look like, whereas being in the space is different.”

Summing, the participants’ retrospective perception of reviewing the design in the IVRE stresses the immersion as distinctive feature of the technology perceived as bringing advantages in the process as compared to their existing repertoires of less immersive materials and procedures. Reflecting on the experience in the CAVE, the designers note the role of the immersive medium in the process, not only within the local situation of reviewing the model but also through guiding the subsequent adjustments and changes made to the design in terms of scheme, representation and even at requirements’ level in consequence to performing design in the IVRE.

Theme III: Reflecting on the use of the CAVE in the broader design practice

This theme addresses the interest about the participants’ perception around using the CAVE in the broader design practice and the potential to complement other less immersive design procedures and technologies. Invited to reflect on the potential connection of using this technology with other usual ways of doing design, and to express their view on the utility of the CAVE, the Medical Planner commented:

“I think it would be hugely beneficial to be able to use it on a daily basis if you would need not have to do that level of pre preparation. So if it’s getting easier to actually put what we develop naturally as architects into the format that we could just put on the goggles and walk into it without having to do anything extra to it, I think it would be hugely beneficial. I loved it. I thought it was brilliant and helpful on so many levels.”

The designer’s reflection suggests the envisaged use of the IVRE in a complex of situations of practice, through enabling checking the design and the atmosphere inside as well as outside the 3D building before it is actually built, and not only during later review, but also in earlier phases of conceptual design. The participants’ reflection on the potential use of the CAVE as design medium in the context of the broader practice indicates a range of possible advantages brought by complementing the daily design procedures with designing in the IVRE. As perceived by the participants, if certain constraints would be mitigated through the development of the technology (e.g. issues regarding the time for travelling to a CAVE set up in a university, or the conversion between various versions of the digital model), the CAVE might usefully complement the practice and support performing activities in a variety of stages in the process.

On the same argument around the usefulness of the CAVE as design medium in relation to the broader set of activities and processes involved in the practice, the Project Director draws the focus on the advantages brought by the IVRE through supporting aspects of social interaction as a “*very, very powerful*” tool. In this sense, it is pointed the benefit of the CAVE to mediate collaborative designing through supporting ‘reciprocal reflection-in-action’ (Schon 1983) among multiple participants involved in a project during exploring, understanding and refining a design. Moreover,

the Project Director's reflection-on the use of the medium indicates possible adjustments to the technicalities of the CAVE to improve the team group experience of exploring a virtual model. In this sense it is suggested the provision with an 'endless floor' as solution for enabling real like walking in large areas of a virtual building without being constrained by the physical boundaries of a 3 meters square environment:

"Let's just assume we've been in the CAVE for 15 times, that newness is of (...) Wow, that would be really powerful, because we all see things in a drawn way or even a model way in a slightly different way, I think, so having the benefit of a group discussion around things. Or if you took my example of the endless floor, and you were walking through that space with a nurse and you were just saying, OK we're going to go to that inpatient room. And the nurse is saying, well that seems like a long way from a scrub or from a dirty or a clean utility, or if it's like this I've got to go back six or seven times. But you wouldn't have that opportunity if you were doing it on your own. I mean if you had that very focused social interaction, (...) it's just you walk through a space and people offer observations about, that's not right or this could be better or there's an issue here. So that would be very powerful." (Project Director)

The participant's reflection on the future use of the CAVE as design medium within the broader practice points that in further situations when the immersive technology would no longer be perceived as a novelty or as surprising, with elements that could interrupt the routine performance of design activities, the IVRE might enhance the development of the process. Subsequently to the designers' familiarisation with the CAVE, the processes of thinking and doing involved in their accomplishment of the practice might be better supported by the immersive environment with regard to issues of noticing things about the design (e.g. clashing elements) not perceived from other types of representations, then developing ideas and refining the model collaboratively. The designer's perception on the potential of the CAVE to be used in connection with the mundane design procedures in the broader practice stresses the advantage of the immersive environment to enable developing and establishing shared meanings of evolving design intentions between multiple participants involved in a design project.

Summing, the participants' reflection on the use of the CAVE to complement the broader practice points the envisaged usefulness of enabling simulating activities or experiences such as moving in the designed spaces, and of supporting a collaborative process based on shared understanding. The use of the CAVE is seen as potentially fitting into various stages in process, from developing the concept design though to later phases of design review. Moreover, reflecting back on the CAVE experience and on the use of technology, the designers offered suggestions for the future development of the technology in terms of overcoming the perceived constraints and adjusting the configuration to better support the practicalities of using the CAVE for design work.

CONCLUSIONS

Concluding, the retrospective discussions with the design team members revealed their recognition of the analytical themes drawn from studying the video data around the IVRE design events they had previously attended. Engaging the participants with the research questions, exposing them to the themes and showing them video clips triggered their reflection-on the processes involved in the design situation of reviewing the hospital project in the CAVE. The designers' reflection revealed how the experience in the immersive environment affected their further process of

developing the project outside the CAVE. In Schon's vocabulary, this points how the designers' appreciations are being shaped through their reflection-in-action within the ongoing performance of design review in the CAVE, and their repertoires of knowledge, understandings, of mediums and procedures become enriched through the design experience in the immersive environment. Also, through bringing the designers awareness of their understandings that underlined their past actions through encouraging their retrospective reflection on the previously accomplished design episodes, these are contributing through informing their further practice in future design situations. Moreover, the retrospective reflection-on how they had performed design review activities in the CAVE and their reflection-on the use of the CAVE as design medium revealed how the use of the technology and the process of performing the design cannot be separated and bound up together in accomplishing the practice. Insights of this study are envisaged to enhance understanding and support integrating the practical consequences of using CAVEs in design activities, and also to potentially inform the development of technology from the practice perspective.

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THE USE OF EVIDENCE BASED DESIGN IN NHS CONSTRUCTION

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Evidence Based Design (EBD) is a process that bases design decisions on credible research and data to produce the best possible environments and outcomes. This process is most effective in hospital design where it can improve patient and staff outcomes and save the organisation money over time. Information regarding the processes and benefits of EBD is readily available, but there is a lack of knowledge on whether it is actually being implemented in the NHS. This paper explores the use of EBD in NHS construction and seeks to determine whether the value adding opportunities it offers are being utilised. An examination of the relevant literature revealed the processes of EBD, the contrasts to traditional hospital design and the barriers to its implementation. These primary themes were further explored through interviews with NHS professionals, researchers and designers, and the use of EBD was investigated via a nationwide survey of architects. The findings show that NHS Trusts have little awareness of the importance of the built environment in hospitals and are sceptical towards the value that EBD offers. This, along with the higher cost of EBD and the current economic climate, contributes to the use of EBD being relatively rare within the NHS, especially on smaller scale construction projects. With a predicted shift away from large hospital projects, the future of EBD in the NHS looks bleak, and therefore this research raises the question of whether the NHS is really striving to get the best value from its construction projects.

Keywords: briefing, design management, evidence based design, procurement.

INTRODUCTION

“Patients with access to daylight and external views require less medication and recover faster”. (Royal Institute of British Architects 2011)

Research studies undertaken over the past 30 years have shown the extent to which the built environment can impact the outcomes of its occupants (see, for example Ulrich *et al* 2008), and more so in healthcare facilities than in any other setting, where patient wellbeing and staff effectiveness can be enhanced (Kroll 2005). The process of converting scientific research into the design of a facility is called Evidence Based Design (EBD). As well as improving patient and staff outcomes, EBD has been proven to have a beneficial effect on business performance, with vast potential monetary gains linked to improvements in patient stay times, medical errors and staff absenteeism (Ulrich *et al* 2008). With NHS Trust budgets being reduced in recent years (HM Treasury 2012), EBD has the potential to offer long-term efficiencies.

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This study reveals that whilst there is a plethora of information on design research studies (see, for example Ulrich *et al* 2008) as well as the process, benefits and barriers to EBD from institutions including the Health and Care Infrastructure Research and Innovations Centre (HaCIRIC) and the Department of Health (DOH), there is lack of literature addressing the extent of EBD adoption within the healthcare sector in the UK. The only institution that has researched the adoption of EBD in healthcare specifically is the US Centre of Health Design (CHD) and whilst leading the way globally on the issue, sheds little light on the situation in the UK.

This research study aims to investigate the current use of EBD within the NHS to determine whether the value-adding opportunities it offers are being harnessed in public health sector projects. To achieve this aim, the research will explore the EBD process, evaluate its potential benefits and assess the awareness of EBD, as well as appreciation of design generally, with NHS professional and designers. The extent to which EBD is used on NHS projects will be evaluated, with special consideration given to the project's size. Finally, working from a speculative hypothesis that EBD is not widely used within the UK, the barriers to its implementation will be examined and discussed.

RESEARCH BACKGROUND

Design and Construction of Healthcare Facilities

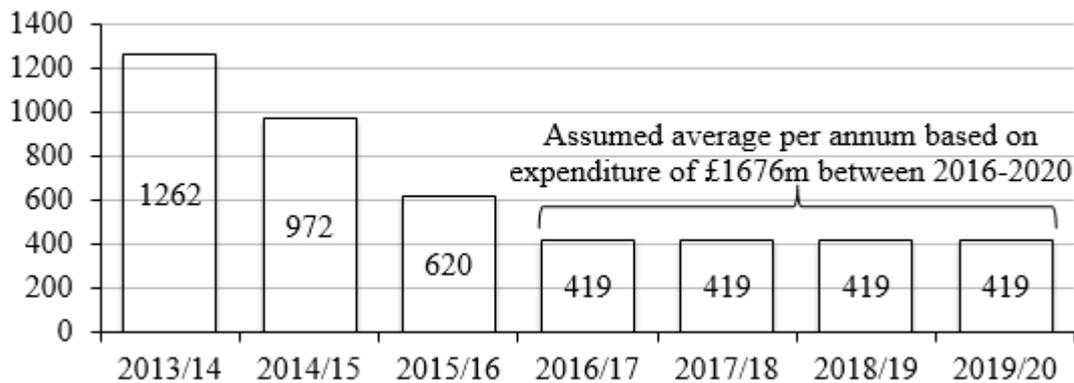
According to HaCIRIC (2009) and Ulrich (2000) decisions regarding healthcare design are often made with little consideration of their potential impact on building performance, occupancy and patients. One possible explanation for this is that until relatively recently the evidence of environmental impact on occupants was somewhat anecdotal in nature. This was until 1984 when Dr. Roger Ulrich carried out a seminal study that scientifically proved the physical environment could help or hinder patients recovery (Zimmerman 2009) and led to the emergence of the field now known as Evidence Based Design (EBD).

CHD (2010) define EBD as “*basing design decisions on credible research and data to produce the best possible environments and outcomes*” and many believe that the implications of EBD are more acute in healthcare facilities than any other type of building (Kroll 2005). Ulrich *et al* (2008) carried out an extensive review of evidence based research in hospital design and organised the potential areas of improvement into three categories; patient safety, other patient outcomes and staff outcomes. The first category includes reducing hospital acquired infections, medical errors and patient trips, slips and falls. The second includes reducing the requirement for drugs, reducing patient stay time and improving the overall patient satisfaction. The last category includes reducing staff absenteeism and turnover. These factors combined currently cost the NHS billions of pounds each year (Patient Safety Agency 2007/2013; Association of the British Pharmaceutical Industry 2012; Deltex Medical Group 2013; NHS 2009) so improving them could provide the NHS with significant cost savings. This concept was put to the test by Berry *et al* (2004) who carried out ‘The Fable Hospital’ study. This estimated that implementing EBD in a fictitious healthcare facility would add £7.8m to the construction cost, but result in an annual operational saving of £1.6m. With a payback period of 5 years, this example makes a strong business case for the use of EBD.

Hoover *et al* (2006) explain that, unlike a traditional healthcare project brief which would usually comprise of a functional list of physical and spatial requirements, EBD

adds a set of results-oriented objectives, such as reducing hospital acquired infections. Once these objectives have been set, EBD follows a four stage process, starting off with rigorous evidence acquisition, followed by design hypothesis development, which is when the collated research is implemented in the design (Hamilton *et al* 2009). Post Occupancy Assessments (POAs) then takes place to see whether the outputs delivered match the hypothesis, before finally reporting and publishing the findings. These stages all require commitment and crucially, sufficient resources invested in them. However, with Government expenditure on healthcare construction expected to steadily reduce until 2020 (HM Treasury 2012) as illustrated by Figure 1, AMA Research (2012) and Kappa Consulting (2011) predict that NHS Trusts consider smaller refurbishment schemes rather than larger projects in the future.

Figure 1: Government expenditure on healthcare projects (£m). Source: HM Treasury 2012)



Despite the decreasing budgets, the NHS Business Case Approvals Process (2013) states that despite the “*already stretched and finite resources for investment... the NHS is committed to providing best value for taxpayers’ money*”, which includes taking into account lifecycle costing as well as initial Capital Investment.

Current Use of EBD in Healthcare

Two surveys commissioned by CHD in 2009 and 2010 indicated that whilst the use and acceptance of EBD has grown over recent years, it is unknown how this knowledge is being translated into the design of new healthcare facilities. Whilst the findings indicated that 71% of respondents ‘sometimes’ or ‘regularly’ used EBD, this may not be a true representation of the industry, as the survey sample was “*heavily weighted towards those already familiar with the work of the CHD*” (CHD 2010). Also, whilst the surveys were intended to be international, over 85% of the respondents were from the USA or Canada, and only 1.8% from the UK. CHD also collate and document examples of EBD in use, via their ‘pebble project’ which invites members to submit projects. Of a total of 37 collated projects, only one is in the UK compared to 31 in the USA (CHD 2013). This implies that either EBD is not as widely used outside of the USA, or that other countries are not as aware of this CHD initiative, which is likely considering that less than 10% of its members are from outside the USA (CHD 2014). It is noteworthy that all 37 examples of facilities using EBD are new build hospitals, implying that the use of EBD on refurbishment projects is non-existent. Anecdotal reports support the opinion that EBD use is still in its infancy, with Stall (2012) referring to it as “*embryonic in practice*” and Goodman stating that “*we’ve only scratched the surface with healthcare providers to actually practice evidence-based design*” (see Stall 2012).

Barriers to EBD Use in Healthcare

There is doubt over the reliability of research evidence used in EBD and Kroll (2005) states that much of it transpires to be more anecdotal than scientific. Ulrich *et al* (2008) explain that this is partly due to the complex nature of hospital environments, making it impossible to isolate the effect of one particular environmental change. Doubts have also been cast over the accuracy of measuring outcomes when they relate to people, as they can be difficult to quantify (HaCIRIC 2008) and are subject to variables such as age, gender and illness (Codinhoto *et al* 2010).

Another hurdle for EBD is investigating the design research. Sailer (see Brooks 2012) warns that scientific research may not be understandable to average designers and Kastner (see Kroll 2005) agrees, stating that their lack of experience may present an obstacle. It doesn't help that the research, often presented in the form of academic papers, is rarely user-friendly and tends to be full of academic jargon (Brooks 2012).

Sailer (see Brooks 2012) highlights the difficulty in persuading clients on a tight budget and timescale to carry out an EBD process. Nussbaumer (see Whitemyer p12) concurs, stating that clients often cannot afford pre-design research. In addition, EBD often leads to a higher capital cost and as such requires a longer term view towards potential operational savings, rather than short term cost (Kroll 2005).

Summary of Research Background

EBD differs from traditional hospital design, partly by its outcome driven nature and by the four stage process it follows. It appears that the use of EBD is not widespread in the UK and possible reasons for this are the difficulty of carrying out the research process as well as the cost and time associated to it. The literature surrounding the current use of EBD, however, is limited and centered largely in the USA.

METHODOLOGY

Theoretical Perspective

Epistemology is principally concerned with the theories of knowledge (Knight and Ruddock 2008). This study is based on a Constructivist epistemological approach, which is the view that all knowledge and meaning is derived from human practices and interaction (Crotty 1998). This concept of knowledge and meaning existing within a social context has clear links to an ontological perspective that Bryman and Bell (see Knight and Ruddock, p7) describe as the world being formed of social constructions built up from the actions and perspectives of the people in it. As such, in order to gain understanding, an Interpretivist approach is needed where the researcher places themselves in the research and makes subconscious judgements based on past experiences and values (Strauss *et al* 2008).

This research study began with the tentative hypothesis that EBD was not widely used in the UK and from this point an exploratory study, using a primarily qualitative research approach, took place in an attempt to formulate a theory. This process followed one particular Inductive approach called Grounded Theory; where theory is seen as growing out of data rather than starting from a specific hypothesis (Costley *et al* 2010). This study loosely followed a Corbin and Strauss form of Grounded Theory, which contains more specific research techniques and procedures than the original Strauss and Glazer approach. Due to the initial tentative hypothesis however, this study can be considered to follow a modified Grounded Theory approach.

Quantitative research techniques were utilised in order to triangulate the data to ensure that a robust argument and theory was formed.

Methods

A literature review was undertaken initially to identify the key areas of relevance. The themes that developed focussed the study in the data collection stage and the review continued concurrently with other data collection so that concepts were constantly updated and compared between sources.

A theoretical sampling approach was taken during the research, allowing emerging concepts to be followed that are not predetermined (Strauss *et al* 2008). The resulting final sample of interviewees included:

- Three Members of NHS Management
- One academic researcher specialising in healthcare design
- One DOH executive, but not in an official capacity
- Three architects involved in healthcare design

The significant amount of data gathered from the interviews was analysed by ‘coding’ following the format set by Corbin and Strauss (2008), which splits data into higher-level categories and lower level concepts. Memo writing, a specialised type of written record that contains the products of analysis and captures the evolving thoughts of the researcher (Strauss *et al* 2008), was utilised alongside this process.

A survey sought to verify or dispute concepts derived from the interview process by using a larger sample. This took the form of an online questionnaire sent to architects on the RIBA Chartered Practice Register (healthcare projects), the Procure 21 framework, and the ‘Architects for Health’ register. In total, an invitation to complete the online survey was emailed to 1150 individuals and practices. From the sample, 63 responses were logged and confirmed to be valid, and went on to be analysed. The inferential statistics Chi-squared (X^2) method was used to analyse the survey data, which was deemed appropriate due to the relatively large sample and because the data is nominal. Other elements of the survey were analysed and referred to via a descriptive statistics method.

RESULTS

Current Use of EBD

The literature highlighted that the use of EBD in the UK and in refurbishments is limited (Stall 2012; CHD 2010). The survey showed that 84% of respondents have used traditional design guidance on hospital projects, compared to 37% of respondents who have used EBD, illustrating that traditional design tools are much more common method of informing design and that the majority of healthcare designers are not using EBD at this time.

A tentative hypothesis at the beginning of this research was that EBD is not used as widely on smaller hospital projects as it is on larger ones. Using Chi-Squared analysis, table 1 shows that the frequency (O) of large projects (over £20m in value) that are subject to EBD (box 5) was significantly higher than expected, whereas small projects (less than £1m in value) was much lower than expected (box 1). The adverse was true when examining projects that have not used EBD. The calculated X^2 falls higher than $P = 0.001$ meaning that there is less than 0.1% probability that these results would occur by chance.

Table 1: Contingency Table Between EBD use and Project Size

	EBD has been used		EBD has not been used		
Small project	1	O = 10 E=20.7	2	O = 48 E=37.3	58
Medium project	3	O = 20 E=17.1	4	O = 28 E= 30.9	48
Large project	5	O = 16 E=8.2	6	O = 7 E=14.8	23
	46		83		129

O = Actual occurrence

E = Expected occurrence

It is interesting to note that of the 10 cases of small projects using EBD, seven of these were carried out by architects who have also carried out projects of £20m or more, suggesting that architects who have implemented EBD on large projects have then decided to apply it to their smaller projects. There were only two cases of architects carrying out EBD who worked solely on small value projects.

The significance of these results is revealed when viewed in the wider context of construction in the NHS. The literature states that due to Government budget cuts the number of large scale projects is likely to drop and be replaced by more refurbishment work of a smaller nature (Kappa Consulting 2011; AMA research 2012) which suggests that the use of EBD will decline as a result.

Barriers to Use of EBD

Lack of Awareness

Fundamental to EBD is the belief that the built environment can have an impact on the wellbeing of its occupants. Interviews with NHS professionals showed that there was some knowledge of this concept, albeit not an in-depth one. The academic researcher believed that “people don’t think that the environment is important”, which reflects a frustration that was found amongst all the interviewees who were advocates of EBD. There was speculation that this could be because those managing projects have little experience or training in design and therefore do not realise its importance. Associated with this finding, there was a distinct lack of awareness of EBD, specifically within NHS Trusts. The architects were more aware of EBD, but one stated that “there are many architects who aren’t aware of the research out there”, which appeared to be the case with one of the architects interviewed.

The study found that the extent of awareness amongst architects of EBD seemed to have a relationship with the size of projects worked on, with 75% of respondents who had only worked on projects under £1m being aware of it, compared to 91% of respondents who had worked on projects with a budget of over £20m. A possible explanation for this is that DOH funded capital projects over a value of £20m are required to undergo an NHS design review, and this more in-depth consideration of design is conducive to an EBD approach. Another possible explanation is that larger projects are more likely to have the resource to facilitate an EBD approach.

Lack of Client Support

It is significant that this study found that support of EBD within NHS Trusts is relatively rare. The academic researcher expressed that there was “*no will to build the Fable Hospital*” in this country because of the attitudes of the NHS Trusts, who are rigid in their ideas, closed to new methods and too focussed on the initial cost of implementing EBD and not enough on the long-term gain. Also attributed to the lack of client support was “*the constant NHS capacity pressure*”, as described by one of the interviewees. All of the NHS staff interviewed noted that patient throughput and number of beds tend to take priority over the nature of the environment, noting that “*The clinical need will always override the environment*”. One NHS manager had seen an example of where views of outside from patient bedrooms were obstructed by a development to increase additional capacity. These issues indicate a lack of desire by NHS Trusts to invest in good design practice, both because they do not believe in the benefits that it can create and also because they are prioritising other factors such as capacity ahead of the environment.

The Nature of The Evidence

A limitation of EBD is that it relies on research that is often considered anecdotal rather than scientific. Scepticism towards EBD from the NHS Managers centred on the difficulty of quantifying the benefits that it brings, particularly when you are referring to factors relating to patient wellbeing and stress. It is likely that this opinion is be echoed by clinicians who are used to dealing with robust scientific evidence. Even when there are measurable improvements to outcomes, the question of how they can be attributed to a particular design element was raised. For example, one NHS Manager stated that patient stay length has been decreasing steadily over recent years, so if an open ward was changed to single rooms and the length of stay reduced, you could not know that it was as a result of this change rather than the trend that would have occurred anyway. The academic researcher admitted that this was an impossible task since it requires a completely controlled environment, which a hospital can never be. These issues were highlighted by Codinhoto *et al* (2010) and Ulrich *et al* (2008) and have proven to be a significant barrier to EBD.

The Process of EBD

A prominent barrier that emerged when discussing EBD was the cost and time of carrying out the research stage. This was raised by Sailer (see Brooks 2012) and Nussbaumer (see Whitemyer, p12) as a potential issue and was highlighted by the architects and academic researcher as well. This stage of the EBD process was described as “*time consuming*” and “*laborious*” and in a world of competitive tendering for architectural services, the fees associated with carrying out this process can make it unappealing to NHS clients. The length of time to carry out the research stage on hospital projects is also deterring NHS Trusts from using it.

The issues of quality and accessibility of research was also raised, with one interviewee referring to many of the research papers as “*rubbish*”, which made the process of finding the relevant evidence difficult and time consuming. Some spoke of the difficulties in retrieving information, as research is often “*buried in journals*” which not all architects have access to. This corresponds with the findings of Sailer (see Brooks 2012), Kastner (see Kroll 2005) and Brooks (2012) in who raised the difficulty of the research process as a barrier to its use. The CHD database attempts to overcome these barriers by collating credible research studies, but it would appear from the findings that this is not well-known or used by UK architects.

Many felt that there was a reluctance to carry out Post Occupancy Assessments with any degree of rigour, largely because there are rarely fees allocated to this stage and there was also mention of the difficulty in accessing the areas and staff in order to be able to carry them out. POAs are an essential part of EBD as it establishes if the design hypothesis has been proved true, and will enable the expansion of knowledge for future design research, which is integral to EBD. Therefore the lack of enthusiasm for undertaking them is another barrier to the implementation of EBD.

Economic Climate

The current financial state of the NHS and the impact this is having on capital projects was highlighted as a problem by most of the interviewees. With many NHS Trusts expected to make savings, all spending is being heavily scrutinised and anything conceived as unnecessary is being scrapped. This can present a conflict for NHS Managers, who often recognise that there are long term cost saving initiatives to be utilised from capital projects, but have no capital to invest in them at the moment. The extreme pressure of the current financial situation for many NHS Trusts therefore means that investment in using an EBD approach is unlikely, and the slow economic recovery means it is difficult to know when that situation might improve.

Poor Planning

EBD is based on the concept of using design as a tool for achieving long-term outcome improvements and efficiency savings. For this approach to be adopted it requires the client to have a long-term plan for their business. All of the NHS managers felt that there was a lack of leadership from central government regarding the long-term building programme for the NHS, and that healthcare was used as a tool for the short-term gain of political parties, with one stating *“because there’s no long term planning, it’s very knee jerk...that’s from the government, that’s lack of leadership”*. The lack of long term planning may stem from the regular shifts in power of political parties, leading the priorities and objectives for healthcare to change frequently and the decisions of previous governments to be altered. The academic researcher was concerned that politicians do not realise that current hospital projects are built for 10–20 years in the future and that waiting until that time to act will result in the current hospitals being unable to cope with advancing medical processes. The lack of strategic planning and the fast track approach to building is not conducive to an EBD approach as it does not allow sufficient time in the process for it to take place.

CONCLUSION

The aim of this research study was to investigate the current use of EBD in the NHS to determine whether the value adding opportunities it offers are being harnessed in public health sector projects. The EBD process has been explored via the use of interviews with people who have researched it, used it or have either been unable to, or chosen not to, use it. The benefits it can offer have been evaluated and it is apparent that EBD can provide significant advantages over traditional hospital design. When taken in context with some of the problems that the NHS encounters surrounding patient and staff safety there is potential for significant wellbeing and financial improvements for the NHS by implementing EBD in their capital projects.

However, the results of this study suggest that EBD is not widely used in the NHS, particularly in smaller construction projects. Barriers to its use that have been explored included a lack of awareness and client support, the expense and time of undertaking it, the current economic climate and poor planning, all of which account for its low level of use. Most of the barriers to EBD stem from the attitudes of the

NHS towards it and the lack of recognition of the importance of design and the environment. Attitudes are often deep rooted and difficult to change, which casts doubts over the future for EBD in NHS construction.

The original hypothesis that EBD is not widely used in the NHS has been supported and it can therefore be concluded that the NHS is not fully reaping the potential benefits that EBD can offer. These benefits relate not only to patient and staff wellbeing, but to long-term financial gains also. The apparent dismissal of the Fable Hospital model implies that the NHS is not seeking the best value for money in accordance with its own Business Case Planning Process. As such, the topic of life cycle costing in NHS construction is one which would benefit from further research.

It is recommended that steps be put in place to help facilitate the use of EBD within the NHS on all, or at least most, of their construction projects. Central government have a key role to play in this initiative, by ensuring that investment is put in place for its delivery, and that training and education for NHS Trusts is not only available, but actively encouraged. Undertaking trial EBD projects and using these as educational resources for NHS Trusts would raise awareness amongst NHS Managers of the potential impact and importance of design. Changing attitudes to healthcare design is essential for the success of EBD in the UK, and this will only be achieved through long-term buy in and commitment from all parties involved in NHS Construction.

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FROM PEDAGOGICAL IDEAS TO A SCHOOL BUILDING: ANALYSIS OF USER INVOLVEMENT IN BUILDING DESIGN

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This study explores a school building design project, which was carried out in collaboration between school staff and students, architects, design engineers and other design experts. This study aims to expand the focus from regarding the users as information briefers in early design phases to cover a long-term user involvement in building design. The research data cover a period of four years. The data include formal documents of the project; interviews of the users, architects and representatives of the client; recordings of twenty design meetings (design team meetings, meetings between users, between users, architects and designers), and design documents produced by the designers and the school users. The results help to interpret the design process as co-design, which expands the users' initially abstract and hidden user needs to visible models and designs. The collaboration requires merging of the users' conceptual tools and the designers' concrete drawings and specifications, the structuring of several co-design forums, coordination by the head-user and specific user groups, and tools for individual working and responsibilities. The results can be used to illuminate and to plan user involvement as a heterogeneous and long-term building design activity.

Keywords: building design, co-design, design tool, user-centred design.

INTRODUCTION

Literature on the user-centred design emphasizes users as a vital source of knowledge and experience for the designer to capture relevant features for the product. A perspective left to lesser consideration concerns user involvement in the course of a long-term, multiform activity between the designers and the users. This study explores a school building design project involving school staff and students, architects, design engineers and other design experts. The project concerns the design of a school for children with hearing and visual impairments, which required a large variety of user knowledge and future-oriented suggestions. As a result of the analysis, a trajectory of collaborative design between the users and designers is presented. This concerns the main phases of the four-year trajectory, and the forums and the tools of collaboration.

FRAMEWORK FOR STUDYING USER INVOLVEMENT IN BUILDING DESIGN

The interest in user participation in design originates in the studies of developing and implementing information systems at the beginning of the 1960s. In general, a better product quality, meaningful uses of products and user satisfaction have been taken up as positive outcomes of user participation. In particular, in the areas where

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technologies mature quickly, designers are turning to the users. User participation has been suggested to be most efficient and influential in the early stages of system development as the costs involved in making changes increase during system development (cf. Ehrlich & Rohn 1994, Noyes *et al.* 1996). Early stage user involvement refers to the actions of ‘briefing what the user needs’ (Barrett & Stanley 1999; Barret *et al.* 2004; Luck 2003) by asking the users to express ideas and opinions or test single products. After gathering user information, it is the architect’s responsibility to create the design concepts and the carry out the design.

Users have also been involved as full design participants in complex services, product families or processes. This study follows the line of Sanders and Stappers (2008) according to which the evolution of the user-centred and participatory design leads to the users becoming partners in co-design, which covers the entire span of the design process. On this basis, user involvement can be characterized as a continuum from informative to the consultative and participative (Damodaran 1996). The results of the studies under the spectrum of user-centred activity, participatory design, co-design or co-creation, all of which have been conducted in the fields of information technology design, systems design, environmental psychology, or facility management, can be used in construction research. In the field of participatory school design, there is a collection of valuable studies, such as the workings of Dudek (2000) and Parnell (2011).

Discussion on user needs prompts refocusing the needs as pre-existing. What if the needs are to be created? Where are they created, by whom, and how do they become design decisions? Joshi and Sharma (2004) suggest that customer preferences evolve in the process of engaging in the concepts, they do not pre-exist. Accordingly, Franke *et al* (2006) distinguish between innovating and non-innovating customers. McDonnell and Lloyd (2014) in their study on the design of a building concept illustrate the importance of the (spoken) articulation of the shared experiences of places and buildings between the users and the architects. Collinge and Harty (2013) underline the role of design artefacts between the users and designers.

The user participation can be approached also from the point of view of potential pitfalls of the design. Much of the users’ relevant knowledge may be related to experiences, routines and complex environments, which are so obvious or unconscious that the users are unable to explicate them (Leonard 2002). As a consequent, it may become difficult for the designers to concretize the users’ unarticulated practices and needs in their product designs. The user-related problems may lead to overly prolonged or delayed decisions, to difficulties arising from the tendency of sticking to the old or existing solutions, to hold-ups in the process due to rivalling user perspectives, or to prolonged efforts of satisfying all stakeholders wishes. This highlights the importance of coordinative design means and tools, which keep the users’ and building design experts’ knowledge and requirements as a coherent package.

METHODS

Research aim, research questions and methodology

The aim of this study is to analyse the co-design of a school building, involving the users’ attempts to develop their work activities and to design a new school building together with the design experts, whose aim is to produce a safe, user-friendly and cost-efficient building. The analysis expands the focus from regarding the users as

information briefers in early design phases to cover user participation as a long-term and multiprofessional co-design, in which the social and material elements merge. The study sets out to answer the following questions:

What were the main phases of the collaborative design trajectory?

What were the collaborative forums and tools between users and designers?

The methodology must be in line with the aim. In this study, practice-based approach (Miettinen & al. 2009) and cultural-historical activity theory (Engeström 1999) are applied. The activity theoretical framework is used because it seeks to explain the complexity of social and material elements in a given activity, rooted in a longer, historical continuum. Lauche (2005) and Tarbox (2006) subscribe the use of activity theory for studying a design process due to its capability of describing and contextualizing the development of the design practices. Illustrations of the use of practice-based approach and activity theory to study design activities arise from user-innovation in sports industry development (Hyysalo 2009), high-tech development in producer-user network (Miettinen & Hasu 2002), IT-development (Kaptelin & Nardi 2007), or graphic designers' tool-mediated activities (Tan 2010).

The unit of analysis is the collaborative design activity that is object-oriented and artefact-mediated. Object-orientedness is a complex term referring to the subject's (organization, group or individual) utter aim or motive of activity in question. Object in this sense is not to be confused with its other meaning referring to an item or piece, such as in object-oriented programming. The attention is on the historically and socially evolving activity, which is mediated by material representations (e.g. artefacts, tools, instruments, or concepts). For example, the subsequent analysis will show how different stakeholders' participation and their objects of activity are connected in the formation of the complex design-concept, which involves the abstract, strategic aims and materially visualized designs solutions. In this sense, the activity theoretical lens helps to understand how the different subjects' (i.e. participants') objects of activity and the uses of tools are intertwined, fluently or with disruptions.

The school community in transition: designing a new building and work practices

The school under study is a Finnish, state-owned special education school providing pre-primary, basic and voluntary additional basic education. The pupils need support due to difficulties related to vision, hearing, language or interaction. The school offers accommodation services. The initial aim to renovate two separate schools due to indoor air problems was changed 2011 by a decision to build one centre for learning and consulting. The planning of the project started in 2011 and the actual design in 2013. The construction started in April 2014 and the new building will be ready for use in 2015. The investment in the school is 39 million euros. The school design for 140 pupils with a variety of special needs and 230 personnel with numerous expertise areas requires multiprofessional design. It involves the school users (students, teachers, administration, parents, rehabilitation and guidance specialists, staff from IT / kitchen / cleaning / maintenance / etc.) and the representatives of the building project (client, architect/s as a main designer, design consultants, and other experts).

The construction project offers an opportunity to explore the users' participation in construction design, which starts before the actual building project and continues as co-design throughout the project. The user has been heavily involved in the design from the very beginning. In parallel with the building design, the school has been

developing foundations for pedagogy and multiprofessional work. The concept called 'spatial concept' has been vital in guiding the school's internal development and connecting it to the building design. A more detailed view of the co-design forums and design tools will be presented in the results section.

Data and analysis

The research data cover a period of four years and include the formal descriptions and documents of the project, interviews with users, architects and representatives of the client, approximately twenty videotaped meetings (design team meetings, meetings between users, meetings between users and architect and designers) and design documents produced by the school users. The data also cover the school's closed Facebook group where hundreds of ideas and questions were raised, and the school intranet for sharing and commenting on the design documents.

The analysis was started by outlining from the data the formal main phases and outcomes of the design process (e.g. project plan including user requirements, design of massing and space models, detail design). In order to trace the activity, three main categories were used: the activity amongst the school users, amongst the designers, and the shared activity between the users and the designers. According to the activities, the participants, forums, the design tools and the outcomes were traced. For example, in an event called 'architects in the user meetings', the architects, the main user and a specific user-group met face-to-face, and the architects' draft and the users' pre-written requirements were presented and discussed, resulting in a new draft as an outcome. According to the findings, a timeline of the trajectory was formulated.

RESULTS

Trajectory, the forums and the tools of the school co-design

In order to answer the research question '*What were the main phases in the collaborative design trajectory?*' the activities of the users and designers were traced. They had visible trajectories of their own. Also the shared activity was traced, which was occurred as presenting, commenting and constructing new decisions and solutions between the users and the designers. As a result of the shared activity, the users' conceptions of the pedagogy and work, and the detailed requirements for the architect, materials, acoustics, lightning and other elements were embedded in the formal designs.

The trajectory of the design activity is presented in Figure 1. From left to right, the three columns present the activities of the project designers, the shared activities between the users and the designers, and the activities of the users. Due to the focus of the present research, the user activities and shared activities are presented in a more detailed manner. The five main phases extending from 2009 to 2014 are presented chronologically on the rows. The titles of the rows represent the researcher's interpretation of the design phases. The main outcomes are marked in grey. For the question '*What were the collaborative forums and tools between users and designers?*' the results are presented along the main design phases.

	Construction project activity	Shared co-design activity	Design activity at the school
National steering / Planning and benchmarking of school concept	2009-2010		2001 Problems with indoor air occur
	2009 Ministry of education and culture: Report of the national needs for special schools	2010 Decision to merge two schools as a "Learning and guidance centre"	2008 Premise: two schools' renovation
	2010 Ministry of education and culture: Decision to start planning		2009 Schools planning to merge
			2010 National & international benchmarking of other schools
			2010 Courses and training of school design
Project plan / Needs analysis +concept formation	2010-2012	2010 User needs analysis, lead by consultant	Core design idea: 'Out from the classrooms' derives from existing practices, visits & national curriculum
	2011 Ministry of education: Decision to build a new school.	Vision of the work environment	
	Investment decision	Ideal spatial model	2012 Benchmarking other schools: discussion and reports of ideas
		2011 Project plan	
		2012 'Spatial concept' of the school design, with interior designer	2012 Knowledge acquired from several special sources
	Bidding and selection of designers	Furniture design to meet the spatial concept, with furniture designer	Sharpening the spatial concept: 'From monastery school to innovative -school'
Space and Layout draft design / Concretising spatial concept	I /2013	Architects presenting drafts of functional space design and massing model to head user	Presenting spatial concept to whole staff and parents
		Knotworking for massing drafts	Building cafes at the school
	Architects: reworked massing drafts	Architects presenting massing model drafts in user meetings	Negotiation on drafts and spatial concept
		Users' comments on massing drafts	Users' working on massing model drafts
		Plan with massing model ready	Students working to design: exhibition 'Lets build the school!'
	Project designers' work	Head user participating to design meetings	Staff acquiring individually knowledge concerning their own space
		Meetings with architects, students and staff	
		Meetings between special design consultants and users	Spatial concept capturing three generic activity spaces throughout the school
			Organizing the work of 13 user groups, from architects' suggestion
	Detailed design / Concretising space solutions	II /2013	Head user participating to design meetings
Project designers' work		Architects visiting and discussing everyday work at the school	
Architects's work		Meetings between user groups and special designers	Spatial concept used to guide design
		Meetings with architects, students and staff	
		Detailed design ready	
	Spatial concept used to guide design	Spatial concept used in intra-school design and development	
Construction / Interior design	2014	Implementation plan for construction ready	User groups working on their special tasks for implementation
	Project designers' work		Students' architecture exhibition 'Lets build the school!'
	Architects's work	Architects in user meetings: interior design	
	5/2014 Construction work starts	Meetings between special design consultants and users	Intra-school work by user groups for interior design
		Interior design with architect plan and 3d model	
	Interior design plans		

Figure 1. Main design phases from the perspectives of the building project organization, the shared co-design and the school user organization

The period during **2009-2010** was the pre-phase for the actual school design, entitled 'National steering' and 'Planning and benchmarking of school concept'. The aspiration to renovate or to build the two schools was brought up in 2001 because of the problems with indoor air quality. In 2008, the premise was to renovate two separate schools, but due to the massive renovation costs, the decision was made to build new schools. According to the national alignments for special education, there was a need for national centres for learning and consulting. Negotiations concerning merging the two schools were sealed by a decision by the Ministry of Education in 2010 to start the planning of the construction. It was followed by an account about

costs, site and the initial user needs. The main design forums and tools emphasized the users' own activity. The first steps of joining the ideas of pedagogy and the school building were fed by benchmarking to more than ten other schools' architecture and activity, and courses/training about school construction. The documents, reports and evaluations of the other schools' solutions were important tools to compare the solutions and to discuss them with the colleagues. It was explicitly decided that the pedagogy would drive the building design, not vice versa. The core pedagogical design ideas derived from the national curriculum, the quality criteria for school buildings, and the schools' own pedagogical ideas, which were crystallized in a phrase 'Moving out of the classroom'. Encouraging the staff to collect and share knowledge from the field generated diverse and multifaceted ideas.

The period 2010-2012, entitled '**Project plan**' and '**Needs analysis & concept formation**' was relevant for the user due to an extensive analysis of the user activities and the requirements for the building. The user analysis, MyWorkPlace-analysis, was a result of observations, interviews, a questionnaire and workshops, and it was conducted by a consultant hired by the client. MyWorkPlace was relevant in including the work practices as part of the school design. User-activating methods were used, which supported the staff themselves to evaluate the needs for the school space in relation to the existing practices. Based on this, the vision of a work environment and the ideal Space model were produced to serve the Project plan, which included the frame for the costs, amount of space and location. In the project meetings, the head user represented the users. In 2011, the Investment decision followed the Project plan.

Teachers and other staff were continuously visiting schools in order to get and share ideas about school architecture in relation to pedagogy. At this time, the ideas for the multiprofessional practices were taken up. The core pedagogical idea was phrased as 'From monastery school to innovative school' (monastery referring to a traditional, teacher-driven activity), which was re-worked as a design concept together with an interior designer and the head users of the school. The concept combining the ideas of a school building, pedagogy and multiprofessional work was generally named a 'spatial concept' and it was visually modelled as four different scenarios. The scenarios visualized the relations between a traditional school building (with separate classrooms with no other shared space) vs. a new school building (with flexible classrooms and open shared space), and traditional teacher-driven pedagogy vs. student-centred, collaborative and action-based learning. Crucially for the latter design activity, the concept involved a classification of the spatial elements to be used across the whole school; 'Spring' (an area for intensive work; a classroom), 'Park' (an area for open work, a shared space) and 'Den' (a small, covered area for quiet work). Whereas the benchmarking supported diversification of the ideas, the user needs analysis and the formation of the spatial concept helped to ground and focus the users' core aims. This knowledge was also used for the Project plan and space programme.

During the first period of 2013, entitled '**Space and layout draft design**' and '**Concretising spatial concept**' the design plans aiming at Functional space design and Space connections design and the drafts for the Massing model were initiated. The designers and the experts responsible for the Project plan were replaced by new ones as a result of bidding. From this on, new architects coordinated the design work. At first, the architects introduced initial models for the Functional space design. According to the architects, this was the first time when the plans became concrete to the user by the means of drafts. Architects and designers worked on the Space model and the drafts of the Massing model but collaboration on this took place between the

architects and the nominated head user of the school. The head user, who worked full time for the project, was responsible for organizing the intra-school design activity and the communication between the users and the architects/designers. The spatial concept was introduced in user meetings as the school's leading design idea and it was discussed by the whole staff. Each staff member was designated to one area of design responsibility. These were 'teaching spaces', 'administration', 'student residence', 'rehabilitation services supporting learning', 'consultancy services', and 'food services'. According to the head user, the criticism from the staff concerning the spatial concept forced to sharpen its rationale. In particular, the ideas of multiprofessional workspaces reducing personal rooms generated tensions and bitter resistance. The head user handled these by explaining the rationale behind the new pedagogical and working objectives, which required more shared spaces. This was linked to the architects' account, which explained the overall space requirements, total amount of space and the budget.

The relation between the spatial concept and architecture was strengthened by the discussions between the head user, the users and the architects. According to the interviews, whereas the users learned about the architectural and material possibilities, the architects understood the requirements from the view of everyday schoolwork. The head user participated in the project design meetings with the architects, designers and the client. Her role was to comment on the plans, to give instant answers or suggestions, or to convey the designers' questions to the other experts of the school. In order for the students to express their opinions on a pleasant learning space, they visited other schools, participated in workshops and eventually started to plan and produce a building design exhibition. The material and the ideas produced by the students were delivered to the architects, who also met regularly. In regular meetings, the students presented to the architects their plans and commented on the architects' drawings. The school design exhibition together with an opera 'Let's build a school!' was presented in the spring 2014. During this period, the user involvement was extensive, as they were encouraged to produce and comment on new ideas.

During **the second period of 2013**, entitled '**Detailed design**' and '**Concretizing the space solutions**', the project aimed at producing detailed designs and implementation plans to be used in construction. For the users, it was time to involve each worker of the community to participate in a user group activity to comment on the architects' models. The multifaceted and detailed design problems led to a formation of specific user groups, following the suggestion of the architect. These 13 user groups were responsible for communication and decision making according to specific spaces, technology or requirements of pedagogical expertise areas. Each group had a leader responsible for delivering the head user the results of the group work. The groups were entitled 'overall perspective group', 'handicraft learning spaces', 'audio-visual', 'school yard', 'spa/pool', 'park area of the spatial concept', 'rehabilitation', 'kitchen', 'consulting services', 'administration', 'home economics spaces', 'arts' and 'accommodation'. In order to finalize the detailed plans, the forming of these 13 user groups was essential. They ensured a focused and a rapid problem solving, and were in constant readiness to take up their own and architects' questions and give comments and make suggestions, even within a few hours' notice. There were a variety of tools that could be used for presenting, commenting, and making suggestions. Mainly, the groups used a document template, which included the description and the aims for the work and the particular questions. The architects worked together with the head user, participated in user group and student meetings,

or visited the particular spaces and facilities of the existing schools (e.g., spaces for physical therapy, swimming pool, classrooms, stairs, kitchen and canteen). At this time, the spatial concept was important in helping the architects to understand the user needs. It was also used to explain the architects' suggestions to the users. As a result, the architects' drawings including questions and suggestions were commented on and modified. The results were delivered to and reworked by the architects until a mutual acceptance was reached. In deadlock or problematic situations due to the missing, inaccurate or conflicting information from the groups, the head user made the decisions.

According to the head user, an important element for the user participation was to ensure the commitment of the staff. This was obtained by obliging each worker to take part in a user group and to sign the outcome documents of the group. This ensured a better time management and personnel involvement in working on the design. Working methods and the use of tools and documents were up to each group to decide, and these included working face-to-face, and on the intranet. The work involved also working with special design experts. For example, in the design of the spa-space, collaboration between the user group, architects, head user, spa-expert, structural engineer, HVAC designers and spa technology suppliers took place. At the end of this period, the designs of the user groups were again merged as one detailed plan, which was finished according to the initial terms and the schedule.

In **spring 2014**, the emphasis was on **the 'Construction'** on site, which started in April 2014 and on **'Interior design'** between the users and architects and with interior designers. For the interior design, the users met several special designers of lightning, technology, acoustics, furniture, decoration, etc. The building information model (BIM) used in the designers' work was also brought for the user. A 3D-videowalking model was constructed from the architect's model to enable examination of the interior between the users and the architects. For example, the model was used to design the signs of passage routes for visually impaired children, the lightning and the interior colour scheme and the usability and safety of the auditorium. In these meetings, the 3D-model was combined with drawings and the real interior materials, which were tested. The period was a phase for opening the design options again, until they became final construction decisions.

CONCLUSIONS AND DISCUSSION

This study set out to suggest that there is a need for building design research requiring multifaceted and long-term user involvement. The aim of the paper was to explore the trajectory of the collaborative school building design between the users and the designers. The analysis illustrates how the elements deriving and carrying the user activity may become a vital part of building design, when supported by appropriate co-design structure, forums and tools.

The successful turn from taking the user as an early information provider to a co-design partner requires several elements. Co-design is a mutual learning path for users and designers as both try to create their own understanding and ideas in order to reach for shared solutions. The user must have means to make the hidden practices and future visions visible for the development. Also, the user must possess enough knowledge about design and construction, which is relevant for developing the ideas with the designers. Conversely, to be able co-work with the users, the designer must possess means to communicate and develop ideas with them, as stated by Luck (2003) concerning the dialogical participatory design. Organizing co-design requires making

the users' and designers' aims and rationale visible, the structure between users and designers (e.g. responsibilities, division of labour, head user/user groups/ad-hoc groups), co-design forums (between organizations, inside user organization) and the tools for designing and managing the knowledge.

The design process involves several iterations of opening and closing of problems. Users with specific needs may become a heavy burden without the appropriate forums to manage the heterogeneous process. A likely success factor in this project was the structuring of the user participation as part of co-design. First, the head user was responsible for presenting and making the users' voice to be heard to the designers, and for making the designers' knowledge available to the users. Second, the formally agreed bridge between the architects and the head user ensured a flexible means to exchange knowledge and functioned as a forum for decision-making. Third, organizing the specific user groups assured the best available expertise to be reached rapidly. Fourth, inviting the staff as members of the user groups encouraged the participation of individual workers. Requiring that each worker approved the outcomes of the group strengthened the staff commitment to the project.

In this study, the reciprocal development between the users' materialized ideas carried by the 'spatial-pedagogical concept' and the architects' drawings was the spine of the design. With other words, the different objects of activity were merged and concretized as design solutions; the users' drive for new working practices, pedagogy and school building were sharpened by co-design, which mutually fed knowledge for the designers to work on the building solutions. The users needed the architects' and the designers' expertise to concretize the spatial concept and to further use it as a tool for the detail and interior design. The tools, such as drawings, or requirement documents, typically combined the architects' drawings with the users' textual comments or the users' 'drawings-on-drawing'. It was also reciprocal: the architects participated in user group meetings and commented on the users' documents. The significance of the tools relies on their ability of mediating different perspectives and holding the stakeholders' aims and practices together (e.g. Miettinen & al. 2009).

The activity theoretical frame was used to analyse the co-design trajectory and the corresponding practices, forms of collaborations and uses of tools. Its strength is based on offering means to study situational co-design practices as part of a longer historical continuum, in which the stakeholders try to merge their initially separated aims as a new, shared design. Based on the results of this study, planning and coordinating the co-design activities needs to take into consideration the conceptual elements (work visions and concepts), material elements (tools and materialized designs) and the social elements of organizing work between stakeholders. Points of interest for the future studies include how the investment in user participation may result in a more accurate design and reduced design modifications and deficiencies, or in a better user satisfaction. Also, the use of digital design tools (BIM, 3D-models, design games) in different design phases has become technologically available, which offers interesting opportunities. The results of this study encourage future research to explore co-design as longitudinal and heterogeneous activity in order to better understand the meaning and the nature of user involvement.

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A DECISION SUPPORT FRAMEWORK FOR HCAI RISK ASSESSMENT AND DESIGN BRIEFING OF HEALTHCARE FACILITIES

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Healthcare facilities are complex and technologically driven built environments therefore controlling healthcare associated infections (HCAI) is a major challenge not only for the UK's NHS services but also for designers and architects. The problem is the very large number of issues that have to be considered and the difficulty of specifying best practice therefore designing the right facility as many of the values are subjective. Quality Function Deployment (QFD) enables the prioritisation of objectives, an understanding of the links between choices and the potential conflicts between them. HCAI-QFD tool has been developed exploiting the features of QFD, but tailored to the needs of the HCAI control practices. By using a preselected knowledge base of issues and technologies that can be used to provide solutions, a decision framework has been developed to enable the user to access, at any point in the process, additional information from linked knowledge sources and the WWW so enabling them to be informed of the issues. The result is that the user can explore each area in depth. When a decision has been made the user can record the details, which are captured in the tool database that is then used to enhance the final report and so produce a full specification of HCAI control issues and requirements. This can be used for HCAI risk assessment and design briefing of healthcare facilities.

Keywords: briefing, HCAI, healthcare, decision making, QFD, risk.

INTRODUCTION

Healthcare facilities are complex and technologically driven environment therefore controlling healthcare associated infections (HCAI) such as *Staphylococcus aureus* (MRSA) and *Clostridium difficile* (CDiff) is a major challenge for the NHS and the health services in other countries. In 2007 a report by Health Protection Scotland showed that the cost of treating healthcare associated infections (HCAI) in acute hospitals was £183 million and 9.5 per cent of all in-patients have an infection associated with their care in hospital.

HCAI control is not just a medical issue; the environment has a part to play in helping to reduce the incidence of the capture and spread of a HCAI. NHS Estates (2002) recognized the built environment's crucial impact on HCAI control efficiency and the role of the designers, builders and maintenance people (DH, 2006) in the prevention and control of HCAI. Health Facilities Scotland (2007) emphasised the need to assess

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the risk of incidence and spread of HCAI that result from the design and layout of the healthcare facility. Therefore, HCAI control involves a wide range of people and organisations ranging from designers, medical staff, facility managers, cleaners and other staff to patients and relatives (National Audit Office, 2009). Reducing HCAI and improving cleanliness involves everyone in a healthcare organisation (DH, 2008). The research undertaken within the HaCIRIC (Healthcare and Infrastructure Innovative Research Centre) programme in HCAI and the built environment has investigated why existing practices consistently fail and where the built environment plays a part. Whilst confirming much of the findings in the above literature this programme has then collected evidence about the transmission of HCAI bacterium within the environment, the effectiveness of cleaning practices and the sort of investment that has been made. A number of focus groups of practitioners across the operational spectrum have then reviewed the findings and confirmed the need for an assessment approach that integrates the variables into a risk profile for existing facilities or a brief for new facilities.

The paper will explore the issues within briefing, the application of QFD as a solution and the development of an approach using QFD designed to overcome the limitations of existing risk assessment and briefing approaches. The paper is focused specifically on issues relating to HCAI, and not the wider design and construction of the healthcare facilities.

Design briefing issues of healthcare facilities

Good briefing implementation is the key to providing a systematic and controlled decisionmaking process thus avoiding expensive mistakes (Blyth and Worthington, 2010, Ch. 2). There is a need to maintain the consistency of the early decisions throughout the process so that users' requirements are progressively captured and translated into effect (Barrett and Stanley, 2000, Ch. 4). However, It is very difficult to capture the reasoning and subsequent decision in the briefing process. This limits the transferability of the process to others and the subsequent stages in the chain. Mechanisms for decision-making must also allow the consideration of a wide range of variables (Coles and Barritte, 2000, Ch. 3). This is manageable if the people and organisation involved in the briefing process could specify all of the requirements. Many people are not familiar with specifying healthcare facilities so are limited by their knowledge. This is largely why the existing briefing and consequent decision making processes fail; the problem is too big and beyond most peoples' comprehension. On the other hand, there is a temptation to require everything to the highest standard, whilst not being able to articulate what the standard is nor whether there is a possibility of trading one requirement against another. To improve this process and minimize errors, the development of decision support tools is necessary (Li, *et al*, 2009). QFD is a technique that enables the prioritisation of objectives, an understanding of the links between choices and the potential conflicts between them. The main objective of the QFD is to achieve overall stakeholders' satisfaction with limited resources (Chen and Ngai, 2008).

Developing QFD for healthcare facilities

QFD is an engineering method for developing product design by systematically deploying the relationships of requirements and product characteristics (Lee and Sai On Ko, 2000). The technique is ideally suited for the evolutionary development of the users' requirements (Rawabdeh, *et al*, 2001) and its purpose is to reduce two types of failure of outcome; the product specification does not comply with users' needs or the

final product does not comply with the technical requirements (Kahraman, *et al*, 2006). QFD facilitates the communication between all parties involved at all stages of a project (Delgado-Hernandez, *et al*, 2007), helps designers to clearly define and prioritize users' needs (Kamara and Anumba, 2001) and can

be a valuable tool in setting performance specifications for building projects (Huovila and Gray, 2005).

QFD is designed for use by experts, which is its limitation particularly in complex environments such as healthcare. To overcome the problem of the fragmentation of the users' knowledge, the basic QFD methodology needs to be developed (Yu, *et al*, 2012). Gray and Al-Bizri (2006) demonstrated in depth how this has been achieved by the preparation of specific lists of 'wants' and solutions for each application. It is this model that has been used to develop the HCAI-QFD tool. HCAI-QFD is a multi-factorial decision support tool that has been developed to enable users from many disciplines to evaluate healthcare facilities (e.g. Ward space) of current as well as new facilities (DH, 2006). The HCAI-QFD tool aims at enabling all disciplines, i.e. medical staff, designers, microbiologists, patients groups, estate managers, facility managers and cleaners to contribute to the identification of HCAI issues, suggestion of actions required, and evaluation of the risk and to then plan alternative approaches (DH, 2006). There are also possibilities to benchmark practice against the best of current practice.

RESEARCH METHODS

The methods used here for capturing the underlying knowledge of the HCAI-QFD tool and data bases fall into two types. The first involves analysing the relevant published literature together with a study of recent investment decisions in this area by the UK NHS (McDonald, *et al*, 2010) then expanding to other HCAI relevant literature. The second is directly consulting users in the field using a Delphi approach to knowledge capture and enhancement. The knowledge acquired as a result of this rigorous search and analysis is structured into the HCAI-QFD database tables. Figure 1 illustrates the development stages of HCAI-QFD tool as well as its ability for continuous enhancement and enrichment while in use.

Developing the HCAI-QFD database tables

The HCAI-QFD database tables were reviewed, modified and enhanced by experts and user groups using a Delphi approach by several iterations to achieve the final model. The panel of experts was selected carefully from a wide range of people and organisations ranging from designers, facility managers, medical staff, cleaners and other staff to patients and relatives. Delphi method facilitated the decision making in this multi-groups multi-discipline situations (Pive, 2008) which is necessary for building effective decision support tools (Chu and Hwang, 2008). By this method the research was extended and endorsed by soliciting experts' opinions (Harty, *et al*, 2007 and Okoli and Pawloski, 2004) and achieving consensus on goals and objectives rather than providing specific answers and predicting future events (Pive, 2008 and Chu and Hwang, 2008) therefore it worked well in this unpredictable area (Manoliadis, *et al*, 2006). Samples from the database tables below (table 1) show that the healthcare facility might be hospital, clinic or care home; with specific functional spaces or 'dirty areas'; general ward, bed ward, single bed ward and theatres. Healthcare facility spaces and functions should meet a specific set of requirements and/or performance criteria in order to fulfil HCAI requirements. For example, the

cleanliness of high-touch areas, which is an HCAI issue can be addressed by architectural solutions such as the introduction of sensor doors, taps, lights, etc. that negate the need to touch things and further reduces the risk of cross infection or recontamination. This issue can be addressed also by regular surface cleaning which is a cleaning management action. Another example of information that users can get from the database of architectural solutions is about the cleanliness of flooring and skirting materials, which should be smooth, easy to clean and with an impervious finish. The numbers of facets and corners should be minimised and the seals at these points must be effective i.e. flush, water tight and with no gaps for dust to gather.

Table 1: Database samples

Facility	Dirty area	HCAI category	HCAI issues	Action category	Actions
Hospital	Single bedroom	Healthcare facility cleanliness	Cleanliness of walls	Architectural solutions	Curtains - standard fabric
Clinic	4-bed ward		Cleanliness of beds		Curtains - disposable
Care Home	General ward		Cleanliness high touch area		Flooring - vinyl
Others	Theatres		Cleanliness flooring/ skirting		Flooring - skirting
		Staff cleanliness	Staff uniform cleanliness		Sensor doors
			Hand wash and cleanliness of medical staff		Basins at ward entrances for clinical hand-wash
			Training of staff for infection control		Basins in sluice/ dirty utility for clinical hand-wash
		Cross contamination control	Patients isolation	Cleaning management	Vacuum cleaners
			Patient separation and privacy		Hydrogen peroxide bombing
			Storage adequacy		Cleaning - surface
			Clean to dirty routing of contaminants		Cleaning - deep

HCAI-QFD underlying knowledge base

Conventionally the QFD approach relies totally on its users to generate solutions (Sakao, 2007) however understanding the requirements and the actions needed to achieve them is a challenge (Sireli, *et al*, 2007 and Chen and Weng, 2006). On the other hand, a paper-based QFD approach requires that the users are able to list all of the requirements and actions, which would be extremely long for a problem as large as HCAI. The HCAI-QFD has been developed to overcome this limitation as it has embedded within it a database of HCAI risks and possible solutions to be tailored by users as well as links to the relevant knowledge, information and research so that at

each point in the questioning process the users can access quickly and in sufficient depth to inform themselves and make enlightened decisions and assessments. The HCAI-QFD is computer based which enables an integrated approach to both the calculations and access to information sources on the WWW through relevant lists of links to pages that provide information from relevant literature and websites. This preloading of the information base must be based on evidence. This paper describes the process of developing the knowledge to put into the framework, not the actual evidence collection, which is described elsewhere (Cloutman-Green, *et al*, 2014).

The HCAI-QFD has been designed to enable many people and various organisations and user groups to independently assess their area which is then integrated into an overall assessment. The consequences of this approach are that each group can deal with their own issues although be made aware of the issues in respect of other groups and that when integrated they will have the opportunity to assess their views against those of the others. The integrated approach then sets the position for the users which can then be benchmarked against recommended practice.

Reasoning and recording of the discussions and agreements

QFD delivers weighted scores for possible solutions through series of steps that involve ranking the requirements as well as the impact of solutions and their feasibility (Kamara, *et al*, 2000). The ranking is subjective and will vary according to the user's perceptions and criteria. It is not a ranking of order but a reflection of the importance of each aspect in the final solution (Bottani, 2009, Shi and Xie, 2009 and Bevilacqua, *et al*, 2006). The HCAIQFD encourages experts to justify their reasoning in order to identify the relationships between HCAI issues and corresponding actions (Okoli and Pawloski, 2004). The HCAIQFD tool is a communication vehicle that helps in formulating ideas (Mirkazemi, *et al*, 2010) and provides consistency in the understanding of issues by all users of this tool (Okoli and Pawloski, 2004). On the other hand, a reporting structure based on a continuous record of decision making through the process using the connected database is made available for decision-makers to record the rationale behind the numerical values entered and the numerical values are explained clearly via text as well as pictures, videos and other available online technologies. This makes it possible to refer back to the original decision making rationale to ensure they address the requirements of HCAI risk assessment at all stages and levels of decision making process and manage the evaluation and feedback process. The following two examples from the database show the reasoning behind the ranking given by the experts:

1. Hand wash cleanliness importance rating is very high because clinical hand washing remains the most effective defence against *Clostridium difficile* (NAO, 2009). The score of the effect of providing basins at point of care for clinical hand-wash on handwash and cleanliness is high as washing hands before and after patient contact requires a hand hygiene facility at the point of care.
2. Not all infection control actions work well with each other as in some instances the effect of one action on another is negative indicating that a trade-off is essential (Delgado-Hernandez, *et al*, 2007) and reflect their feasibility (Kwong, *et al*, 2007), e.g. deep cleaning and decontamination (cleaning management action) has a positive correlation with linoleum and marmoleum flooring (architectural solutions action) because this type of flooring is easy to clean however it is

difficult to 'seal' to prevent absorption of fluids and subsequent staining. On the other hand deep cleaning and decontamination has a very negative correlation with carpet flooring because this type of flooring does not respond well to being deep cleaned with bleach based products, which are required if there is any spillage of body fluids.

The HCAI-QFD produces assessment reports that show the results of the decisions taken during the running of the HCAI-QFD session as well as the reasoning behind these decisions. These reports give a weighted score for each HCAI element as well as the importance, quality assessment and technical feasibility. HCAI control actions with the highest importance scores and lowest feasibility rate are the most problematic situations, which need more attention so that informed trade-offs could be made.

CONCLUSION

The HCAI-QFD is a proof of concept tool that takes the best of leading practice in other industries to produce innovations for healthcare facilities design and management. The QFD technique can be a powerful tool if modified and developed to meet the specific needs of HCAI issues. The HCAI-QFD has provided the necessary developments by taking a user perspective and providing information to meet the weaknesses in the existing QFD applications. The HCAI-QFD has the potential of continuous enhancement and enrichment while in use. The HCAI-QFD database of HCAI risks and possible solutions can be tailored and expanded by users as well as the links to the relevant knowledge, information and research. By adding access to information outside of the tool through links to websites and relevant knowledge sources the underlying knowledge base is constantly being upgraded as new information and websites are developed and the user can be better informed with the latest developments in the field. As advances in knowledge searches are built into the WWW structure then the user has automatic access to enhanced search capabilities. On the other hand, this tool provides a generic starting point for adaptation to a specific use by a particular user. Each user has a different level of knowledge and appreciation and this is

accommodated by the ease of access to external knowledge sources and the ability to set user tailored HCAI issues and corresponding actions. The user can provide a value judgement in terms of prioritization of their requirements. This can be cascaded down and tracked as the basis of the decision can be recorded not only in numerical terms but also in supporting text that describes the context and thinking behind the subjective decision.

In conclusion the inherent risks in the healthcare facility environment that have to be removed to ensure the highest level of patient safety, can form the basis for changing practice, changing the environment and the methods of working. This adaptation of the QFD techniques can bring structure and support to achieving these aims, a continuity of memory of the progressive development of the decision-making process, a record of the decision and its context as well as a method of informing the user of leading practice via the WWW and other knowledge sources. The HCAI-QFD review process delivers a weighted score for each risk element thus enabling rational decisions to be made. The HCAI-QFD tool is focused specifically on issues relating to HCAI, and not the wider design and construction of the healthcare facilities.

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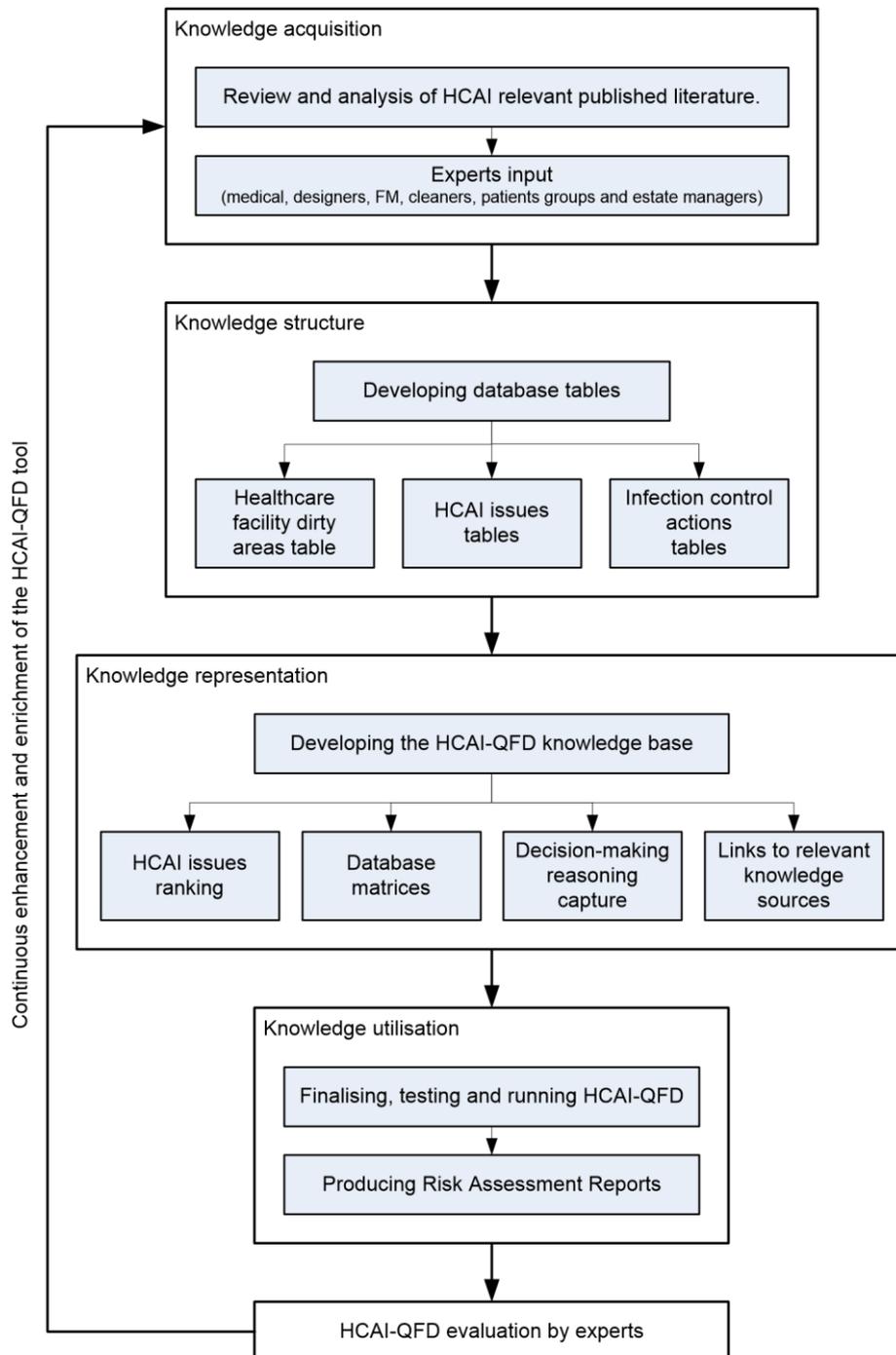


Figure 1: HCAI-QFD development stages

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EXPLORING THE FIELD OF PUBLIC CONSTRUCTION CLIENTS BY A GRAPHICAL NETWORK ANALYSIS

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Because public construction clients form the majority of construction clients and procure over 40% of the construction output in most countries, they are important actors in the construction industry. Yet, the field of research on clients is still underdeveloped. In order to identify the research gaps in this field, a graphical network analysis of existing literature is performed. The analysis is based on a query executed in the scientific database Scopus resulting in around 3,300 publications. By connecting the papers and their references as nodes in a network, an overview is created of the most important topics as previously studied by academic scholars. Collaboration, innovation and sociology are the most studied subjects found. Research methods, public sector and project management are other issues that have attracted scholars to perform research on public clients. Most of the topics are, however, not limited to public clients and based on a relatively low number of specific contribution from the perspective of the public client itself, it can be concluded that especially the public aspect of the construction field is neglected. This opens up interesting opportunities for future research.

Keywords: graphical network analysis, public construction clients, research agenda, research theme identification.

INTRODUCTION

Because clients are ‘the initiators of projects and those that contract with other parties for the supply of construction goods or services’ (Atkin, Flanagan, Marsh, & Agapiou, 1995), they are important actors in the construction industry. Opposite to clients in mass-production sectors, clients in the construction industry play a large role in the creation of a facility. They directly engage in the planning and construction and in this way they shape not only the product, but also the construction process (Hartmann, Reymen, & Van Oosterom, 2008). Construction clients can be classified as private individuals, private corporate, and public sector (Blackmore, 1990). The main interest of the private sector is achieving profit (Boyd & Chinyio, 2008), whereas the goal of public sector clients is maximising value for money (Morledge & Smith, 2013).

This paper focuses on public sector construction clients. The public sector consists of central and local government and nationalised corporations. Together with semi-public clients they form the majority of construction clients and procure over 40% of the construction output in most countries (Boyd & Chinyio, 2008). Many private sector clients, who have usually less experience in procuring goods or services tend to follow the model of the public clients (Winch, 2010). Public clients therefore play an

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important role in shaping the nature of the construction industry (Manley & McFallan, 2006).

Work in the public sector is carried out wholly or partly with public funds (Winch, 2010). Because of this, the public sector must be accountable to taxpayers in how projects and services are procured. Taxpayers have the right to know that their money is spent consistent with approved published policies. Contracts must be awarded fairly and without discrimination in a transparent and accountable way. A substantial body of (European and national) legislation and regulations has been developed to enforce these objectives. The obligations demand a high level of responsibility, transparency and accountability. Failure to comply with regulations could result in lawsuits or criminal prosecution. In extreme cases failure to comply can lead to taking-over of administration of an authority by central government (Morledge & Smith, 2013).

In the Netherlands a group of large public clients - the Dutch Construction Client Forum, consisting of ministries, the governmental housing department, railways, housing corporations and hospitals - expressed the need for developing a theoretical foundation on the challenges they face in this specific field. Because of the exemplary role in society and the strict playfield in which public construction clients operate, a scientific approach is needed. The results of a previous exploration of existing literature (Eisma & Volker, 2014) showed that the majority of the papers on public construction clients focus on projects, rather than the (internal) organisation of the client. Also public aspects are merely neglected. A more thorough analysis is therefore needed to gain a full understanding of the body of literature in this challenging field of study. This paper builds on this work in providing a broad qualitative analysis of the nature of the body of literature by means of a graphical network analysis. The aim of this paper is to create an overview of scientific research publications on public construction clients, to discover links between this field and other scientific fields, and reveal underlying patterns of research topics. The extended scope of this review could lead to new research themes that address the gaps in field of construction clients.

METHOD

The increasing amount of research papers can make the identification of relevant publications for a certain topic time consuming. When searching for relevant publications in a scientific database such as Scopus, there is a tension between finding as much papers as possible and defining a specific search query in order to avoid the risk of leaving important publications out. It can, therefore, be fruitful to find a way to distinguish the important publications from the ones that appear to be less relevant for a specific aim. For this purpose a graphical network approach is used. This network, in which papers form the nodes and references are the links, is the result of authors that cite other authors. Networks of publications and researchers evolve under influence of peer pressure, rules of conduct and funding (Chappin & Ligtoet, 2014). The concept is that good science is continued and that good scientists are credited. However, due to the large quantity of scientific research projects and publications, important results may be overlooked. Analysing the citations in scientific networks enhances the understanding of the cohesion, quality, level, and coverage of a specific part of the literature (Chappin & Ligtoet, 2014).

In this research the network of papers on public clients is constructed from possibly relevant publications and their references included in Scopus. To ensure a wide range of publications, it was important to devise a search query that covers all potential relevant sources and topics. Terms for specific topics can vary between different

research fields (Murray, 2009). Therefore multiple synonyms for every term were included. The search query was developed in an iterative way and was finalised in February 2014. It is reflected in figure 1:

```
TITLE-ABS-KEY(client OR commissioner OR {local authority} OR principal OR sponsor OR buyer OR owner) AND TITLE-ABS-KEY(construction OR infrastructur* OR urban* OR transport* OR project OR maint*)AND TITLE-ABS-KEY(public) AND(TITLE-ABS-KEY(brief* OR purchas* OR procur* OR contract* OR tender* OR administration OR {public private} OR ppp OR govern* OR perform*) OR TITLE-ABS-KEY(architect* OR project OR process OR information OR {supply chain} OR portfolio OR facility OR accommodation OR housing)) AND PUBYEAR > 1989AND (LIMIT-TO(LANGUAGE, "English"))
```

Figure 1: Search query

To limit the number of publications, only publications from 1990 or later that are written in English are included. Certain topics, such as Medicine, Earth and Planetary Sciences and Nursing were excluded to eliminate non relevant publications. The search query produced around 3,300 publications. The network was created using the method described by Chappin and Ligtoet (2014). In short, this method goes as follows: first the references, including their citations are exported. Google Refine is used to clean the data, removing typing errors and combining different spellings of the same reference (for instance P.E.D. Love and P. Love). If this step is not performed, the real structure of the network will not be displayed because of non-valid scattering of the data. The results highly depend on the accuracy of this step since a shared reference is only recognised when it is spelled exactly the same in both instances. Because Google Refine is only able to remove those multiple spellings to a certain degree, a manual correction was also needed.

Then the file was imported in Gephi, a program which recognises references between documents. It connects the documents retrieved from the search query (3,300 documents) with their references (in total around 67,000) in a network. This resulted in a network of around 70,000 nodes and mutual connections. To increase clarity, nodes with less than four references were filtered out. In this way, non-relevant publications were omitted, while maintaining the structure of the network. Subsequently the size of the nodes was made dependent on the number of times the publication was cited: the more citations, the larger the node. Significant publications directly attract attention in the graphical view. If a publication is only incidentally cited, it remains a small node or is even completely left out of the network.

In the final step, nodes were grouped based on modularity. With this function, Gephi analyses the network and groups nodes that share references. This enables the identification of common themes and topics in the literature on public construction clients. Each group was given its own colour to be easily distinguished. By looking at the titles and abstracts of publications in a certain group, the groups are then labelled according to the topic that is addressed.

RESULTS

Figure 2 shows the network that was constructed in the graphical network analysis as described in the previous section. This figure depicts a little more than 1,000 nodes and almost 2,000 connections. This generates two types of results: four insights in the structure of the network and an overview of the six most important research themes. Both contribute to the exploration of the field of construction client research and identification of current research themes, which can be used to set up a research agenda for the coming years.

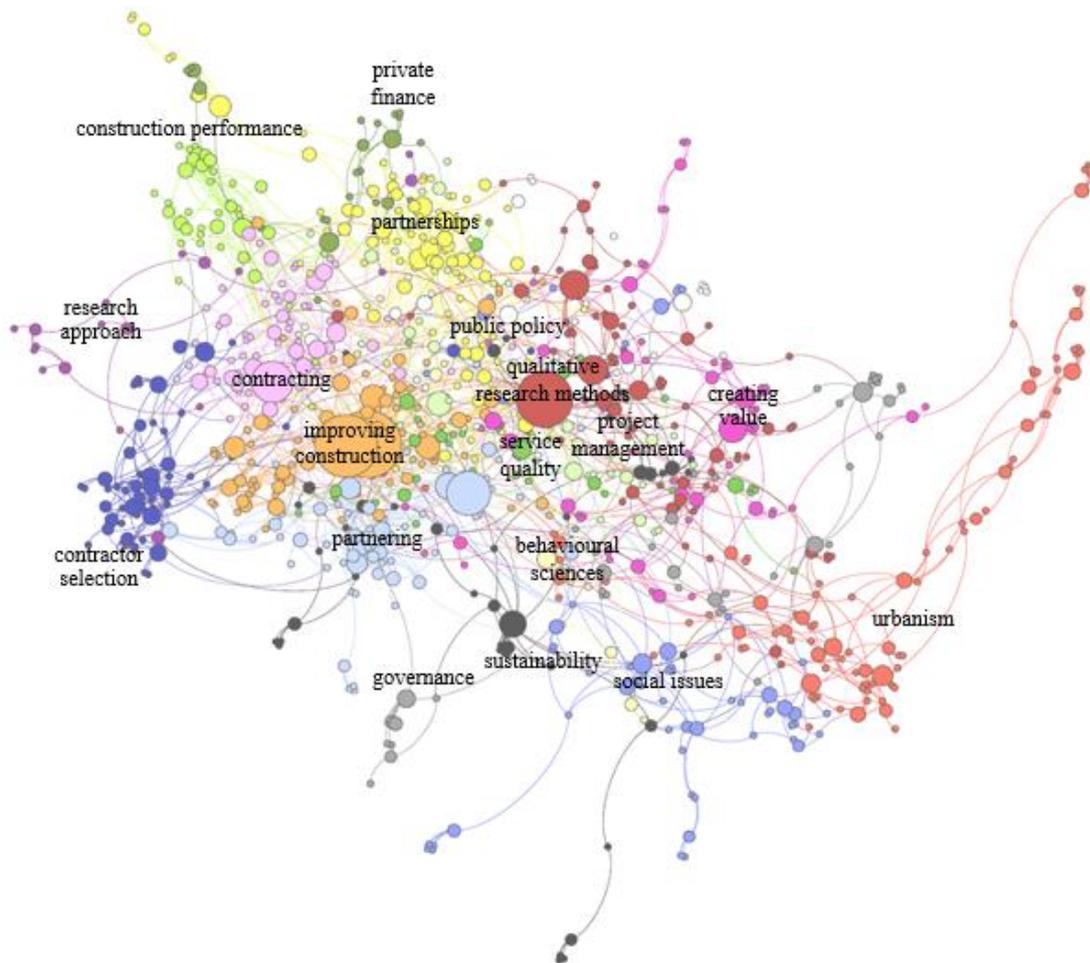


Figure 2: Network of papers and references from search query

Network structure

The structure of the network has a number of characteristics. First, it indicates that the research performed on public client is a rather coherent group. The left side of the graph shows a concentrated area with tightly interwoven nodes. This means that the authors of these papers often cite each other. The right side is more dispersed, indicating looser mutual connections and less links to the core of public client literature. Some groups in this part spread across the network, indicating less uniform groups.

Second, a total of 18 groups are identified. This shows the multidisciplinary nature of the body of literature in this field. Third, despite the coherency, there are a number of outliers: nodes that have only one connection to the rest of the network. The reason for this loose connection to public construction client literature could be a recent publication date or a low familiarity of the publication.

Finally, the size of the nodes shows the relative importance of five generally well known publications used by the scholars in this field. These are: 1. Egan's report, 'Rethinking Construction' (1998) (cited 50 times); 2. Latham's report, 'Constructing the Team' (1994) (cited 45 times); 3. 'Case study research - Design and methods' by Yin (2003) (40 times); 4. 'The Economic Institutions of Capitalism' by Williamson (1985) (cited 30 times); 5. 'Comparison of U.S. Project Delivery Systems' by Konchar (1998) (28 times). This confirms the importance of generic reports on change in the construction industry, such as the Egan and Latham reports, for the

development of a field. Even twenty years after appearance, these publications still offer relevant information and serve as reasons to focus on clients as research subject. The use of Yin's publication acknowledges the character of the performed research that is often based on case studies and qualitative research. Furthermore, 'The Economic Institutions of Capitalism' and 'Comparison of U.S. Project Delivery Systems' characterize the movement from publicly financed and traditionally Design Bid Build projects towards integrated and PPP based collaborations.

Research themes

Based on the network we were able to identify 18 groups of research topics. To enhance the analysis of these groups, they were manually clustered in themes. This clustering was performed by an analysis of the title and abstract of publications in those groups, leading to the recognition of six major research themes (See Table 1). These themes are: Collaboration, Innovation, Sociology, Public sector, Research methods, and Project Management. Looking at the size of the groups in numbers of nodes, these findings indicate a strong focus on improving construction beyond the project context with numerous partners on an urban scale in dedicated partnerships.

Size of group (number of nodes)	Colour	Group	Theme
111	Yellow	Partnerships	1. Collaboration
105	Orange	Improving construction	2. Innovation
97	Red	Urbanism	3. Sociology
87	Dark red	Qualitative research methods	5. Research methods
73	Magenta	Creating value	4. Public sector
72	Pink	Contracting	1. Collaboration
65	Light blue	Partnering	1. Collaboration
60	Blue	Social issues	3. Sociology
56	Dark blue	Contractor selection	1. Collaboration
47	Black	Sustainability	2. Innovation
45	Grey	Governance	4. Public sector
44	White	Public policy	4. Public sector
42	Light green	Project management	6. Project management
40	Lime	Construction performance	2. Innovation
36	Green	Service quality	2. Innovation
24	Dark green	Private finance	1. Collaboration
22	Light yellow	Behavioural sciences	3. Sociology
21	Purple	Research approach	5. Research methods

Table 1: Overview of groups and themes in the network

Only a minor portion is dedicated to private financing of public works, corresponding with the current state of the construction industry in which a lot of projects are still based on a traditional way of financing. Issues that belong to the core of public client research, such as social issues, governance, behavioural sciences and public policy, are addressed by scholars but not as prominent as expected. On the other hand, we notice that improving construction is definitely considered as a responsibility of public clients. Finally, we see the relative importance of project management related issues

that are shaped by the client, such as contracting, partnerships and contractor selection. Below the research themes are discussed in detail.

Theme 1: Collaboration

Most groups in the network can be assigned to the theme of collaboration, consisting of publications on the topics of Partnerships, Contracting, Partnering, Contractor selection, and Private finance. These groups are situated at the centre of the network, indicating that these topics are most prominent in the literature on public construction clients.

Because of the large group size and the central position, we conclude that the group on partnership agreements and ambitions is the most important topic for our field. It consists of papers on partnerships, PFI/PPP (Private Finance Initiative/Public Private Partnership) and briefs. It does however not feature large nodes, which indicates that no papers really stand out; they are more or less equally cited. The group Contracting features papers on contract choice, tendering and procurement. This group has strong links with Partnering and Improving construction, meaning these authors (such as Alhazmi and McCaffer (2000)), seek to improve construction by (new) contract types. Partnering consists of papers on collaboration between partners and integrated teams. It links with Improving construction, which indicates that the papers in Partnering focus on a close cooperation between different kinds of construction parties to improve the complete industry and the potential success and fail factors, see for instance Black, Akintoye, and Fitzgerald (2000).

Contractor selection, located at the left edge of the network, features papers on selection of contractors and competitions. It has strong ties with Improving construction and Contracting, which also relate to team composition and contracting. Contractor selection differs from these groups by a focus solely on the contractor, such as the work of Chinyio, Olomolaiye, Kometa, and Harris (1998) and Fong and Choi (2000). Private finance at the edge of the network focuses on corporate finance, BOT (Build Operate Transfer), and privatised infrastructure. This can be characterised as PFI or PPP. The strong connection with the Partnerships group, which includes for example the publications of Walker and Smith (1995) on privatised infrastructure and Fisher and Babbar (1996) on private financing of toll roads.

Theme 2: Innovation

The second largest theme can be characterised by innovation and consists of the groups Improving construction, Sustainability, Construction performance, and Service quality. These groups are mostly located in the centre of the network.

Improving construction focuses on problems of the construction industry: inefficiency, poor on-site safety, waste and failure to deliver the desired quality to time and cost (Mead & Gruneberg, 2013). Improvement is sought in multiple approaches: briefing (Barrett & Stanley, 1999), procuring (Khalfan, 2011), and partnering (Humphreys, Matthews, & Kumaraswamy, 2003). Sustainability is a much dispersed group, only recognised by a common drive to search for sustainable solutions. The authors in this group, such as Sourani (2011), see a special role in this for the government. This aspect makes this group interesting for our research.

Construction performance is located near the edge of the network, which means that this is not very prominent in the public construction client research. This is probably due to a focus on all actors in a construction project, not solely on the client. It consists of publications focusing on reducing construction time and costs and enhancing quality, such as that of Chan and Kumaraswamy (1996). This group is

connected to Service quality, Partnering, Improving construction and Contractor selection. It links topics such as collaborating with improving the performance of the construction industry. Service quality is a dispersed group, situated in the centre. It includes mainly papers on the quality of contractor's services and is connected to Partnering and Partnerships. This indicates a focus on close collaboration between clients and contractors.

Theme 3: Sociology

The third theme consists of groups with a sociological nature: Urbanism, Social issues, and Behavioural sciences. Urbanism is situated at the edge, which means it has a weak connection to other topics in the network. Although it is a large group, it involves small nodes, indicating little citations. This group features topics related to urbanism: gentrification, poverty and cities. It is connected to Social issues, Governance and Creating Value, indicating a relation with public sector aspects.

Social issues deals with papers on competitive advantage, social cost, homeownership and collective action. It is also situated at the edge, indicating a weak link with public construction client literature. Yet, this topic is closely connected to Urbanisation, but also links to Improving construction, Service quality and Creating Value because it is a widespread group. The group Behavioural sciences is small and dispersed, connected mainly to Social issues. It does, however, feature some interesting publications on characteristics of public clients for innovation adoption, amongst others the publications of Hartmann *et al.* (2008) and Songer and Molenaar (1997).

Theme 4: Public sector

Public sector features the groups Creating value, Governance, and Public policy. Creating value directs at an important task of public clients: being cost efficient and focusing on value creation. This group is situated both at the edge of the network and in the centre, which means it directly relates to public client literature, but also papers outside the field of construction. Governance consists of papers on public services, public management and governance structures. Because of its situation at the edges of the network, it is not prominent in the literature on public clients. This is striking, because these aspects are generally considered as important issues in public client operations. The group Public policy features topics such as public policy, innovation, and major projects. It is dispersed but centrally located, which indicates connections to various topics in the core of field.

Theme 5: Research methods

Research methods features groups that are not related by content to public construction client research but by methodology: Qualitative research methods and Research approach. The first group consists of publications on qualitative and case study research methods. Because of the large and dispersed number of connections to other groups, it shows that many papers in the network apply mostly qualitative types of research. The group Research approach, which is significantly smaller than Qualitative research Methods, consists of papers on research approaches in general, not only qualitative methods. Despite being at the edge of the network, it is connected to Construction performance, Service quality, Governance, and Improving construction. This means that qualitative as well as quantitative research is done on these topics.

Theme 6: Project management

The sixth theme consists of only one small group: Project management, containing publications on project/strategic management, stakeholder approaches, and incentives. The scattering of the group means that it is connected to a lot of topics in the network. The lack of coherence indicates that project management often involves a combination with other topics, such as innovation, partnering and collaboration, see for instance Agranoff (2007).

CONCLUSION

This paper provides an overview of the current literature on all aspects of public commissioning. The network analysis of existing literatures showed a multidisciplinary compilation of a range of 18 groups of topics, spread over six major research themes on issues in the field of the public client. The broad range of topics included aspects that relate 1) to the construction industry in general, such as innovation, improvement, sustainability, partnerships and social issues, 2) the project, topics such as collaboration, project management, contractor selection and contracting, but 3) also concerns that specifically related to the public character of these type of clients, such as governance, partnering and public policy. This resulted in the distinction of the following six research themes: Collaboration, Innovation, Sociology, Research Approach, Public Sector and Project Management.

The broad range and mixture of societal, financial, economic and managerial aspects indicates that the field of public clients is multifaceted by nature. The groups also displayed promising links to other scientific fields such as social sciences, public administration, business administration and innovation sciences. The prominence of research approach as a research theme can be considered as deviant, but could also be interpreted as a sign that the field values empirical data. Furthermore, it is a result of the method used to provide this overview, which does not distinguish between particular research topics and chosen research methods. Based on the fact that five out of 18 groups focus on this subject, we conclude that collaboration (with a specific focus on partnering) is the most important topic in this research field. Hence, we cannot tell if this means that this topic is the most important for clients or the most popular in the literature. Contracting and contractor selection are also prominent in the theme Collaboration.

Although our search terms were specified on public clients, most topics are not limited to these specific actors in the construction industry. For instance, the topics Contractor selection, Construction performance, and Project management can be researched both for private and public clients and from contractor perspective or client perspective. The same applies to groups like Sustainability and Partnering, which can be seen as important tasks for public clients, but are not limited to these actors groups in construction. Only three topics can be directly attributed to public clients: Creating value, Public Sector and Public policy. These are however not large groups, which means that only a small portion of the retrieved results focus solely on aspects that directly and specifically relate to public clients. These groups include typical responsibilities of public clients, such as accountability, transparency and policy making. These findings indicate that additional research is needed to evenly develop the knowledge on public construction clients. An important next step would be to connect the currently identified research topics and themes to current and upcoming research gaps and translate it to a research agenda for the future of research on public commissioning.

Finally, we all know that clients have an important role as change agent in the construction industry and initiator of projects. Especially public clients have to deal with a complex system of public and professional values in an industry that is undergoing significant changes due to financial restrictions and changing responsibilities. A strong need therefore exists among public clients to develop a scientific foundation about the approach to face the challenges existing in the industry. This study shows that despite the numerous publications in which the client is mentioned, the client is still relatively under-acknowledged as a research field which deserves significant attention from scholars in the field of construction management.

DISCUSSION

As shown above, a network analysis can be useful to investigate a large body of literature for several reasons. First, with a graphical network analysis it is not necessary to define a very specific search query. This contributes to the user friendliness of the method. Second, because automated scripts are used, the amount of publications is not an issue. The only condition is that all synonyms for a term are present in the query to cover all possible relevant publications. Third, the method is useful for filtering out non-relevant papers. Depending on the applied filter, only publications with a certain number of citations is displayed. This means that, although the search query was broad, only relevant papers appear in the network. The incidental reference with no other connection to the network is not displayed. This saves time when reviewing all references returned from a search query. Four, important papers directly stand out, because the size of a node depends on the number of citations. Although it is also possible to see the number of citations in Scopus, the network analysis also shows not only the importance of the citing publications, but the total structure of citations and references.

A drawback of this method is that it does not distinguish between non-relevant publications and new relevant publications that are not cited yet. A manual check of the newest publications is therefore necessary to ascertain that all relevant references are included. The choice for the filter value is also important. If the value is set too high, there is the possibility of filtering relevant papers and losing the structure of the network. If it is set too low, the structure remains intact, but too much non-relevant papers remain in the network. This increases the chance of overlooking important publications. Overall, a graphical network analysis appears to be a promising method to create an overview of the current state of knowledge on a specific field among the ever growing body of literature in the field of construction management.

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USING THE LITERATURE BASED DISCOVERY RESEARCH METHOD IN A CONTEXT OF BUILT ENVIRONMENT RESEARCH

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For two disparate research groups, unaware of each other's work, one group can inadvertently solve a problem prevalent in the other. Without considering work from both groups together, such breakthroughs may remain undiscovered. The solution is literature based discovery (LBD), a method which involves investigation or search for novel hypotheses connecting work from two or more disparate contexts. However, LBD has predominantly been used to address medical problems, and its uptake outside medical research remains scanty. In the context of built environment research, there are countable studies that have claimed using LBD and moreover, they presented sparse details. On one hand, studies that have claimed using LBD as a research method seem to confuse it with traditional literature reviews, and on the other hand, even those that could have used LBD seem unaware that they used some kind of LBD-style analysis. Following the original principles of LBD, this paper presents an LBD-inspired research method and a demonstration of its applicability within a built environment research context. The findings indicate promising leads to encouraging LBD and elucidating several misconceptions surrounding its use in built environment research. It is hoped that this paper will encourage future research in built environment, like construction management research, to confidently use LBD appropriately and consciously.

Keywords: built environment, carbon emissions, literature based discovery.

INTRODUCTION

The objective of any piece of research is to advance knowledge within the respective field or context of inquiry. There is a possibility, however, that a problem prevalent in certain field or context might be unknowingly solved by another disparate field, oblivious to the problem (Hristovski *et al.* 2005). Such inadvertent breakthroughs can remain undiscovered and consequently unpursued, if no inquiry ever considers the disparate fields, together. Revelation of such undiscovered knowledge is the domain of literature based discovery (LBD). LBD is a form of text interrogation of scientific literature to identify “... *nontrivial assertions that are implicit, and not explicitly stated ...*” (Smalheiser 2012: 218). It is argued that coalescing disjoint literature can generate hypotheses and subsequently, yield new knowledge (Weeber *et al.* 2001).

Coined in biomedicine-related works (Swanson and Smalheiser 1997; Swanson 1986), LBD has proliferated through several studies (Smalheiser 2012; Smalheiser *et al.* 2009; Torvik and Smalheiser 2007; Srinivasan 2004), but a few (e.g. Ittipanuvat *et al.*

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2013; Yung *et al.* 2013; Dixit *et al.* 2010; Kostoff *et al.* 2008b) outside medical research. In the context of the built environment research, LBD was used to identify parameters that led to variations and inconsistencies in buildings' embodied energy (Dixit *et al.* 2010). In another paper (Dixit *et al.* 2013), it is reported that a model meant to facilitate lifecycle energy analyses of buildings was developed aided by the LBD method. Yung also acknowledged using LBD to analyse several previous studies related to energy analyses of buildings (Yung *et al.* 2013). However, there is limited articulation of why and how the LBD method was used, since none of the studies (Dixit *et al.* 2010; Dixit *et al.* 2013; Yung *et al.* 2013) provided any details beyond citations. LBD uptake outside medical research, especially in built environment research, remains promising but sparsely articulated.

There are several studies that can be placed in the context of the built environment (e.g. Egebjerg 2013; Ibn-Mohammed *et al.* 2013; Dixit *et al.* 2012; Dakwale and Ralegaonkar 2011; Ramesh *et al.* 2010; Sartori and Hestnes 2007; Casals 2006) for which there is sufficient evidence to suggest that LBD could have been an appropriate method to use, or at least cite. Analysing each of these studies is beyond the scope of this paper but attention is drawn to a particular one. Based on literature and interviews, the study (Egebjerg 2013) compared the movie industry (i.e. film making) and the construction industry, with the aim of identifying what the latter could learn from the former. Such a methodology is reminiscent of LBD, where LBD hypotheses (i.e. how movies can inspire construction) are generated and then corroborated through empirical studies. For instance, Swanson's LBD hypotheses (Swanson 1986) were experimentally corroborated in DiGiacomo *et al.* (1989). For Egebjerg (2013), both LBD-hypothesising and corroboration could have been possible. On the whole, the prevailing mysteries regarding use of LBD in built environment research raise intriguing questions worth to explore. In concurrence with assertions in Smalheiser (2012), it is likely that researchers never recognise the difference between carrying out an LBD analysis and the traditional literature/text analyses, while others seem unaware of LBD.

The foregoing discussions raise several concerns regarding the efficacy of LBD adoption in built environment research:

- no study exists to underscore the efficacy of LBD method in built environment research;
- LBD has previously been inappropriately or redundantly cited as the research method, moreover with insufficient details provided;
- it is insufficient for a study to claim using LBD just because it based its analysis and findings on literature;
- LBD could have been the appropriate method for many studies that did not mention any method used; and
- it is likely that some researchers are unaware that they used some kind of LBD-style analysis and such ignorant use is unlikely to be efficient.

While these concerns are rather many to exhaustively address in a single writing, work presented in this paper shades light on several of them by presenting an LBD method and demonstrating its application to a particular case (i.e. addressing carbon emissions from buildings) that falls in the context of sustainability in the built environment.

A BRIEF REVIEW OF LBD

The founding works in LBD were based on the 'ABC' approach, popularised by a Venn diagram (see Swanson and Smalheiser 1997: 184). This form of syllogism

prescribes that for mutually isolated literatures A and C, if A reports a relationship (AB) with a term/concept B, C reports a relationship (BC) with the same term/concept B, hypotheses (AC) can be derived connecting A and C (Smalheiser 2012). If nothing has previously been explicitly reported regarding the connection between A and C, then it can be of significant interest or rather, a new form of discovery (Weeber *et al.* 2001; Swanson and Smalheiser 1997). From two scientific literatures, one related to fish oil and another on Raynaud's disease (a condition of intermittent blood flow), Swanson "*proposed [a] hypothesis that fish oil might ameliorate Raynaud's syndrome*" (Swanson 1986: 12). Considering blood viscosity (term/concept B), patients with Raynaud's disease (Literature A) had abnormalities in blood viscosity (AB), yet eicosapentaenoic acid (Literature C) found in fish oils lowers blood viscosity (BC). Considering literature A and C, a connection AC was hypothesised that patients of Raynaud's disease could benefit from Fish oils (Swanson and Smalheiser 1997; Swanson 1986). Several subsequent LBD studies were undertaken some of which were successfully corroborated (DiGiacomo *et al.* 1989) or replicated (Srinivasan 2004; Weeber *et al.* 2001; Lindsay and Gordon 1999). A predominant LBD process is that denoted as a closed discovery (CD) approach (Kostoff *et al.* 2008a; Weeber *et al.* 2001). The CD process simultaneously starts with the disease (C) and fish oils (A), looking for common linking B-terms like blood viscosity, working towards identifying linkages between A and C (Kostoff *et al.* 2008a). The CD process resonates with LBD in form of two-node analyses and indeed, some researchers (Smalheiser *et al.* 2009) have gone ahead to develop tools (Arrowsmith 2007) that can guide carrying out CD LBD processes. Unfortunately, all these efforts are still limited to medical research.

THE PROPOSED LBD RESEARCH METHOD

Following the CD process, the proposed LBD method can be summarised into two phases, composed of six stages (see Table 1).

First phase (stages 1 to 4)

A comprehensive literature search is performed on two disparate 'contexts' of inquiry (i.e. A and C) to generate the corpora (i.e. peer reviewed journal articles) for performing LBD. Using adequate linguistic specifications (see Frantzi *et al.* 1998) and appropriate software, terms are automatically extracted from each context. 'Recall' and 'Precision' are two aspects that the Term extraction process has to optimise (Naumann and Herschel 2010). 'Recall' relates to the number of terms that can be retrieved, whereas 'precision' is related to the relevance or plausibility of the extracted terms. Higher 'precision' can only be guaranteed at the expense of lower 'recall', and vice versa (Ganti and Sarma 2013).

In well-structured and online corpora (e.g. in MEDLINE), it is possible to know the approximate number of terms to work with (see Weeber *et al.* 2001: 551). However, for a semi-automated process suggested in this work (i.e. articles manually gathered from different databases), only an estimate can be possible. For instance, for literature consisting 20 articles, assuming an average full-article length of 7000 words, this would constitute working with 140,000 terms. To manage the winnowing process towards precision, an initial working number of terms from each context should be set. Meanwhile, the decision of setting the minimum term length (number of characters per term) depends on the desired precision and recall. Shorter terms are usually good on recall but not precision. Also, terms can be unigrams (i.e. one word terms), bigrams (i.e. two word terms) or n-grams (Frantzi *et al.* 1998; Ittipanuvat *et al.*

2013). Because of some limitations highlighted later, the current approach considers unigrams. The 'recall' for unigrams is usually high since, unigrams can exist either on their own, or as nested terms (i.e. sub-terms of bigrams/n-grams). In Ittipanuvat *et al.* (2013), unigrams accounted for over three quarters of the total terms extracted. Though unigrams present rather a bigger sample space to work with, measures (e.g. a stop word list) need to be undertaken in order to ensure precision (i.e. limiting retrieval of irrelevant terms).

The stop word list is primarily a tool used to distinguish between potentially useful and non-useful terms (e.g. frequently occurring terms like 'is', 'to', 'what' etc.) (Weeber *et al.* 2001) and it has previously been employed in LBD studies (see Lindsay and Gordon 1999; Swanson and Smalheiser 1997). The stop list can be precompiled based on the predicted suitability of terms (Swanson and Smalheiser 1997) or compiled concurrently with the term extraction process (Lindsay and Gordon 1999). As part of the synonymy and stemming rules (Lindsay and Gordon 1999), it is suggested that only exactly (i.e. not synonyms) matching words should be considered in order to control unnecessary recall and noise. However, singular-plural stemming rules (Lindsay and Gordon 1999) can be applied and in such cases, the terms (e.g. house and houses) should be combined into one. Illustrations of linguistic filtering reveal that most terms are usually composed of nouns, verbs or adjectives and for multiword terms, they are usually constituted of at least a noun (Frantzi *et al.* 1998). Thus terms extracted should be linguistically filtered to nouns, verbs and adjectives in that order of preference. For automated filters like those in medical databases, linguistic filtering can be automatically set. The approach suggested herein is semi-automated since linguistic filtering is manually done by inspecting each extracted term.

Lexical statistics are used to manipulate the extracted lists of terms in order to retain the most plausible ones. Initially, terms should be sorted/ranked by their frequency (Tf) (i.e. number of times a term appears in the corpus). However, using term frequency alone for further evaluations means that terms appearing less frequently might be missed out (i.e. since they are low ranked), yet they may be plausible. To circumvent this, the concept of inverse document frequency (iDf) developed in Jones (1972) can be used. The iDf weighting boosts terms with low frequency, yet concentrated in few specific documents/articles. This consequently yields a Term frequency-Inverse document frequency (Tf-iDf) measure (Salton and Buckley 1988). Tf-iDf (see formula in Table 1 footnote) is a more preferred measure and has been cited in LBD studies (Lindsay and Gordon 1999; Ittipanuvat *et al.* 2013; Srinivasan 2004) as a better measure of relevance of a term than frequency alone. Therefore, terms should be ranked by Tf-iDf and low-ranking terms may be discarded. Unlike in biomedical databases where terms can be automatically classified into their respective predetermined semantic categories (see Smalheiser *et al.* 2009), manual categorisation is suggested, which rather demands 'human intervention' and acquaintance with qualitative data analysis techniques. However, this does not entirely manifest as a disadvantage since it gets the analyst up-close with 'what the literature is saying'. To guide the categorisation process, a paradigm model, initially proposed in Strauss and Corbin (1998) and subsequent texts (Corbin and Strauss 2008), is suggested. It consists of Phenomena (i.e. what is going on?), Conditions (i.e. what are the causes), Actions/interactions (i.e. what is the response?) and Consequences (i.e. what are the results?). Categories are developed (i.e. using appropriate software) from key terms and it is possible for a given term to belong in several categories. Essentially, a term is

evaluated (according to where it appears in the text) and the approach involves ‘coding’, “... *an analytic process through which data are fractured, conceptualised, and integrated ...*” (Strauss and Corbin 1998: 3). Coding should be done by sentence and paragraph, through questioning the major idea embedded therein.

Table 1: The proposed LBD method

No.	Step	Procedures	Remarks
1	Literature data retrieval	Specify context/dichotomy (i.e. A and C). Identify core /key terms. Identify literature databases. Retrieve literature for each dichotomy in relation to key terms.	This is where the boundary of literature is specified. Appropriate search arguments are crucial to ensure comprehensiveness.
2	Term extraction and linguistic specification	Specify the number of terms and minimum characters per term. Specify number of words/strings per term. Specify level of term synonymy. Specify desired linguistic filter. Build a stop word list.	This demands a balance between 'recall' and 'precision'. Appropriate software can be used to extract terms from the texts/articles.
3	Lexical statistics*	Retrieve Term frequency (Tf). Retrieve document number (D). Retrieve Document frequency (Df). Compute Term frequency-inverse document frequency (Tf-iDf). Rank terms to identify most plausible ones.	Tf, D and Df values are computed by the software used in extraction. Terms are ranked by Tf-iDf and an appropriate cut-off list is selected.
4	Category development	Code around key terms using the paradigm model (i.e. Phenomena, Conditions, Actions/interactions' and Consequences). Identify major categories that emerge.	Coding is done using software. Key terms are coded by sentence and paragraph. Other terms are coded to where they appear in text. Categories are developed by assessing the context of how the term is used.
5	Semantic similarity	Compute Cosine similarity of vectors/categories for A and C.	Query terms by context per vector. Compute similarity of vectors.
6	Deducing relations	Investigate similarity of vectors and identify top ranked terms per vector. Make inferences.	If a vector in A is similar to that in B, then the terms contained can be related by a hypothesis

* Tf is the number of times a term appears, D is the total number of documents, Df is the number of documents in which the term appears and Tf-iDf is computed as $Tf \times \log(D/Df)$.

Second phase (stages 5 and 6)

Literature (Ganti and Sarma 2013; Naumann and Herschel 2010; Pesquita *et al.* 2009) discusses several similarity measures (e.g. Jaccard Index, Dice coefficient and cosine)

which are also often used in LBD studies (see Ittipanuvat *et al.* 2013; Miyanishi *et al.* 2010). This work considers the cosine similarity measure. At this stage, categories based on the key terms only would have been developed from the corpora. From appropriate coding software, it is possible to retrieve terms that intersect with a given category; several term-combinations (e.g. terms in both A and C, in A only and in C only) associated with a developed category can be worked out. It is possible for a given term to belong in several categories. The categories are transformed into vectors for which similarity between them is computed. Since vectors only work with integers, each term is therefore represented by its Tf-iDf measure. Put another way, a category composed of terms is represented as a vector composed of Tf-iDfs. This idea, initially suggested in Salton and Buckley (1988), is usually used in works related to document indexing and retrieval. The similarity between two vectors is a property of the cosine of the angle between them (i.e. 1 if the vectors are identical and 0 if they are not). The cosine values are computed using the cosine vector similarity formula (Salton and Buckley 1988: 514) as per the Equation below:

$$\text{Similarity}(A_v, C_v) = \sum(w_{A,t} \times w_{C,t}) / \left(\sqrt{\sum w_{A,t}^2} \times \sqrt{\sum w_{C,t}^2} \right)$$

where A_v and C_v are Tf-iDf vectors representing literature contexts of A and C respectively; $w_{A,t}$ and $w_{C,t}$ are the weights (i.e. Tf-iDf) of a term t with regard to literature A and C respectively.

The deduction of relationships (i.e. plausible hypotheses) is then based on the cosine similarity measure and the Tf-iDf measure. It is assumed that vectors (i.e. categories) with cosine similarity values closer to 1 will be more related and thus plausible for generating plausible hypotheses. This assumption is rather not new (see Miyanishi *et al.* 2010: 1554), though needs cautious interpretation. Although it would be considered that the lower cosine values offer fewer linkages to explore, they may, ipso facto, be potential sources for novel relationships. Nonetheless, the key guidance to pursue any plausible hypothesis/relationship regarding any term in the vectors is based on the cosine similarity score and the term's rank/weighting (i.e. Tf-iDf). In other words, it is inferred that the plausibility of a hypothesis linking an A-Term to a C-Term is related to the cosine similarity between the two vectors that describe how that term manifests in A and C.

APPLICATION OF THE METHOD

Personal experience and anecdotal evidence suggested that there was little, if anything, implemented in the Ugandan building sector to address carbon emissions. This was confirmed by a nil return when a systematic search for literature involving the key words of 'building(s)' or 'construction' and 'carbon emissions' was implemented. A similar search involving the United Kingdom (UK) returned a rich collection of publications, suggesting that there may be lessons that can be learnt from the UK for the Ugandan context. Therefore, considering carbon emissions in the building sector in Uganda as an area for investigation in the context of promoting sustainable construction was warranted. A comprehensive literature search was performed to retrieve literature from Uganda (denoted as A) and that from UK (denoted as C). The searched databases (in fields of Title, Abstract and Key words) considered to cover most of the academic journals in English, were Science Direct, Engineering Village, ProQuest, EBSCO Host and Web of Knowledge/Science. The key words considered for A were Uganda and emissions, whereas for B, UK or United Kingdom, buildings or construction, and emissions. A typical search argument was in

form of: search in Title-Abstract-Key words (United Kingdom OR UK) AND in Title-Abstract-Key words (emissions OR greenhouse gases) AND in Title-Abstract-Key words (building* OR construct*). After filtering, a total of 105 articles were considered, 29 for A and 76 for C. The articles were imported into Nvivo 10 software (see Bazeley and Jackson 2013; QSR Nvivo 2013) to extract terms. Consequently, appropriate linguistic filters and a stop word list were applied in term extraction. While there was no limit on the maximum number of characters in a term (i.e. Term length), a minimum was arbitrarily set to three. Although Nvivo 10 comes with a default stop word list, more terms were progressively added, and the total came to around 8000 words. To balance precision and recall, while presenting a manageable number of terms, only 1000 terms were extracted from each context A and C. Lexical statistics (i.e. Tf-iDf) were computed and used to rank the extracted terms. This was performed by exporting the lists to Microsoft Excel and applying appropriate formulae. Each of the extracted terms was then converted into a node (i.e. Nvivo10 nodes function) in order to 'tether' it with the document/article (and precise location) it appeared in. The name of the node corresponded to the name of the term. Using the paradigm model as described before, categories were developed (i.e. using Nvivo10 coding) around the key search terms (i.e. emissions and buildings).

Using Nvivo 10 query functions (i.e. Matrix coding queries), it was possible to generate terms that belonged to each of the developed categories, with respect to A and C, ranked by their Tf-iDf measure. For each pair (i.e. a given category/vector but split into terms as mapped to A, and terms as mapped to C), the cosine similarity value was computed. For instance, a vector (representing a category named 'strategies to reduce emissions') was mapped to A, and the resulting list of terms noted/ranked. The same vector was then mapped to C and also the resulting list of terms noted/ranked. The cosine similarity of the two vector's lists was then computed. If the similarity was found to be (or nearly) zero it implied that the 'strategies to reduce emissions' in A were (almost) 100% dissimilar to those in C. The resulting terms, using appropriate sorting facilities in Microsoft Excel, were then investigated to isolate: terms in the vector that are present in both A and C ($A \cap C$), A only, C only and the union of A and C ($A \cup C$). In arriving at relationships, the terms were validated by re-examining the article where they appeared, in line with the vector's description.

FINDINGS AND DISCUSSIONS

The top ten terms (out of 1000) considered in A showed that: biomass, forests, urban, CDM (clean development mechanism), electricity, charcoal, wood, stoves, solar and land are important terms in relation to emissions, whereas in C, cooling, SAP (standard assessment procedure), embodied, dwellings, housing, wind, electricity, stock, zero and office are important terms in relation to emissions and buildings. Electricity, solar, power, climate, renewable, energy, costs, construction, fuel and technology were the top ten terms present in both A and C, ranked by their average normalised Tf-iDf scores. In LBD nomenclature, these are referred to as the B-terms. They are the ones that create the primary linkages between A and C. So, the relationship (AB) of such a B term with respect to A, compared with the relationship (BC) of the same term but with respect to C, forms the primary basis of LBD analyses. Some of such relationships can be the same (e.g. if a 'causes of emissions' vector returns 'energy' in both A and C), justifying that an issue is indeed prevalent in both A and C, while other relationships might differ. The discretion of what to investigate or pursue then lies in the hands of the analyst, guided by the aim of carrying out the LBD study.

Several categories were developed and the similarity in relation to B terms ranged from 0.81 to 0.86, with the 'strategies to reduce emissions' category scoring highest. Since the maximum score was 1, the results implied a good relationship between A and C, a signal that perhaps similar actions exist in both contexts. When terms not common to both contexts were also added (i.e. $A \cup C$), the similarity reduced i.e. by 48% in causes of emissions, 43% in barriers to reducing emissions, 65% in strategies to reducing emissions and 44% in regulations related to emissions. It was clear that there was a significant difference between A and C, regarding the strategies to reducing emissions, compared with other categories. From such information (see Table 2), several relations could be deduced and once corroborated, yield new knowledge. For instance, an assertion can be posed that CDM (i.e. a highly ranked term in A) can be used to address emissions from buildings through applying SAP (i.e. a highly ranked term in C). Certainly, literature searches performed indeed proved that there was no current research to support that assertion, and this could be a potential research problem for which once empirical research is conducted, yield new knowledge. To the discretion of the analyst, a plethora of plausible suppositions can be elicited from the information.

Table 2: Similarity with respect to 'strategies to reduce emissions' category

Cosine similarity		Distribution of terms**		
$A \cup C$	$A \cap C$	Terms in A	B terms ($A \cap C$)	Terms in C
0.30	0.86	Project, CDM, Forest, Development, Improved, diesel, Land, Rural, Biomass Market, Stoves, Wood, Charcoal, Briquettes, International, Local, Global, Many, Small, Countries, Activities, Benefits, Level, Private, support	Energy, carbon, Emission, Renewable, New, Solar, Electricity, Fuel, Low, Change, Power, Sector, Policy, Sustainable, climate, Potential, System, Environmental, Government, Consumption, Construction, Study, Demand, Technology, Research	Heat, Reduction, New, Technologies, Cooling, Low, Savings, Gas, Measures, Design, Homes, Efficiency, Zero, Performance, Domestic, Water, Significant, Thermal, Dwellings, Space, Generation, Wind, Housing, site, standard, SAP

** In each column terms are listed separated by commas, beginning from the highest as ranked by Tf-idf weighting.

CONCLUSIONS

This paper has highlighted the efficacy of the literature based discovery (LBD) method in built environment research. Although LBD has proliferated, it is mostly still limited to addressing medical problems and uptake in built environment research is promising but sparsely articulated. Built environment research seems to confuse the difference between carrying out LBD analyses and the traditional literature searches/reviews, a situation that culminates into stifling efforts to proliferate LBD. An LBD research method was presented and a demonstration of its application in the context of built environment research provided. In the example, a relationship between carbon emissions, clean development mechanism (CDM) and the standard assessment procedure (SAP) of buildings was coined. The overall findings underscore the untapped potential of LBD in built environment research and moreover, LBD adds scientific rigour to traditional literature review techniques. However, some limitations were met. Unlike biomedical research, the approach used was semi-automated and thus some tasks were limited to only what could be reasonably and manually handled.

In addition, the LBD analysis demanded some levels of subjectivity since terminology and databases related to built environment research are not as highly specific and descriptive as those of medical research. Although software was used, it was not tailor-made for LBD. For instance, Nvivo10 was not able to automatically extract multiword terms. Nevertheless, LBD remains a potentially appropriate research method that can address problems in built environment. It is hoped that more work will build on this information to encourage use of LBD in wider fields of built environment.

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STAKEHOLDER ENGAGEMENT IN RESEARCH: THE CASE OF RETROFIT 2050 RESEARCH PROJECT

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Stakeholder engagement has recently been increasingly identified as key to research projects success. Stakeholder engagement is often seen as communication of the completed research project findings; however engagement with stakeholders that focuses on communicating with and involving them in the knowledge production process is increasingly accepted as the best practice. The study aimed at exploring how the Retrofit 2050 research team engaged fully with relevant stakeholders. The study examines how key stakeholders were recruited, engagement approaches and how the whole process was managed. It illustrates the application of the approaches for stakeholder analysis, engagement and knowledge exchange strategies. This research presents a literature review that considered the power of stakeholder engagement to sustainable urban retrofit research and identified the main process of stakeholder engagement and management. The authors provide participatory and participant observational research perspective of how key stakeholders were engaged throughout the research process. The findings indicate that, engaging with key stakeholders in research can legitimise the result and improves the quality of research output. The study highlights that, personal or one-to-one method of stakeholder engagement is the most commonly used approach to promote stakeholder-researcher relationships. It provides a research case study that can serve as a reference for the systematic consideration of other research teams about the practical approaches for stakeholder engagement in interdisciplinary sustainable urban environment research projects.

Keywords: participatory research, stakeholder engagement, stakeholder analysis, retrofit

INTRODUCTION

Academic researchers are currently responding to the call to generate useful, useable and used research by adopting effective strategies for engaging non-academic stakeholders in academic research (Boaz and Hayden, 2002). Incorporating stakeholder perspectives is increasingly becoming important in research with environmental and societal relevance as a growing number of successful research projects are judged by the bigger impact on knowledge, society, the economy and the people (Allen *et al.*, 2013). The contribution of stakeholders is more pertinent in complex socio-technical research project such as sustainable urban retrofit. Stakeholder engagement is an important piece throughout an entire research process in terms of data collection and the dissemination of research outputs (Carney *et al.*, 2009); however, O'Haire *et al.* (2011) argue that engaging relevant stakeholders early

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in the research process and maintaining good relationships are important to building trust and credibility. The importance of stakeholder engagement in academic research cannot be underestimated, as it helps researchers gain a better understanding of how to enhance mutual learning and knowledge exchange between researchers and their identified stakeholder community (Carney *et al.*, 2009). Stakeholders are more likely to participate in a research when the research could impact on policies that directly affect their lives and interests (Mallery *et al.*, 2012). Moreover, researchers engage with stakeholders for various reasons including: the need to add legitimacy to the research output, compliance with the conditions of research funding agencies, and as part of the dissemination process (Carney *et al.*, 2009). This research presents the general overview of the Stakeholder Engagement within the Retrofit 2050 research project. It explores the practice and process of involving key stakeholders throughout the research process. Second part provides an overview of the Retrofit 2050 research project. Relevant and current literature on stakeholder engagement strategies are examined in the third section. The final part highlights practical approaches adopted in engaging with stakeholders in the Retrofit 2050 research project and presents conclusions and recommendations for researchers with the desire to engage stakeholders in research.

THE RETROFIT 2050 RESEARCH PROJECT

The Retrofit 2050 project (Re-engineering the city 2020-2050: urban foresight and transition management) is an EPSRC funded programme of research to investigate transitions to sustainability in the built environment of Britain's city-regions between 2020 and 2050. It brings together an inter-disciplinary research team from Cardiff University, Salford University, University of Cambridge, Reading University, Oxford Brookes University and Durham University, as well as commercial partners from across the private and public sector including Royal Institution of Chartered Surveyors (RICS), Building Research Establishment (BRE), TATA; ARUP; Core Cities group; Department for Environment, Food and Rural Affairs (DEFRA); Welsh Government; Manchester City Council; Cardiff Council; Carillion; Environment Agency Wales, and Neath Port Talbot Council (Retrofit2050, 2014).

The essence of the Retrofit 2050 project is to bridge the gap between what is needed for urban scale retrofit and how this might be achieved. The work looks through a socio-technical lens for transition through retrofit in the built environment in an urban context. The Retrofit 2050 project comprises four interlocking technical work packages: Urban Transitions Analysis; Urban Foresight Laboratory (2020-2050); Urban Transitions Management; and Synthesis, Comparison and Knowledge Exchange as illustrated in Figure 1. The Retrofit 2050 project adopts Participatory Action Research approach which involves researchers and stakeholders engaging actively in the knowledge production collectively focused on effecting social change. A participatory research approach incorporates stakeholder knowledge into the whole research process (Allen *et al.*, 2013).

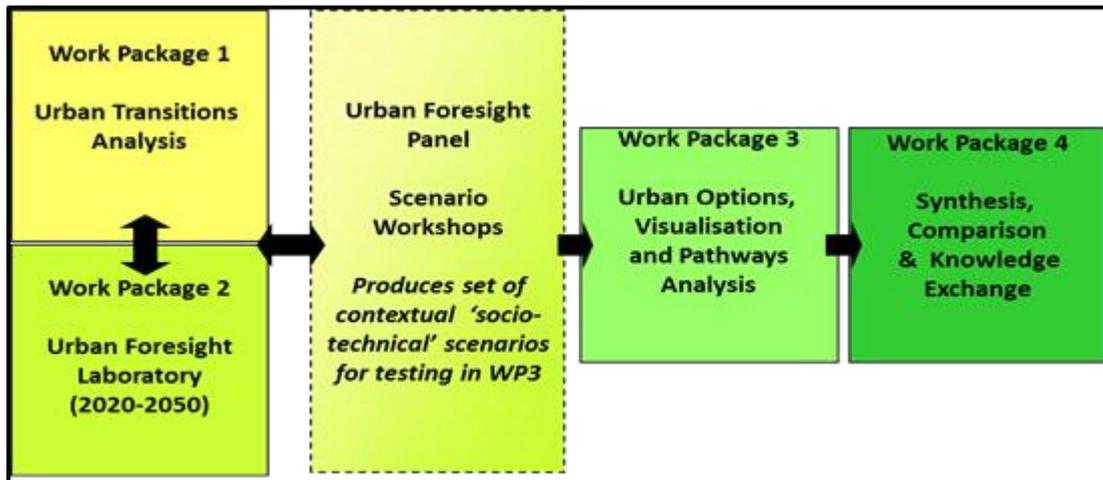


Figure 1: The Project Structure (Source: Eames, 2011)

LITERATURE REVIEW

Understanding and Defining Stakeholders

Stakeholders could be any individual or group who has a vested interest in the result of a body of work. Durham *et al.*, (2012) however add that the stakeholder is any person or group who influences or is influenced by the research. For the purposes of this study, stakeholders are individuals, groups or organizations who have a personal or professional interest in the topic of sustainable urban retrofitting and/or is been affected and influenced by the results of the Retrofit 2050 project. The level of stakeholder influence on the project varied and those with significant influence on the research or significantly impacted by the work is described as the key stakeholder (Opoku *et al.*, 2012). For a research project to be successful, the interests and influence of the key stakeholders must be recognised. A stakeholder's interest in a project can stem from the potential to influence the decision, and/or from the potential to be influenced by the results of the research. They can act as individuals or groups who have interest in an issue or a policy (Gardner *et al.*, 2009; Allen *et al.*, 2013). Researchers normally engage with different types of stakeholder depending on the relevance of the research or the interest/power that these individuals, groups of people or organizations have on the project; for example, public, industry/practitioners, policy makers (Farell *et al.*, 2001; Carney *et al.*, 2009).

It is important that the appropriate people are identified and engaged throughout the research process, to play the important role of informing the design of the study as well as making good use of the results once the study is completed. Gardner *et al.* (2009) describe the term stakeholder engagement as any process that involves stakeholders in some form of collaborative effort directed towards a decision. It is sometimes used to describe the broad range of interactions between the researchers and stakeholders through information delivery, consultation, involvement or collaboration in the decision-making throughout the research process.

Identifying and recruiting stakeholders

Academic researchers use various approaches when identifying potential stakeholders, but one common approach is the use of individuals who were known to the principal investigators through professional relationships. Identifying the relevant stakeholders of a given research project is as difficult and important as the research process itself; the choice of which stakeholders to engage is influenced by the interest and the power

of the stakeholder on the outcome of the research (Baldwin, 2000). O'Haire *et al.* (2011) state that stakeholder selection should be based primarily on availability and convenience, knowledge, and personal contacts. The identification process is called stakeholder analysis; which refers to a process of developing a list of stakeholders, identifying their interests and analysing their influence (Mitchell *et al.*, 1997). Stakeholder analysis is therefore a process of identifying stakeholders, analysing their influence, and thereby concentrating on preferential stakeholders (Reed *et al.*, 2009). Other methods of identifying and recruiting stakeholders include: direct methods; in-person interactions and personalized letters, emails, and phone calls and indirect methods; postings on web sites, blogs, and newsletters requests to stakeholder interest organizations and referrals through existing stakeholders (Mallery *et al.*, 2012). Also "snowball sampling", which involves identifying stakeholders through referrals from others, is a commonly used in identifying stakeholders (O'Haire *et al.*, 2011).

Stakeholder Engagement Strategies

There are numerous reasons why researchers engage stakeholders in research projects such as improving the policy relevance of the research (Durham *et al.*, 2012). To achieve the full benefits of stakeholder engagement in research projects, a strategic approach should be adopted with clear objectives, milestones and an evaluation plan. O'Haire *et al.* (2011) suggest that researchers bringing together diverse stakeholders may require paying much attention to group dynamics in addition to the presentation of the research topics. Carney *et al.* (2009) believe that researchers should plan the stakeholder engagement element of their research in a strategic and transparent manner to ensure that, how stakeholders have been engaged in the formation, execution and dissemination of research can be communicated more accurately. Researchers engage stakeholders using a variety of methods, including one-to-one meetings, advisory committees, public fora, focus groups, telephone interviews, e-mail, conference calls or Webinars, citizens' juries, workshops, conferences, and online questionnaire (O'Haire *et al.*, 2011). The person one-to-one method of stakeholder engagement is one of the most commonly used as it ensures a time of focused stakeholder attention to the issue under research. It also promotes stakeholder-researcher relationships ensuring a better understanding of each other's needs and priorities. In-person methods are helpful for brainstorming, clarifying and stimulating a deeper understanding of issues (O'Haire *et al.*, 2011). However, regardless of the method used to engage stakeholders, it essential to influence the contacts, establishing long-term partnerships, and building trust and credibility. It has been stated that stakeholder engagement can improve the quality of research output resulting in rich and diverse knowledge through the involvement of people with diverse social value (Pahl-Wostl, 2007 cited in Carney *et al.*, 2009). The legitimacy of findings from any research project can be enhanced through the engagement of the key stakeholders. Allen *et al.* (2013) commented that the roles of stakeholders in research are varied and can include anything from identifying research questions, sharing values and preferences, providing quantitative data or local expertise, commenting on research concepts and results and more importantly, learning from the research process. When stakeholder engagement in a research project is for the purpose of co-production of knowledge both the stakeholder and the researcher gain mutual learning. Such stakeholder engagement helps ensure the relevance of the research to policy and also give credibility to the research outside academia (Carney *et al.*, 2009). Stakeholder engagement should not be conceptualized as communication of research results after the project is complete (Green *et al.*, 2009; Allen *et al.*, 2013), but should rather focus

on communicating with and involve stakeholders inclusively throughout the whole research process. Stakeholders should not be passive recipient of the research findings as Carney *et al.* (2009) believe that good research requires the active input of all relevant stakeholders.

METHODOLOGY

The study adopted a qualitative research approaches through participatory methodology, with Participant Observation as the data collection technique. Bergold (2012) describe participatory research as a research paradigm which involves the stakeholders in the process and outcomes of the research. It is about conducting research with and for the research subjects; research with the people rather than on the people. Participatory research methodology aims to reflect, explore and disseminate the views, concerns, feelings and experiences of research participants from their own perspectives (Swain and French, 2004) and support the involvement of research stakeholders in the knowledge-production process (Bergold, 2007). Qualitative data collection for this study was done through observation, and document analysis. Participant observation has been used in a variety of disciplines as a tool for collecting data about people, processes, and cultures in qualitative research (Kawulich, 2005), through participation, observation, and interrogation (DeWalt and DeWalt, 2002). Kawulich (2005) describes participant observation technique as the most natural qualitative data collection method that connects the researcher to the most basic of human experiences. However, one major weakness levelled at participant observation methods is the potential lack of objectivity, as the researcher is not an independent observer, (Iacono *et al.*, and 2009). In participant observation method, the researcher serves as the primary instrument for observing and collecting data (Creswell, 2003) and this help develop a holistic understanding of the context and the phenomena under study. Finally data is analysed through a detailed sequential process of reviewing all documents associated with the whole Retrofit 2050 research project.

STAKEHOLDER ENGAGEMENT: THE CASE OF RETROFIT2050

Stakeholder engagement in the Retrofit 2050 projects took place at different stages throughout the research process. Forms of stakeholder engagement included availability of projects working papers and brochures, newsletter updates, involvement in workshops and symposia and project advisory group (PAG) meetings. To ensure the effective engagement of the stakeholders in the research process, a working paper on knowledge exchange strategy was developed to guide the research team (Opoku *et al.*, 2012). The recruitment and selection of stakeholders for the Retrofit 2050 project began with a stakeholder analysis; compiling a target list of key regional stakeholders from industry, local/regional government, third sector and community organisations. Stakeholders were selected on the basis of their local knowledge and organisational affiliation. The identified key stakeholders on the Retrofit 2050 projects have been grouped into the following as illustrated in Figure 2; practitioner community, policy community, academic community and general.

Practitioner Community

The practitioner stakeholder community includes all built environment professionals, construction organizations, suppliers/installers, energy/green deal companies, clients, developers, and owners. Professional institutions, think tanks, and trade associations are all relevant players in this project. The project's findings will reach out to the built environment practitioner community, and will provide a clear understanding of how

urban designers, engineers, planners, technology experts, infrastructure providers and regulators can effectively plan for urban transition.

Policy Community

The policy community were local and central government agencies involved with energy, climate change and urban sustainability policies. Key routes into the policy community include the Government’s Chief Scientific Adviser (CSA) and the key departments. The research enable policy-makers at national, regional and local level to gain a better understanding of how future change will require new and innovative forms of governance and the way in which technology roadmaps can help shape future thinking in cities.

Academic Community

The academic stakeholder community included university institutions and research centres working on retrofit related projects (EPSRC Sustainable Urban Environment-SUE community). The research draws together new and existing futures-based thinking and academic research focused on energy, waste and water set within a socio-technical framework. This enables the further development of urban knowledge which represents an integrated approach to knowledge generation for cities in the UK and internationally.

Public Citizens

The general public stakeholders included think tanks, NGOs and community organizations. The project team worked closely with key third sector stakeholder groups in the two case study areas of Manchester and Cardiff.

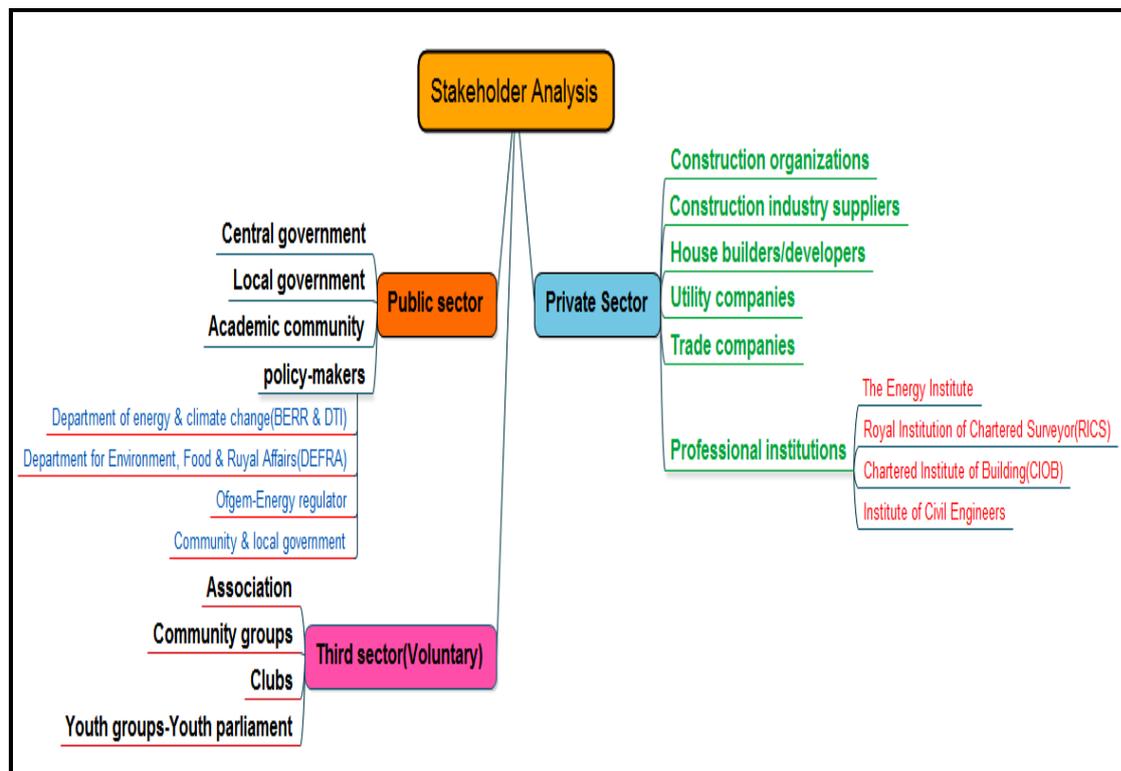


Figure 2: Retrofit 2050 Stakeholder Analysis

Stakeholder Engagement Approaches

Various approaches were adopted by the Retrofit 2050 research team to suit each stakeholder to be engaged in the research process. The key stakeholders were engaged throughout the research process; contributing to the process as well as receiving the research project findings. The stakeholder engagement approaches used in the Retrofit 2050 project are discussed below:

Expert Reviews

As part of the work of the Retrofit 2050 Urban Foresight Panel, more than twenty reviews were commissioned from leading national and international experts from academia, industry, government and civil society organizations on aspects of retrofitting including urban design, governance, transport, energy, water and waste. The workshop addressed one of the key objectives for the project; developing and evaluating city-regional visions and pathways for urban-scale retrofitting. This was the first workshop of the Retrofit 2050 project and focused on exploring the meaning of urban retrofitting and drivers for sustainability, it considered the historic reshaping of the urban fabric and the way that current niche and mainstream activities might seed future transitions. The output of this workshop was a report that drew together the diverse range of ideas and insights forming the basis of further workshops.

Conferences and Exhibitions

The research team took part in a number of relevant exhibitions and conferences dedicated to sustainable urban retrofit including the RetroExpo exhibition and conference, the Greenbuild and Ecobuild exhibitions in 2012. An academic conference was held to share knowledge and findings from the Retrofit 2050 project and engage in a process of comparative and mutual learning with leading national and international academic peers, together with a small number of key stakeholders from policy and practice. Also, policy/practitioner conference was held with the aim of making the findings of the research project accessible, useful, and useable for policy makers, government, local governments, property owners, practitioners, and third sector organisations with an interest in the future of retrofit

Workshops/Symposia

As part of the research process of linking the contextual scenarios with the regional case study context, regional scenarios workshops brought together a panel of experts from the public, private and voluntary sectors to explore visions of retrofitting to the year 2050. Whilst the activities of the Retrofit 2050 project are primarily UK focussed, a workshop was held to provide a window into understanding the dynamics of retrofitting activities on the global stage. It explored the politics and processes of retrofit as they unfold in different countries and contexts across the world.

Engagement with Policy and practitioners

Policy makers and practitioners were actively involved in both the knowledge production process as well as the dissemination process. Among them was a presentation on EPSRC Retrofit 2050 project at HM Treasury in London. Also dissemination Seminars were organised for practitioners that included the Chartered Institute of Building (CIOB) sustainability group; Women in Sustainable Construction and Property (WSCP), Deloitte Real Estates, the Institute of Environmental Management and Assessment (IEMA) and the Cardiff County Council.

CONCLUSIONS AND RECOMMENDATION

In conclusion, this study presents participant observational perspective on how the Retrofit 2050 research team engaged with the relevant stakeholders throughout the research project. The discussions show that it is essential to understand the process and the benefits of stakeholder engagement in research. Engaging with relevant stakeholders in research can improve the quality of research output, legitimise the result, and more importantly enhance the policy relevance of the research. The stakeholders engaged in the Retrofit 2050 research project impacted greatly on the overall success of the project. Stakeholders were part of the research process taking part in knowledge production, data collection and research dissemination workshops, seminars and conferences. The active engagement of non-academics (policy makers, practitioners and the general public) in the research process provided the relevant and diverse perspective/opinions needed to tackle the research problem. Key findings from Retrofit 2050 research project have been presented to both academic and policy/practitioner audiences at a number of seminars, workshops and conferences.

The study highlights how to engage with stakeholders and the choice of appropriate stakeholder engagement approaches in academic research. More should be done in terms of further empirical studies to showcase the enormous benefits of engaging stakeholders in academic research. It was noted that the process of identifying, recruiting, contacting, and engaging stakeholders in research takes longer than anticipated and would be helpful to have a realistic assessment of the timelines. Also there is no perfect approach for stakeholder identification and prioritization and combining several approaches when necessary is the best way to manage stakeholders. The following recommendations have been identified through the study to enhance stakeholder engagement in research:

- Stakeholders should be engaged early and throughout the research process;
- Researchers should employ multiple methods of engagement that suits individual stakeholder needs and requirements;
- When using in-person stakeholder approach, it is prudent to undertake icebreaker sessions when stakeholders are not accustomed to each other or come from diverse backgrounds;
- Finally stakeholders should be provided with easy-to-understand and concise informational materials at the beginning of each engagement.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support of the Engineering and Physical Sciences Research Council (EPSRC), (Grant Number EP/1002162/1) for funding this research project. We would also like to thank members of the Retrofit Team and all stakeholders who have been part of this project

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“TAKING OFF MY GLASSES IN ORDER TO SEE”: EXPLORING PRACTICE ON A BUILDING SITE USING SELF-REFLEXIVE ETHNOGRAPH

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There has recently been a growing interest for ethnographic studies in construction. This interest is predicted upon the belief that ethnographic research to the construction industry can provide a powerful way of illuminating construction practices in new ways. The purpose of this paper is therefore to explicate how ethnography could be used to answer research questions in construction. Drawing on rich empirical data from a field study where the researcher went native, working as a dogsbody on a building site, this paper illustrates how the researcher first battled contrarious roles, only to realize that the transforming perspectives were the true resource. The paper presents the practices on the building site from an observer perspective and a worker perspective respectively and concludes that a self-reflexive ethnographic approach can account for the variations, contradictions, and tensions embedded in the practices of construction.

Keywords: ethnography, self-reflexivity, identity.

INTRODUCTION

While ethnographic research in construction has remained relatively rare there is now a growing interest in and awareness of the utility of an ethnographic approach to the construction industry (Pink *et al.* 2012). Those that are advocators of more ethnographic research in construction argue that it can provide a powerful way of illuminating construction practices in new ways (Gherardi and Nicolini 2002; Bresnen 2009; Pink *et al.* 2012). Until recently there has been relatively little emphasis on theory generation around the actualities of construction practice, rather a defining characteristics of construction research has been an apparent reluctance on the part of many researchers to embrace the interpretative and qualitative methods more generally (Pink *et al.* 2012; Phua 2013). Building sites have been described as being chaotic, complex, and in constant flux (e.g. Cicmil and Marshall 2005; Ness 2010), constituting an “*ad hoc environment*” that is rapidly changing in temporal and spatial dimensions, and therefore often requires unpredictable configurations (e.g. Groák, 1994). It has been argued that those workers engaged in this reality rely heavily on practiced-based learning rooted in, and between, single individuals rather than in technical and managerial systems (e.g. Styhre *et al.* 2004; Knauseder 2007) Many aspects of the particular practices of a building site would therefore seem to benefit from research methods that allow the researcher to collect data and experience amidst the actual practises as they unfold. Specifically, a deeper understanding of the “*realities*” and lived experiences of those within the industry can contribute to deeper insights into the ramification of socio-cultural systems by the capturing of significant

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variations, contradictions, and tensions (Löwstedt and Räisänen 2012) and would enable problems to be reframed in ways which account for both specificities of the context to which they relate and the socialities and materialities and experiences through which they unfold (Dainty 2008; Pink *et al.* 2012).

In relation to this, the purpose of this paper is to explicate how ethnography could be used to answer research questions in construction. More specifically it explores how a self-reflexive approach can provide complementary perspectives on the practices of a 'field'. Based on rich empirical data from a field study of a building site the researcher here reflects on how insights from both an observer role and a worker role respectively can account for the variations, contradictions, and tensions of the practices of a building site.

ETHNOGRAPHY, FIELD STUDIES, AND SELF-REFLEXIVITY

Brewer (2000:10) describes ethnography as “*the study of people in naturally occurring settings or 'fields', by means of methods which capture their social meanings and ordinary activities, involving the researcher participating directly in the setting, if not also the activities, in order to collect data in a systematic manner but without meaning being imposed on them externally*” – i.e. ethnography is “*telling it from the inside*” (ibid. pp.17). Ethnography is not one particular method of data collection but rather a style of research that is distinguished both by its objectives and its approach. The objectives are to understand the social meanings and activities of the people in a given 'field' or setting and its approach involves close association and often participation in the fields (Brewer 2000). In ethnographic research these 'fields' are seen as socially constructed realities and ethnographic research is therefore by nature qualitative (Dent, 1991).

Brewer (2000) argues that “*ethnography*” sometimes has been used as a synonym for qualitative research as whole, and virtually describes any approach as ethnographic that avoids surveys as the means of data collection. He therefore proposes to distinguish between “*big*” ethnography or “*ethnography-understood-as-the-qualitative-method*”, in which ethnography really is a perspective of research rather than a way of doing it, and “*little*” ethnography to mean the same as “*field research*” or “*ethnography-understood-as-fieldwork*” where ethnography instead means a particular way of doing qualitative research (ibid. 17-18). It is not so strange, however, that field study often is equated with ethnography. Ethnography is after all concerned with understanding people in their natural occurring settings and field study is a particular research methods that provides the researcher with route to understand “*local*” knowledge in ways that is not accessible through standard interviews or focus group methods (Tutt *et al.* 2012).

However, field study, or “*little*” ethnography, is still not all that small. Field studies involve judgments about: the object of the research, which is to study people in naturally occurring settings; the researcher's role in that setting, which is to understand and explain what people are doing in that setting by means of participating directly in it; and the data to be collected, which must be naturally occurring and captured in such a way that meaning is not imposed on them from outside (Brewer 2000: 18). The data naturally consist of descriptions and accounts provided by the people in the research site, together with the researchers observations on activities and interactions and the context in which they take place. The researcher, in general, does not seek to test a prior hypothesis. Rather, he or she seeks to theorize through the data in an inductive manner. Analysis of the data is itself an emergent process. The

researcher seeks gradually to develop an empathy with the data, to understand what they tell of people's realities and the process through which they unfold (Dent 1991). This involves direct and sustained contact with the people, within the context of their daily lives, watching what happens, listening to what they say, asking questions, and producing a richly written account that respects the irreducibility of human experience and that acknowledges the role of theory as well as researcher's own role (O'Reilly 2005:3). It is therefore very important that the researcher has a reflexive awareness of her or his specific field study is informed by and builds on theory and then self-consciously considers how theory and practice remain in dialogue through the research process – i.e. in order to understand the precise meanings of research findings, it is also important to attend to the ways that ethnography is informed and the precise meanings of the concepts engaged in its production (Pink *et al.* 2012:8).

It is therefore increasingly common for contemporary ethnographic field studies to deploy a self-reflexive approach, wherein the author explicitly considers how their status, background, and experience influence the research process (Clifford and Marcus 1986; O'Reilly 2005), however, construction researcher have seldom adopted a self-reflexive approach to writing: the subjective 'I' is mostly absent in writing within construction research journals and books, hence the position of the author, and their identity, remain unknown to the reader and unexamined by the author (Sage 2012:93). Sage (2012) argues that those small number of works in construction that actually has used a self-reflexive approach to ethnography, have treated their own identity as a given when self-reflecting and have given rather little explicit consideration to how their own ethnographic identity are been cultivated and transformed across the research process. In the reporting of his field study in construction, Sage (2012) therefore adopts a more engaged approach to an ethnographic field study and reports back on how his own identity changed throughout the field study. He argues that it is important to accept and reflect on the way your own identity transforms as you engage in a field study. In a similar manner, this paper is using a self-reflexive approach in order to account for how the researcher's own identity transformed throughout the field study. The following parts of this paper are therefore written in such style for the reader to get to know the subjective "I" of the researcher.

THE SETTING

This paper is based upon data from a four weeks long field study at a construction site. The construction site project was operated by a large construction company here referred to as Alpha and comprised of the construction of 40 residential apartments allocated between two separate buildings. I got access to the site first through an initial contact with a regional manager at Alpha, and then via a district manager that in turn directed me to the site manager of the aforementioned project. As common for ethnographic approaches I was not seeking to test any prior hypotheses (Dent, 1991) with my field study but rather to explore practices on a construction site as they emerged before me, and the purpose I duly stated for admission was "*that I wanted to learn how it works out on an actual construction site*". I entered the site in January 2014 by which the project was about 70-80 percent into its projected progression.

My strategy for the field study was to try to actively participate in the day-to-day activities as much as possible. I regarded this an eligible strategy for many different reasons. One reason was that this seemed to be the best way to study the setting in such a way that meaning was not imposed on it from outside (Brewer, 2000), i.e.

rather than my presence being associated with someone that observed I wanted to try to blend in by working like everyone else. As it turned out, this strategy proved to work even better than expected. On the first day I was given a set of working clothes and safety gears to wear just like everyone else on the site. The safety helmets that you wore on site followed color-coding that indicating the rank you had on the site. I learned that the site manager and the site leaders wore white helmets, the construction workers blue and the apprentices and visitors red. I wore a red helmet which turned out to be a great advantage if you wanted to blend in on the site. There were about 15-20 apprentices on site, and there was also a large number coming and going from week to week. I realized that many faces were new for others as well and not everyone knew everyone's name, and coupled with all the visitors on site also wearing the red helmets I felt that my presence on site passed rather unnoticed.

TRANSFORMING IDENTITY: BEING OBSERVER/BEING WORKER

Another reason for the strategy to actively participate in the construction work was that I imagined that my understanding of the practice of a building site would be more profound if I had tried to practice it myself. This ambition to actively participate got fulfilled by a large margin, in fact, it merely took a few days for me to be fully assigned with work. Initially this work mainly consisted of carrying and moving various material and tools as well as a lot of cleaning and clearing up. It could be for example, moving large piles of building timber from one place to another (\approx 4 hours), throwing plasterboards away for disposal (\approx 1,5 hours), carrying parquet between different floors in the building (\approx 2 hours), or cleaning out apartments before an ensuing filling (\approx 1 day). I learning from the site manager that it was common for apprentices to get these more "boring" tasks in the beginning. I felt that the construction workers really responded to the red helmet I was wearing because I could hardly go anywhere on the site before some construction worker asked me to do some work. However, in due time I was assigned to do "real" construction work as well. I don't have any construction background at all but I accepted every task that was given to me and it turned out well. Before the end of my field study I had actually performed most of the task that a regular construction worker do on a building site, for example measuring, sawing and putting up beams in an outdoors storage room, screwing plasterboards, putting up boards with a nail gun, doing decision founding range measurements with laser, putting out clinkers, be in recipient of deliverances, and directing a crane operator.

There were several motivational factors for me to focus on the task given to me and to perform my utmost. First, I didn't want to make any mistakes that could draw attention to me. Second, I wanted them to recognize that they could trust me with the tasks they gave me in order for them to give me more without having to think twice about it. However, I also realize now in retrospect that a significant motivational factor for me focusing on the work given to me also was grounded in myself – as a person in this world. I am a very competitive person by nature, I want to perform well regardless of what I do, and I furthermore found myself to really enjoy doing the work that they gave me.

All these circumstances progressively transformed my identity on the site, from being an observer foremost to being a worker foremost. While this was the initial ambition I also reflected on that my worker role occasionally grew out of proportion, to an extent that it inhibited the grand purpose of the study. Some days I was so deluged with construction work that I had no time to take any field notes, or no time for any

reflections besides the work right in front of me. I also realized that while carrying piles of lumber all alone for four hours would make me useful on the site, it could hardly provide me with much useful data on the construction practices.

In the due course of these four weeks on site I was constantly pulled into a worker role, which I actively had to step out of in order to be able to observe. While all this was on going I thought of this constant flux between the observer role and the worker role as nothing else than a big problem. However, now in retrospect I realize that this transforming perspective was a true resource.

RESULTS

In this part I present two aspect of the practice of the building site – from two different perspectives: the observer perspective and the worker perspective respectively. A concluding discussion will then argue that these two perspectives can complement each other to account for the complex variations, contradictions, and tensions of the practices of a building site.

“PLANNING ON THE SITE”

Observer perspective

My overall impression from observing the practices on the building site was that they were characterized by little systematized control and planning. Even where there were plans, it seemed like no one seemed to pay too much attention to them. The practices on the site seemed rather to be characterized by ongoing reactive and person-based problem solving.

A typical episode could be:

Two construction workers come to talk to the site team leader about how to construct a stair. The team leader starts to explain to them. At first they don't understand him, but soon they do. One of the workers says to the team leader: “You just thought of this now didn't you” and the team leader seems delighted and smiles “Hell, yeah”. This dazzled me and when the workers left I asked the team leader if there really was no construction plan for the stair. Team leader “No, no, no”. Another team leader overhears this and says “Come on, of course there is a construction plan for the stairs” Team leader 1: “No there isn't” Team leader 2” I know for a fact that there is” Team leader 2” Ok there might be one...but you know that there is a reality also right?”

This made quite an impression on me and the next day I asked the team leader how the building process progressed – “*if everything was going according to plan*”:

Team leader: “I really don't know” Me: “Don't you have any plan?” Team Leader: “No...I mean I don't feel like I should have to sit and plan...I did one plan in the beginning but I mean that was flawed the very first day already...and then I didn't feel like sitting down and do yet another one.”

This approach towards plans and planning was not only a characteristic of this particular team leader, but typical for all the construction workers on site. It involved both planning of the building process, as well as the specific building plans. In general they seemed very skeptical towards the building plans and the architects that made them: “*they don't know about reality*”, “*they can't be trusted*”, “*it is almost always something wrong*” and a common practice for them was to incorporate their own personal solutions instead and “*just solve it*”. They usually communicated this to the

team leaders only after they had solved it: "The plan said that ...but that was no good because...so we did this instead..."

I have no construction background myself, so I could never decide whether the plans were flawed or not. But I observed a constant skepticism and indifference towards the plans, and not only did they seem to assume that the plans were wrong, but I could also sense that they wanted the plans to be wrong – so that they would get to use their own person-based problem solving. Because there seemed to exist a collective pride related to the craftsmanship and the particular of being a good "*problem solver*". My inference when observing this was that this pride consequently affected their attitude towards plans and planning.

Worker perspective

As I progressively transformed into the worker role by my active participation in the construction process I also progressively started to think of plans and planning in a different way. After working on the site for a while I could sympathize with their skepticism and reluctance towards plans. I realized that no plan could in detail account for the high degree of unpredictability embedded in the building process; the complex chains of dependencies and variations in between social interactions, materiality, and the unpredictable physical environment, etcetera.

The following is a very typical episode of me working on the site:

One of the team leaders assigned me with the task to receive a shipment of window frames in marbles. My task description was to be at the deliverance spot, review the shipment, sign off, and then just pile up the frames outside the building. However as I arrive at the spot it starts to rain, the delivery guy informs me that it wouldn't be good for the frames to lie out in the rain. Since the frames are very heavy and the space very limited inside the building, I didn't want to risk carry them all to any inconvenient spot, so I decided to go and find the team leader to ask him where I should put them.

I look for him for about 15-20 minutes and finally I find him in the second building on the fourth floor. He tells me: "I don't know.... You have to put them wherever there is room". I go back to the first building and look for a place on the first floor but the flooring isn't done in those apartments there. I ask the worker there when he will do the flooring, to know whether I could stack the frames there or not. He tells me that he don't know, that he needs to wait for the filling to be done first and he don't know when, but that it should be that afternoon. So I go to the second floor. It is kind of chaotic there because a shipment of doors has just arrived and someone has just stacked them in the stairwell, so there is no room for me to access any of the apartments on that floor. So I go to the third floor. There the flooring is done in one of the apartments so I decide to put the frames there and I go down and start to carry them. When I am about half way through one of the workers stops me and asks me if I could carry the frames to the fourth and fifth floor instead, he tells me that he is the one that is supposed to put them in place and ask me if I could carry each one of them directly to the rooms where they are supposed to be put in place. I say yes, no problem. However when I arrive at the fourth floor carrying one of the heavy frames with me I see that there are cabins standing everywhere and blocking the rooms. It was the floor dresser on that floor that had moved them there because he needed room in the kitchen where he was putting in floors. So, I had to carry the frame back down again and put it back where it was before. I then tried to find the worker to inform him that there was no room for the frames where he wanted them – but I couldn't find him.

Then I tried to find the team leader to inform him where I had put the frames in the end – but I couldn't find him either. And then I forgot to tell him when I saw him, and he never asked.

This episode is very typical for the practice on site. It illustrates the constant negotiation of onsite space and time and the effect the physical environment can have on the sequences of events; here for example, it suddenly starts to rain. It also illustrates how complex and juxtaposed all the micro processes are and how hard they are to overlook. The team leader did not know where to put the frames; and he didn't know where I put them in the end; he also didn't know that one of the workers needed them on the fourth floor; and that worker, in turn, didn't know that there were standing cabins where he wanted the frames and he also didn't know where I put them in the end; and he could only start to put them in place after he find them; and after the floor dresser was done on that floor – and so on.

From a worker perspective, the unpredictability of the building process seemed to spring from the aggregate of a myriad of episodes like this.

“SAFETY ON THE SITE”

Observer perspective

On the very first day I entered the site I was given a safety introduction by one of the team leaders. This introduction was mandatory and was given to everyone that was going to spend time on the site, including every subcontractor and visitor. The introduction took around 10 minutes and included pretty much what I expected from a safety introduction, i.e., there was no surprises; no more than expected, and no less.

One thing that was stated in the safety introduction was that it was mandatory for everyone on site to wear all the safety equipment at all time, including the helmet, the glasses, the jacket, the shoes, and the gloves. This was also stated on signs that were put up on the fence that confined the building site area, and on the doors of the building barracks.

Observing the workers on site I noticed how this regulation was breached time after time. The helmets were on the majority of times, however, the jackets, the gloves, and the glasses were taken off countless of times. At one occasion I asked the team leaders about this and they seemed to have rather different opinions on the matter, one of them was expressing indifference and the other frustration:

Team Leader 1: “We have more important things to think about”

Team Leader 2: “Yeah, but if you didn't have to nag about it all the time like some other kindergarten teacher...then you would have time for the more important things”

At this point I could see that the safety regulations wasn't followed, but I wasn't sure about the reasons, and even when I asked I couldn't get univocal answers. I heard reasons like “*forgetting*”, “*not important*”, “*yeah, yeah...I know*”. My initial inference was that this was related to and embedded in the macho culture that I observed on the site. However, when looking from a worker perspective I managed to see other things as well.

Worker perspective

In one of the first days I was asked to move large piles of parquet floors from one floor to another. There were quite heavy and it didn't take long for me to start to sweat

heavily. In addition to the heavy workload and the warm safety jacket, there were also hot fans running in the apartments and in the stairwell. The buildings were built in concrete and these fans were placed there to help the concrete to dry out, which it needed to do as fast as possible because other building sequences depended on it. However all of this made it incredible hot and I had to take my jacket off. Then I also started to get mist on the inside of my glasses. And I therefore had to take my glasses off – in order to see. I kept doing this when I needed to and I learned that everyone did this and that the group accepted it.

What I also learned during these weeks is that it hurts to be a construction worker. Doing work in the chaotic environment, with stuff laying around everywhere, it seemed unavoidably to get hurt. During these weeks: I tripped on an electric cable on the floor and fell into a metal bar and hurt my elbow, walked into an electric cabinet and hurt my knee, somehow managed to stick my thumb into a hole in a wall and twist it, got a large wooden beam on my arm when sitting and screwing leaving me with a large bruise on my arm – this could easily have been much worse, because it was falling towards my neck and one of the workers screamed at me and I could just barely get my arm up in time. By experiencing it from a worker perspective it became very clear to me that a safety introduction alone could not do much in regards to preventing accidents, as long as a building site is what it is.

DISCUSSION AND CONCLUSIONS

The results reported in this paper describe how my own “*ethnographic self*” transformed and fluctuated between being an observer foremost and being a worker foremost while doing a field study of a building site. Czarniawska stated (2007: 21) that: “*An observer can never know better than an actor; a stranger cannot say more about any culture than a native, but observers and strangers can see different things than actors and natives can*”. This can be seen as both the strength and the weakness of the observer perspective; while it might be easier for an observer to see new things in a ‘field’, it is definitely harder to see the same. The observer perspective and the worker perspective presented in the result section are simplifications. In reality they are approximations and overlapping subspecies of each other. However, they serve well to elucidate how self-reflexivity and different perspectives can account for the complex variations, contradictions, and tensions of the practices of a ‘field’.

The team leaders and the workers discussed planning in terms of a “*timewasting*” activity and they expressed a lack of trust in what any plan would “*know about the real reality of a building site*”. This could, from an observer perspective, be interpreted as relating to the rather chaotic environment on the site (a causal relation). However, by working on site myself and experiencing the constant negotiation of time and space (e.g. Groák, 1994) I gradually started to sympathize with their (limited) planning practices, because, from a worker perspective a scepticism towards plans seemed to be a consequence of, rather than a cause of, the specific circumstances on the building site. By the same token, from observing the workers on site I could discern a certain culture resisting the use of the safety workwear and overall precaution. This is something that has been concluded by many researchers in construction before (e.g. Gherardi and Nicolini 2002; Dingsdag *et al.* 2008; Ridley and Channing 2008). However, when I started to transform from being an observer foremost into being a worker foremost other insights regarding the safety on site emerged before me. During these four weeks on the field I did also take my safety workwear off at several occasions, however this had nothing to do with the culture on

the site. The reference “*taking my glasses off in order to see*” in the title of this papers has therefore both a figurative and a literary meaning. By taking my “*observer glasses off*” and entering into a self-reflexive participating mode I could see that I was taking my safety glasses off because of the specific circumstances on the site, and by constantly hurting myself while in the worker role, I could also see that no safety introduction or safety culture could *alone* much prevent accidents from happening as the risks are also more broadly embedded in the actual circumstances of a building site.

Pink *et al.* (2012) maintained that taking an ethnographic approach in construction is a powerful way of illuminating construction practices in new ways and that it would enable problems to be reframed in ways which account for both specificities of the context to which they relate and the socialities and materialities and experiences through which they unfold. Drawing on data from an ethnographic study in which the researcher could experience the practices on a building site as they unfolded, this study has elucidated the tension and contradictions that exist between socialities and materialities within construction practices, i.e., the impetus for practice in construction is embedded in both its culture and its industry-specific circumstances, and can therefore not be explained using only either one of them.

Self-reflexivity in ethnographic studies has mainly been depicted as an approach by which the researcher considers how their status, background and experience influence the research process (cf. Clifford and Marcus, 1986; O’Reilly, 2005). In this respect self-reflexivity is mainly concerned with how the researcher’s presence is affecting the studied ‘field’. However, self-reflexivity could also be an important part of the research results. Sage (2012) illustrated how his transforming identity on the field increased his understanding of the researcher/researched relationship – and this study has illustrated how my own self-reflexivity, in itself, helped to increase my understanding of the practices of a building site, and hopefully this can serve as an enticement for the use ethnographic methods to answer research questions in construction.

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HUMAN BEHAVIOUR AND CULTURE

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A SPANISH SUBCONTRACTOR IN A UK CULTURE

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Globalisation of the construction industry has meant that people from different national cultures often work together. This creates many additional challenges for the industry, one of which is forming and maintaining a positive safety culture. This study focuses on a Spanish subcontractor working in the UK on a large construction project (+£500m). Throughout a 9-month period, an ethnographic study was undertaken to explore the safety-related challenges that were created for the principal contractor; the lead researcher was able to spend time on the project as a participant observer to gather data around this phenomenon. Despite some regarding it as suspicious, ethnography has now emerged as another approach for understanding the construction industry. This paper demonstrates that through this qualitative approach, new avenues can be explored to broaden and improve our understanding of the industry. The Spanish subcontractor had a faster but less safe culture than their UK counterparts and found it difficult to change their ways and comply with stricter regulations. During the study period, the Spanish subcontractor was stopped numerous times for safety reasons, and even temporarily removed from site. These failings led to the appointment of a health and safety advisor which did lead to some improvements. The challenges did not only occur when the Spanish subcontractor was not following regulations or revealing a poor safety culture, but also when they appeared to display competence. Under UK legislation, the principle contractor is required to check and monitor the competence of the subcontractor and their systems. However in one scenario the principal contractor did not know anything about the Spanish system the subcontractor were using, so how would it be possible to monitor competence? Findings suggest that whilst the Spanish subcontractor may have been a low-cost option initially, safety risks were increased leading to significant amounts of time, money and resources being required to attempt to control these risks.

Keywords: ethnography, migrant, Spain, UK.

INTRODUCTION

In most countries, large construction projects employ significant numbers of ethnic minorities (Dainty *et al.*, 2007) as labour and specialist subcontractors are drawn from the global construction market. Hispanic workers in the US have received some attention in literature yet there is very little or no research on Hispanic or Spanish-speaking workers in the UK. The case study project explored here is currently under construction by workers of a large number of nationalities, including the Spanish subcontractor who forms the focus of this research. This paper aims to explore the safety-related challenges of this Spanish subcontractor with a mixed Spanish and Portuguese workforce, operating within a UK culture, whilst also enabling reflection on the use of ethnography as a successful research method in this field.

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THE SAFETY OF MIGRANT WORKERS

A poor safety culture is often highlighted as a factor in the causation of accidents. Creating one positive safety culture among an organisation is a difficult task, especially when the organisation is large, which makes it harder to steer, even with full commitment (Hudson, 2007). This task becomes even more challenging when the organisation has migrant workers from various backgrounds. In the UK, there is no doubt that an influx of migrant workers is creating additional challenges to employers (Tutt *et al.*, 2011).

In a study by the HSE (2013a), migrant workers were at a greater risk in construction than British born workers because of language differences, inexperience or lack of understanding of UK Health and Safety standards and cultural differences. In 2006/07 an influx of migrant workers into the UK was identified as the reason for a 25% increase in fatalities, due to communication issues and poor work practises (Owen, 2007). In the following year almost a fifth (17%) of recorded construction deaths involved migrant workers, despite migrant workers only estimated to comprise of 2.4% of construction workers (Tutt *et al.*, 2011). Research found that two-thirds of migrant workers received no health and safety training, while the other third tended to have a short site induction, but this is often not understood or communicated effectively (McKay *et al.*, 2006). Communication barriers with migrant workers have not only been highlighted as a problem in Australia's culturally diverse construction industry (e.g. Loosemore and Lee, 2002), but Sells (2007) describes it as a 'leading concern' amongst migrant Hispanic trades workers.

The influx in Hispanic workers in the US has enabled their construction industry to meet its workforce demands, but unfortunately this has occurred with costs in health and safety of Hispanic construction workers, as Hispanic workers appear to experience a large number of accidents compared to their employment levels (Goodrum and Dai, 2005). Dong and Platner (2004) found that nearly one-third of Hispanic construction workers spoke only Spanish, and their risk of fatal occupational injury was almost twice that of other construction workers. According to Brunette (2004), Hispanic workers, in general, come to the US with a poor understanding of Health and Safety, little or no experience in building trades and had little or no government enforcement of safety regulations. With English not being their mother language, any understanding of the educational or training exercises will be significantly lower than for the native speakers. Clearly, the influx in Hispanic construction workers to the US has created additional challenges and is receiving attention. Yet, research on Hispanic migrant workers from Spain working in the UK is very limited. This could be because there are less Hispanic workers in the UK than in the US, however, as the industry becomes more global, many workers from various backgrounds will be required to work together, including Spanish and UK employees.

Workplace Accident Rates in Spain and the UK

The HSE (2013b) released European comparison figures for the estimated incidence rates (per 100,000 workers) of fatal accidents at work in 2010. This included all workplace fatal injuries except road traffic accidents and accidents on board transport. The UK had the third lowest rate (0.71 per 100,000 workers) out of the 23 European countries behind Slovakia and the Netherlands. Spain was the tenth lowest with an incident rate of 1.76 per 100,000 workers. This inconsistency between Spain and the UK may suggest there is a difference within the safety culture of the two nations.

RESEARCH APPROACH

Ethnography is an established qualitative research methodology that often uses participant observation as a main research tool. Since observational research does not intervene with the activities being investigated (Alder and Alder, 2000) ethnography is particularly suitable for studying sensitive issues (safety in construction is often a very sensitive issue) since this type of research can provide rich, detailed descriptions about the unknown or little known (Li, 2008).

This study investigates a Spanish subcontractor in a UK culture that was based at a large construction project (+£500m) for a 9 month period. ‘Moderate’ participant observation was implemented, which DeWalt and DeWalt (1998) suggest can provide a good balance of essential involvement and necessary detachment to remain objective. Therefore, although time was spent actively engaging through observations, conversations with employees and attending meetings; time was also spent detached to recording findings and avoid the risk of getting so close to the subjects that objectivity can be lost. The data collected was recorded, coded and analysed through software program, nVivo, with the highlights of the findings being summarised within this paper.

By employing this research method, the primary aim of this study was to identify the difference in the safety culture between the Spanish and UK workers and the safety-related challenges caused by a Spanish subcontractor working in a UK culture. The following ethnography describes in detail the ‘real life’ safety-related challenges that employing a Spanish subcontractor in a UK culture caused. The passages have been presented as detailed as possible to allow the reader to concur with the interpretations made or to make their own interpretations. The fact that different interpretations are possible is an accepted aspect of this type of research and does not reduce the validity of the study. For ethical reasons, and to protect the subjects within this study, names within the following passages are false.

¿DÓNDE ESTÁ EL SOL?

A Spanish Subcontractor in a UK Culture

In the summer of 2013, a new Spanish subcontractor began working on a large construction project in the UK. This offered an opportunity to explore the safety behaviours of Spanish and Portuguese operatives and management in a UK culture. However, their introduction onto the site did not last long, as they were quickly removed after causing design, operational and safety concerns revolving around incomplete method statements and risk assessments during a trial construction. On their return to work, the lead researcher, investigated through ethnography. The following passage describes highlights of the findings in first person.

The First Visit

James, one of the safety advisors, was going out to do a regular workplace inspection on the Spanish subcontractor’s site, and I had the opportunity to accompany him. On his previous inspection he found that the design of a 21 metre work platform had been incorrectly erected. There were pins and bracing that were missing, misplaced or not clipped on, while four operatives were working at the top. He had to stop the works. The temporary designs of the works were being altered between the approved documents and what was being built on-site. James was hoping to see improvements.

Once they arrived on site, they met with Pedro, one of the management staff of the Spanish subcontractor. While James addressed another issue that had arisen, I had a

chance to introduce myself and chat with Pedro. Pedro explained that he was enjoying the project and was grateful to be there, but admitted he knew his team would need to improve their safety practices if they wished to stay for the long-term. Following my further questions, he continued to say that they had been receiving severe criticism for their safety practises and ‘they were right’ to be criticised but it was very difficult to adjust their safety culture. They were used to their way of working, a way he described as ‘quicker and less safe’. He further explained that they were doing their best to reach the safety expectations but it was not proving easy.

During the inspection and other site visits, I began to observe the Spanish and Portuguese workplace behaviours. It became clear their behaviours were different to that of the UK workers I had seen on the project. The Spanish and Portuguese workers appeared to be more tolerant to taking risks: they would often walk behind moving plant without being acknowledged by the driver, use mobiles while driving and the housekeeping was not the same standard as on other sites on the project. Though UK-based workers were also observed taking unsafe risks around the project, it was not to the same frequency as the Spanish and Portuguese workers. James, the safety advisor, was also of this opinion.

Climbing the Tall Piers

On another visit, I had the opportunity to go up the piers being constructed with representatives from the Spanish subcontractor and the principle contractor including Ben, a safety rep in the section. Ben was moved to work with the Spanish subcontractor in hope that it would help to improve their ways of working. Ben had worked with Portuguese workers before so said he knew what to expect. He thought the Spanish and Portuguese workers on the project were ‘great guys’ but he did admit it wasn’t as enjoyable as working with the UK workers, due to the restrictions with language barriers. There were still many of the Spanish and Portuguese operatives that did not speak English, but Ben seemed to think their English was improving. He said to me that the Spanish subcontractor’s operatives thought it was great that the principal contractor was so concerned about their safety and had never had anything like it before. He expanded to say that it wasn’t the workers that were resistant to the safety demands, but instead the Spanish subcontractor’s management who were ‘more concerned about the bank accounts’. Though the Spanish and Portuguese operatives were happy for improved safety methods he didn’t think their behaviour had changed to become more safety conscious – they were still used to their way of working. Ben cared about their safety and had reported a serious breach by four of the Spanish subcontractor’s employees: a manager and 3 operatives had ignored a physical barrier and a red ‘do not use’ tag on the access stairs to a pier. This occurred directly after the ten minute brief, in which the contents had been created by the principle contractors H&S Manager in an attempt to improve their perceptions. This resulted in a safety re-induction of all of the Spanish subcontractor staff and an official written warning for failing to adhere to the principal contractor’s health and safety standards.

The Spanish subcontractor had placed nets around the working platform on the piers to catch any falling objects. Standing at the top of the pier, Ben and I noticed that these nets had accumulated a lot of debris that had fallen, far more than you would expect for accidental falls. During a weekly meeting with the principal contractor and the Spanish subcontractor, which I was fortunate enough to attend, this issue was brought up. The principal contractor had concluded that the nets must have been used as ‘a bin’ rather than a protective safety measure (the net is only meant to be there to

catch something if it accidentally falls). A design to close the gap to reduce the falls was insisted upon the reluctant Spanish subcontractor in the meeting.

‘What does this tell us? That concrete pours are more important than safety?’

The Weekly Meetings

As an ethnographer, I found the weekly meetings fascinating. The mood in the meeting room was tense with strong flashes of frustration and anger. For well over an hour the Spanish subcontractor would be ‘hammered’ for their failure to comply in various areas. During my first meeting, I sympathised with the Spanish employees, though it was clear others had lost their patience with them.

The meeting room also revealed the attitudes of the Spanish subcontractor's management. One of the most revealing examples revolved around a simple safety design that had been requested for months. A basic safety design was required since there was a 450mm gap between the toe-board and the handrail, which meant if objects were dropped, they could bounce on the metal walkway and over the toe-board. Hence, the toe-board was not sufficient and the principal contractor suggested using netting. On one occasion a chamfer was actually seen resting on top of a toe-board, meaning it could easily fall over the side - totally defeating the toe-board's purpose. This basic safety design had been requested for months without completion, yet when a temporary design change was needed for a concrete pour to commence, the design was ready within two hours. The Spanish subcontractor's project manager was asked directly in the weekly meeting: ‘What does this tell us? That concrete pours are more important than safety? Why can you not get us this safety design?’. The project manager replied that he could not confirm a date as it was in the hands of an external designer and out-with his control. The principal contractor found this answer hard to believe, especially when it was possible to obtain a temporary design for a concrete pour within two hours. This perhaps suggests that the Spanish subcontractor did not want to spend time and money implementing netting around the working platforms and did not perceive it as an urgent or important issue.

Many of the other safety issues were slow to being closed out including ladders on the access to the piers, which did not comply with the UK regulations. This issue was raised in October and new ladders finally arrived in March the following year. The principal contractor was also demanding the Spanish subcontractor's project manager to plan the works, a legal requirement (CDM, 2007) that was overdue. It appeared the project manager was perhaps struggling to complete this task because he was not trained to the UK standards (his UK site managers training was not for three months). He explained that he didn't know what other subcontractors were doing around them, so for example he didn't know which areas were available for loading/unloading.

On-site it appeared that there was this lack of integration between the neighbouring UK-based subcontractor and Spanish subcontractor. When speaking to Goggsy, a site manager of a UK-based subcontractor working in the site area next to the Spanish subcontractor, he explained that he was always looking for improve their ways of work and was curious to see the Spanish subcontractors systems. His suggestions to them were apparently just ignored and they seemed not interested. Despite being site neighbours it was clear that there were separate teams and safety cultures. According to Loosemore *et al.* (2010), such segregation caused by language and cultural barriers, can pose challenges with not only safety but also waste, quality and productivity.

A large construction project or a pub in England?

I also got a chance to speak with the Cristian, a member of management staff for the Spanish subcontractor. I had met Cristian in the weekly meetings but this was the first time he had the opportunity to speak with him on-site. Cristian had previously worked in construction projects in Spain, but had to move due to the difficult economic situation in Spain. He therefore came to the UK to work in a pub and learn English. After two years the opportunity arose to return to the construction industry, working on this project in the UK. When I asked if there was a big difference in safety between UK and Spanish construction, he explained that: the culture is undoubtedly very different, that higher safety standards were expected in the UK and that the codes were more detailed. He gave the example that in Spain ‘a ladder is just a ladder’ but in the UK there are required sizes and specifications. The closest he had come to UK standards in Spain was when he had worked in high-speed rail. The smaller projects in Spain were less safety conscious. Just like Pedro, he said the work on the jobs he had done in Spain was ‘much quicker than here but less safe’ and that they could do ‘a lift a day’ – a very fast rate. He did go on to say that though the culture is less safe in Spain, it is not a ‘disaster’ and he had not seen any major injuries. Comparing the statistics, a HSE report (2013) found that Spain has approximately 1 extra workplace death per 100,000 workers than the UK.²

Cristian had found it very stressful working on the project and even said that at times he enjoyed working in the bar in England more than working on this large construction project. He explained that sometimes he thought it was very frustrating working with the principal contractor, especially as the Spanish subcontractor was reliant on their equipment. Sometimes Cristian would have five men ready to work but the principal contractor would impose an action that they must do before the works could be carried. But this action, a safety requirement or other, sometimes did not require all five men, which meant a greater cost. Cristian seemed to think that the principal contractor did not seem to understand.

How do we check competence when we don’t know what they are doing?

There had been several occasions where the Spanish subcontractors had not reached the safety standards expected and work had to be stopped. However, there were even challenges when the Spanish subcontractor appeared competent. During operations the Spanish subcontractor planned to use a Spanish scaffold system; a system they appeared competent in and had all the required documentation from Spain to communicate that they were qualified and competent. Yet this system was unknown to the principal contractor, so how would it be possible to monitor and check competence in this particular system? (UK legislation – Construction (Design and Management) Regulations 2007 – requires this). It was concluded by the principal contractor that to be able to continue, the Spanish subcontractor would have to use a system that was used and recognised in the UK in order to check competence. Though through further investigation into the system being used, it was actually found to be out of date (it had been superseded since tender) and hence the system had to be changed anyway. Had the system not been superseded and had to be changed because of lack of knowledge in the work system, it would have been very frustrating for the Spanish subcontractor.

We need paperwork as well as your concrete

On another occasion on site, I got another brief opportunity to speak with Pedro. Having heard that poor method statements and risk assessments had an influence in

² UK is 0.71 and Spain is 1.76 deaths per 100,000 workers. Note this is deaths across all industries.

their initial removal during the trial construction period, I was curious if Pedro could enlighten me on such safety methods used in Spain. Pedro explained that back in Spain they have risk assessments or something similar but they are often not completed properly or even at all. He had found that the paperwork requirements on this project were much greater than to what he was used to.

‘If you pay me another salary...’

Behavioural-based safety (BBS) training was introduced across the site. One of the most powerful tools used in BBS sessions are safety videos. Yet with this tool being in English, the impact on little or non-English speaking migrant workers is significantly reduced. Translating the subtitles from English to Spanish would be a very timely procedure, and one English and Spanish speaking employee joked that he would only do it if ‘you pay me another salary’. This reduction in understanding is similar to Brunette’s (2004) findings for Hispanic workers in the US - where non-English speaking workers gained less from training than English speaking.

Safety Advisor or ‘Policeman’?

There were fears from the works manager within the section that there would be a major incident, and he had therefore requested as much coverage as possible from the principal contractor’s safety team. The problems and issues had been noted by the principal contractor’s project director, who told the Spanish subcontractor in a meeting that they had to improve. Following fears that the Spanish subcontractor could be removed from their post due to these safety concerns, they employed their own full-time safety advisor. The new safety advisor felt like a ‘policeman’, having to watch the Spanish workers very carefully. However, the safety performance certainly made improvements following his arrival. Even from the weekly meetings this was evident - safety discussions had taken over an hour, but as items got closed out from week to week, the safety aspects could be discussed within 20 minutes.

A key factor in this improvement was the liaison between the Spanish subcontractor’s new safety advisor and their management. The Spanish subcontractor appeared to feel more comfortable taking advice from their own employee, especially when it involved cost. The improvements have been positive, but there are still incidents occurring and a lot of work to do moving forward. Had this improvement not have occurred, it would have put the principal contractor in a very difficult position. If they were to remove the Spanish subcontractor, the dismissal process would have to be flawless, which would require time to gather all the evidence and issue formal written warnings. The principal contractor could also not afford to wait too long to make such a decision, as if an incident occurred and an investigation concluded that the principle contractor were mismanaging the subcontractor - by giving regular verbal warnings with no action, the principle contractor could be liable.

ETHNOGRAPHIC FINDINGS IN CONTEXT

The above ethnographic findings should be situated in relation to current understanding of Hispanic workers in an English-speaking country. In this study the Spanish subcontractor were unfamiliar with the safety demands placed upon them. This difference in safety expectations caused great stress, a factor that has been suggested to have a contributory role in accidents (Murphy *et al.*, 1986). The differences in national culture also caused issues with systems of work and paperwork expectations for method statements and risk assessments. In reflection, it is therefore of no great surprise that Brunette (2004) stated that a clear understanding of the

cultural backgrounds of the Hispanic workforce is critical. As well as causing issues and stress with the systematic practices, this study also found that the difference in national culture also brought other negative factors such as: lesser safety training and supervision, inadequate safety knowledge, communication and literacy issues. These negative factors were also identified in a study by CDC (2008) as contributory factors for 200 Hispanic workers deaths in the US. The concerned principal contractor acted on these negative factors by ensuring all safety communication was available in both Spanish and English, having BBS training sessions and insisting on the appointment of a full-time safety advisor. Though these negative factors were concerning, the two greatest concerns were caused by: the Spanish subcontractor's apparent acceptance of unsafe conditions and their desire to work fast.

The Spanish subcontractor's site was subject to a variety of unsafe conditions usually involving poor housekeeping; though more severe conditions were witnessed such as the incorrectly erected 21 metre high working platform. Despite the safety issues caused by such conditions the workers appeared to tolerate these risks. In a study by Roelofs *et al* (2011), Hispanic workers in the US felt that their only option in opposing unsafe conditions was to leave the job, rather than 'speak out' against these conditions, and that the 'need for a job' was often a factor in tolerating the unsafe conditions. At the time of this study, Eurostat (2014) had Spain's unemployment rate at a staggering 25.6%, compared to the UK's 7.1%. Such economic disadvantage has been used to partially explain why there is disparity in injury rates by investigators (eg. Pransky *et al.*, 2002). Though this lack of opposition to unsafe conditions may have been due to the 'need for a job' and economic disadvantage, the reluctance to 'speak out' against hierarchy has been found to be within Hispanic national culture. One of Hofstede's (1997) four original dimensions, Power index (PD) is related to how the hierarchical structure of the organisation is interpreted and in countries with high PD, the management's authority is accepted as a natural consequence of inequality. Spanish speaking countries score highly on PD and despite Spain being in the lower end of this group with 57, this score is still considered high. In such high PD cultures, organisation is hierarchical with decision making decentralised (Mearns and Yule, 2009), which means decisions related to safety are made by superiors and are expected to be obeyed by subordinates (Gyekye and Salminen, 2006). This cultural trait could also partially explain why there was a high turnover of operatives in this study - workers were more likely to leave than discuss their safety concerns or other problems. This high turnover was frustrating for the safety management that were trying to change and improve safety attitudes and behaviours; a frustration that corresponds with literature, which has suggested that stable groups are linked with low accident rates (Gherardi and Nicolini, 2002).

The Spanish subcontractor would work at a much faster rate and were aware that this approach was less safe. The workers appreciated emphasise on safety, but thought the managers were less involved in safety for financial reasons. In Roelofs *et al*'s study a similar conclusion was found; that Hispanic workers in the US were found to be under greater pressure to work fast, often to assure supervisors' bonuses. The workers in Roelof *et al*'s study also took responsibility for not taking safety precautions themselves and 'going along' with it - again a high PD culture trait.

CONCLUSIONS

In this study, the Spanish subcontractor was initially a low-cost option, but due to cultural differences there were increased risks and safety-related challenges. The Spanish subcontractor's risk assessments and method statements were originally of a

lower standard, and it appeared that their workers were more prone to taking risks, such a walking behind moving vehicles. Language barriers seemed to cause confusion and separations in the safety culture, make work less enjoyable, limit interventions and make it more difficult to improve behaviours through training. These issues resulted in extra expense and the need for additional resources including extra supervision, training available in other languages (or having interpreters) and having posters, signs, toolbox talks, ten minute briefs available in other languages. There were also challenges when the Spanish subcontractor appeared to be displaying competence, as a system they were using was unknown to the principal contractor and hence they could not monitor competence. It is recommended that for future cross cultural collaborations, such challenges are planned and priced for.

There has been very little research into differences in safety culture on construction sites across various nations. This could be due to the narrow research methods used in the industry. Pink *et al.* (2013) describe the strength of the ethnographic approach as being able to make informal (or unofficial) practises, interactions and ways of knowing visible. Despite all the safety-related challenges discussed that were made visible through this ethnographic approach, the accident and incident statistics of the Spanish subcontractor were not noteworthy in comparison to others on the project. Hence had a more traditional quantitative approach been applied these issues could have gone unnoticed. This paper adds weight to the argument that through ethnography, new avenues are possible which can widen the range of findings and understanding in the industry.

Statistical evidence suggests that Spain is a more dangerous place to work than the UK. In this study, the Spanish subcontractor acknowledged that their safety culture within the construction industry is 'less safe' but more productive. This may have resulted in a national cultural clash that could feasibly have led to many of the safety-related challenges outlined. As the industry becomes more globalised, with employees from a variety of backgrounds having to work together, understanding this area will only gather importance.

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MALAYSIAN CONSTRUCTION PROFESSIONALS: WHY ARE THEY LEAVING?

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War on global talents has been going on for decades and the international mobility of talents has been increasing and has caused tremendous downside effects to countries such as Malaysia. According to the World Bank, up until 2010 there were estimated 1 million Malaysians working abroad and thus instigated the establishment of Talent Corporation in 2011. Nevertheless, in order to effectively entice these talents in coming back, finding out who are they and the main reasons they left Malaysia in the first place are mandatory. Although there are many researches in this area, little is known with regards to Malaysia, *let alone* the talent loss among the Malaysian construction professionals. An empirical study using a quantitative survey and interviews was carried out amongst Malaysian construction professionals working abroad, in an attempt to identify their characteristics and determine the main push and pull factors. By using SPSS and Rasch model of measurement, these factors are then ranked according to their importance. Interestingly the Malay professionals left Malaysia after gaining experience thus they are older as compared to the Chinese professionals. In addition, the most important reason of leaving Malaysia is due to lower income received in Malaysia. However, surprisingly other important motivations are related to personal behaviours such as to get exposure, curiosity, to challenge one's ability and also to live and work in a better environment. Therefore the main reasons are not just about money issue, they also revolve around other aspects of life. These findings hopefully would provide some insights for policy makers and the government in identifying this group of people and understanding the reasons they are leaving and thus could come up with more effective programmes of retaining and attracting these valuable talents in overcoming the talent loss phenomenon.

Keywords: brain drain, construction professionals, push and pull factors, talent loss.

INTRODUCTION

War on global talents has been going on for decades. During the post-World War period, many talents such as doctors and scientists left Britain for the United States (Hansen, 2003). At that time the United States was undoubtedly the leader of western science and magnet for top-level European scientists and technicians (Brandt, 2004). The international mobility of talents has been increasing since and has causes tremendous downside effects on third world countries that are supplying these talents such as South Africa (Mattes and Richmond 2000). After all the money spent on educating them to become highly talented persons is lost investment when they move to the Organisation for Economic Co-operation and Development (OECD) countries

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instead of servicing their own country. The series of economic and political changes have great influence on the migratory flow of the highly skilled. However the immigration policy in the receiving countries was the chief reason for the increase in talent loss (Lowell, 2001). For example, some countries would grant permanent residence status and even citizenship status if the person possesses rare and highly valuable talent.

Looking at the Malaysian scenario, as early as in the nineties, a research on Malaysia talent loss was conducted and the result alarmingly reveals Malaysia has the highest talent loss of tertiary educated population (Carrington and Detragiache, 1998). A more recent study has reported that the once attractive immigration country, Malaysia starts to lose her best and talented brains to other countries in this region especially to Singapore (World Bank, 2011). In 2010, it was estimated that 1 million Malaysians are working abroad and from this figures, 30% of them have tertiary education, i.e. the highly talented or skilled people. This happened after Malaysia was placed at the fourth spot out of 59 countries for its high public expenditure on education versus Gross Domestic Product (IMD, 2010). So far in terms of global war on talents, Malaysia is already losing the battle due to the outflow of highly talented citizen to other countries. Previous research on Malaysians diaspora was carried out on respondents that involved almost 50% overseas students and 80% of Chinese ethnic (Foo, 2011). However little is known concerning Malaysian construction professionals. Therefore this research aims to identify the characteristics of the Malaysian construction professional diapora and to identify the main push and pull factors behind this phenomenon among the Malaysian construction professionals.

Push and pull factors initiating migration are present in the source as well as in the receiving regions of migrants (Lee, 1966). Unfavourable conditions in the emigration places are traditionally defined as the push factors, and the benevolent conditions the faraway places are determined as the pull factors (Krugman and Obstfeld, 1991, Sylvester 1993, Filler *et al*, 1996; Jovanovich, 1997; Tassinopoulos, Werner, 1998). Some authors (Brandi *et al*, 2003) found out that push factors are more common to unskilled mass migration, and the pulls ones are likely to affect more highly skilled migration. Salary differentials between less developed countries and more developed countries often cited as the main attractant are but an indication of the expected real productivity of the émigrés (Keely, 1986).

METHOD

Target population

The target population for this study is the Malaysian construction professionals working overseas. However the lack of official statistics on the brain drain made it difficult to select indicators and sample dimensions. A record of who have stayed behind and who have left was not available from their respective professional bodies and from the Immigration Department. In order to identify these respondents, snowball nonprobability sampling technique was used (Chua, 2006; Cresswell, 2009). At first the samples were selected among friends and personal networks. These respondents are currently working with companies other than Malaysian companies and also staying in the host countries. Then more respondents were introduced through their personal contacts and through Malaysian community associations in the host countries. This study managed to identify 127 Malaysian construction professionals based mostly in Europe, Middle East, Asia Pacific and Asian countries. The respondents came from different background ranging from quantity surveyors,

architects, engineers, technical assistants and technician. The professional status is equated with tertiary level of education. Semi-structured interviews were also conducted in getting more in-depth information in relation to the questionnaire answered earlier.

DATA COLLECTION

Questionnaire survey was administered through open source web survey software. Each of the respondents was contacted via email with the questionnaire attached. Once they agreed to participate in the study, they were allowed to answer the questionnaire already provided. To ensure that only the targeted group responded to the questionnaire, four initial screening questions were asked in the survey; 1) their highest academic qualification, 2) their occupational group, 3) their current location and 4) the origin of their company. A total of 152 responses were received but only 127 (83.6%) respondents answered affirmatively to all four screening questions. The questionnaire was adapted from brain drain studies by Inkson (2004), Hugo (2004), Sheehan (2006) and Baruch *et al* (2007).

The second stage of data collection was conducted through semi-structured interviews. Four respondents; each from Australia, The Netherland, Singapore and United Arab Emirates had agreed to be interviewed. The sessions were conducted using Skype chat and call, and ranged in length from 60 minutes to 4 hours. Questions were asked based on the questionnaire that each of the respondents had previously answered in order to probe deeper and understand a particular phenomenon (Shelden *et al*, 2010 and Cresswell, 2012).

Sample

From 127 respondents, only 24 (18.9%) were female and 103 (81.1%) male. In this study, respondents were divided into 10 groups according to their host countries as displayed in Table 1.

Table 1: Host countries of respondents

Host countries	Frequency	Percent	Cumulative Percent
Singapore	16	12.6	12.6
Australia	8	6.3	18.9
UK/Europe	21	16.5	35.4
Saudi Arabia	4	3.1	38.6
UAE	18	14.2	52.8
Bahrain	5	3.9	56.7
Qatar	41	32.3	89.0
China	6	4.7	93.7
Thailand/New Zealand/ Columbia/Brunei/India	8	6.3	100.0
Total	127	100.0	

There were 13 countries involved and surprisingly Qatar provided the most numerous feedbacks even though World Bank (2011) reported that many Malaysians were in Singapore. Meanwhile United Kingdom came in second, followed by United Arab

Emirates. Singapore however came in fourth. In addition there was also one respondent from Columbia and India respectively.

With regards to the ethnic of the respondents (refer Table 2) Malay and Chinese were almost equivalent in number but the Indians and other races form a minority group.

Table 2: Ethnicity of respondents

Host countries	Frequency	Percent
Malay	64	50.4
Chinese	53	41.7
Indian	4	3.1
Others	6	4.7
Total	127	100.0

This proportion however cannot be related to the population of Malaysia citizen whereas at 2010 50% were Malays as opposed to 22.6% who were Chinese (Department of Statistics Malaysia, 2011). However the Chinese respondents made up more than 40% in this survey. Even though strong attempts had been put to get more respondents with architectural and civil engineering background, almost 60% of the respondents were from quantity surveying background and the second biggest group was from the mechanical and electrical background.

The age of the respondents ranged from 24 years old to 62 years old with 37 years old as the median age. Further analysis on the race of respondents shows that the majority of Malay respondents were between 35 to 50 years old while majority of Chinese respondents were between 26 to 40 years old. More than 80% of the respondents had acquired their bachelor degrees and almost 30% had acquired master degrees. Still there were quite a number of diploma holders among them. This is to be expected, as the sample focuses on the professionals.

Their mean salary in Malaysia was RM5280 but overseas, their mean salary was RM22,619, which is almost four times more. The majority of the respondents received incomes between RM 5,000 to RM 25,000, with the biggest group is in the RM11,000 to RM15,000 range. The maximum salary in Malaysia was RM23,000 as compared to RM65,000 in Qatar.

Analysis was carried out to identify the level of experience of the respondents. The data revealed that there were two categories of people who went abroad; the younger group who left to further study and decided to remain and the older group who left after gaining experience. The median experience was 14 years and the mean is 13.6 years (*Median*=14.0, *Mean*= 13.6). By coincidence the Chinese respondents were the majority with less experience, with 17 (32%) out of 53 from 0 to 10 years' experience in comparison to the more experience Malay respondents with 53 (82%) out of 64 with experience between 11 to 25 years of experience. Furthermore the result also indicates that the majority of the experienced Malay professionals (82%) were located in the Middle East, especially in Qatar (56%). Meanwhile the Chinese professionals concentrated in Singapore (28%) and the UK (28%).

Instrument

Initially descriptive statistics were used to describe trends or patterns in the characteristics of the respondents (Cresswell, 2009; Sekaran and Bougie, 2009; Chua, 2012). This study used the Statistical Package for the Social Sciences (SPSS) version

20.0 to analyse data that was collected from the online questionnaires. Determining the push and pull factors is vital in understanding the major reasons our Malaysian construction professionals left their country. This study adapted measures from previous studies as stated earlier. There were 23 items under 7 variables of career related, personal behaviour, national policy/regulation, children education, environment/surrounding, family related and lastly business related. The response options for all items using 5-point Likert scale were ranging from (1) strongly disagree to (5) strongly agree. As Bond and Fox mention (2007), this explicitly recognizes the scale as ordered categories only, where the value of each category is higher than of the previous one, but by an unspecified amount. That is, the data are regarded as ordinal (not interval or ratio) data. Also, the model transforms the counts of the endorsements of these ordered categories into interval scales based on the actual empirical evidence, rather than on some unfounded assumption made beforehand. Consequently, the Rasch model analysis of data from Likert-type items in opinion/attitude questionnaire is intuitively more satisfactory and mathematically more justifiable than the traditional approach of the summative method.

The seven variables are as mentioned below:

Career related variable was measured by comparing between Malaysia and overseas in terms of lacking in employment opportunities, professional development, job recognition and appreciation; lower and static salary received, working under poor environment, similar modus operandi and discrimination in the organisation.

Personal behaviour variable was measured by 4-items scale that examined individual needs such as curiosity/to seek adventure of working abroad, to get exposure of living in different country and becoming world/global citizen.

National policy/regulations was measured using 2-items scale that related to inequality in ethnic politics or policy issues and tax system. Lack of access to quality education for children was the item under children *education category*.

Next was the *environment or surrounding* category that comprising of 2-items scale; lower quality lifestyle (safety, cleanliness etc.) and support from sizeable Malaysian community overseas.

Expanding or establishing new business might be one of the reasons people went abroad and it was measured under *business related* variable

Lastly was *family related* that was measured by examining their spouse's nationality, employment, due to separation or divorce and whether to be close to family members overseas.

RESULTS

Analysis was carried out using Rasch model of measurement in order to produce linear measures with the logit unit since the data were ordinal data. Summary of the results provides high person reliability (0.86) and item reliability (0.98) with 0.86 Cronbach Alpha. Hence Table 3 shows all the variables ranked in order of logit units with the lowest logit being the easiest factor to endorse and the highest logit being the most difficult factor to endorse.

Table 3: The push and pull factors in ranked order of endorsement

Item	Total Score	Measure (logit)	Rank	Remark
Lower income	588	-1.07	1	
To get exposure	539	-0.37	2	
Curious / to seek adventure	518	-0.18	3	
To challenge ones ability	514	-0.14	4	
Static salary increment	507	-0.08	5	
Lower quality lifestyle	500	-0.03	6	
Lack job recognition	471	0.18	7	
Poor working environment	467	0.21	8	
Inequality in ethnic politics	466	0.21	9	
Becoming world/global citizen	453	0.30	10	
Lack promotion	446	0.34	11	
Stringent tax system	435	0.41	12	
Lack access to quality education	419	0.50	13	
Lack professional development	403	0.59	14	
Discrimination in organisation	401	0.60	15	
Sizeable Malaysian abroad	400	0.61	16	
Similar modus operandi	393	0.65	17	
Lack employment opportunity	360	0.83	18	
To establish/expand business	299	1.17	19	
Due to spouse's employment	258	1.42	20	
To be close to family abroad	216	1.74	21	
Married to non-Malaysian	203	1.86	22	
Due to separation/divorce	187	2.04	23	

The result shows that *career related* variable which is received a lower income in Malaysia is the easiest to endorse factor and this is the main reason the Malaysian construction professionals left their country. As previously mentioned, the difference in salary between Malaysia and overseas is almost quadruple. Receiving higher salary is more important for older professionals because of commitment in raising their families in host or home countries. Older means more experience and in this study a large number of the respondents is in this category (*Median*=14 years). Thus it is not surprising that this factor is the easiest to endorse.

Personal behaviour such as to get exposure working overseas is in second place of the most agreeable factors. For example in the field of offshore architecture, one interviewee has opted to move to The Netherland since it is technologically more advanced and more challenging in comparison to Malaysia. International exposure is not just important to them but also to their children. As said by one of the respondent, intercultural change would broaden the children's mind, as they get to mingle with other kids with different backgrounds. Next is curiosity or to seek adventure as the reason that pushed these professionals abroad. 28% of the respondents have at least one family member or distant relatives working abroad. Stories and experiences narrated may have stirred curiosity and encouraged others to seek the same adventure as well. To challenge one's ability was the next most agreeable factor in deciding to become expatriates. In general, the Malaysian construction industry has been using the traditional method of construction with few mega projects launched. Therefore there has not been much opportunity for Malaysian professionals to be involved in cutting-edge construction. Going abroad gave them the opportunity to be involved in mega projects and at the same time to challenge their ability in handling and managing different types of construction works. 54% of respondents from the Middle East

countries have the most experience (*Mean* = 17.7 years) compared to other countries (*Mean* = 8.8 years). They were involved in construction of skyscrapers and oil and gas related construction uncommon in Malaysia.

The fifth most agreeable factor is the *static salary increment*. Salaries in Malaysia have been increasing but at the same time the costs of living has also been increasing. This means that there was little spare cash left.

Lower quality lifestyle includes bad work-life balance experienced in Malaysia had made an impact to the Malaysian construction professionals, thus it is ranked sixth. A respondent from Australia mentioned that his work-life balance was currently excellent as compared to when he was in Malaysia. Back then, he had to work even on weekends and consequently spent less time with his family. But in Australia, when it comes to family matter, his employer forced him to attend to his family first. At the office everybody respects each other's obligations to their family, a value that was hard for him to enjoy in Malaysia.

Lack of job recognition received from Malaysian employers also had some impact towards pushing these professionals away to other countries. It was not the working culture in Malaysia for employers to appreciate good work done by employees, as voiced out by one of the respondent. Simple phrases like "*thanks for your help*" or "*good job*" or "*brilliant*" is more than enough for employees to feel appreciated. During his tenure in Malaysia, he accepted that non-appreciative words were just the way the architect work.

Poor working environment is ranked 8th out of the 23 factors listed. According to one of the respondent, in Malaysia, working hours was normally from 9.00am - 6.00 pm. If the employee went home on time, the boss would have questioned, and this occurred every day. Working until 10pm at night was considered normal for the employees and most of the time they worked past midnight. There was no time in lieu system in Malaysia; no matter how late the employee worked the night before, he must be in the office at 9.00 am on the dot the next morning. However the practice is so much different overseas where any overtime needs to be justified and the employer would ask if the employee can do the given task or not.

In contrast to many reports by Malaysian mass media saying that race biased politics was the main reason Malaysian Chinese have been leaving, surprisingly *inequality in ethnic politics* is ranked 9 in terms of most agreeable factor. However the Bumiputra privilege has become a very big issue socially and politically when it comes to the quota and status given to the Bumiputra as stated in the Malaysian Constitution. The Chinese has been very vocal in supporting the meritocracy system. In this study, the Chinese respondents made up 41.7% of the sample population as compared to the Malay respondents (50.1%) and there is significant difference between answers from both ethnic groups.

As the list goes on, the factors have become more difficult to endorse and that includes family related factors. Thus to be close to family members abroad, married to non-Malaysian and due to separation or divorce are the most difficult factors to be endorsed by the respondents and it could be said that these have nothing to do with their expatriation.

CONCLUSIONS

These findings provide a new insight to the issues of talent loss or brain drain among Malaysian construction professionals. To some point it also confirms some of the

results from the previous research on Malaysian diaspora which was presented by 50% of students studying abroad (Foo, 2011), such as the most important push factors is the lower income received in Malaysia as compared to other countries such as the Middle East countries. On top of that personal behaviours are mainly the main factors these people are leaving. These professionals are encouraged to go abroad not because of the external factors but because of their own personal traits as suggested by Selmer (2010) in the study among academic expatriates. This empirical study also verifies that inequality in ethnic politics is not the most important push factor as portrayed by other researchers (Tyson, 2011) when it comes to the Malaysian construction professionals. The effect of each push and pull factors are also depends on the host country. For example, tax system is totally different from one country to the next. In UAE, there is no individual income tax imposed on the citizens and also on the expatriates. However in European countries the individual income tax imposed is even higher than Malaysia. Such variations may have affected the results of this study as about 54% of the respondents were working in the Middle East countries. Nevertheless, demographic factors such as spouse's employment, having family members abroad, married to non-Malaysian and due to separation or divorce are among the least affected factors in deciding to go overseas.

Demographically reveals that more men went abroad as compared to female. Further analyses disclose that there was some ethnic bias when it came to level of experience. Malaysia is losing valuable talents among the Malay construction professionals because they left after gaining experiences in Malaysia as compared to the Chinese professionals who left for their tertiary education and have decided to remain in the host countries and gain their experience there. The trend of the more experienced professionals who could contribute more towards the Malaysian construction industry leaving and providing their specialist elsewhere is most likely continuing. However if the Chinese professionals decided to come back eventually, much will be gained due to their training, practices and experiences that they have gained throughout the years while working overseas.

There are a few limitations of the study to prevent it from producing generalised statements. One limitation is the bias from the skewed distribution of respondents towards the Middle East countries. Another potential limitation is the bias of the occupation of the respondents towards the quantity surveying professionals. Further studies in this area should try to get a more balanced number of respondents across different countries and occupations in order to eliminate some of the weaknesses of the current study.

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THE OUTCOMES OF CROSS-CULTURAL ADJUSTMENT: A CASE OF BRITISH EXPATRIATES WORKING ON INTERNATIONAL ARCHITECTURAL, ENGINEERING AND CONSTRUCTION ASSIGNMENTS

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The main aim of this study is to investigate the consequences of cross-cultural adjustment in an under researched sample of British expatriates working on International Architectural, Engineering and Construction (AEC) assignments. Adjustment is the primary outcome of an expatriate assignment. According to Bhaskar-Srinivas *et al.*, (2005), Harrison *et al.*, (2004) it is viewed to affect other work related outcomes which could eventually predict expatriate success. To address the scarcity of literature on expatriate management in the AEC sector, an exploratory design was adopted. Phase one is characterised by extensive review of extant literature, whereas phase two was qualitative exploration from British expatriates' perspective; here seven unstructured interviews were carried out. Further, cognitive mapping analysis through Banaxia decision explorer software was conducted to develop a theoretical framework and propose various hypotheses. The findings imply that British AEC firms could sustain their already established competitive advantage in the global marketplace by acknowledging the complexity of international assignments, prioritising expatriate management and offering a well-rounded support to facilitate expatriate adjustment and ultimately achieve critical outcomes like performance, assignment completion and job satisfaction.

Keywords: British expatriate, adjustment, performance, job satisfaction, assignment completion, international assignments.

INTRODUCTION

Globalization, uncertain domestic markets and increasing competition have encouraged construction firms to internationalize (Santosa and Loosemore, 2013), resulting in international job mobility which has now become a common experience for growing number of people (Bonache, 2005). Parent country nationals are usually sent on these international assignments to ensure that the policies and procedures of the home office will be carried out in the foreign operation (Gudmundsdottir, 2013). The primary purpose of expatriation is to transfer knowledge (Reiche and Harzing, 2011), set up subsidiary offices, manage subsidiaries or in some instances handle multiple projects. These relocations are inherently costly and have both positive and negative outcomes. Unsuccessful assignments could lead to high downtime costs, direct moving costs, damaged reputation of the firm etc. (Dowling

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and Welch, 2004). Successful assignments on the other hand could lead to retention of repatriates, encourage international mobility among employees, deployment and transfer of expertise etc. to name a few (Yan *et al.*, 2002). Operating in a different cultural setting is demanding (Ko & Yankg, 2011), to such an extent that the cultural shock experienced by the expatriate significantly affects his/her performance and consequently the assignment completion (Hall, 2005). In all these aforementioned cases, cross-cultural adjustment of the expatriate is paramount. Adjustment is defined as a state where variations or modifications become apparent in an individual to accommodate environmental demands (Berry, 1992) like, differences in culture and language, living conditions and working harmoniously with co-workers from different cultural backgrounds (Jassawalla *et al.*, 2004). Inability of expatriate to adjust to new setting is acknowledged as the main cause of expatriate failure (Min *et al.*, 2013). Hence, researchers like Shaffer *et al.*, (2006); Hechanova *et al.*, (2003) and Caliguiri, (2000) have explored factors predicting cultural adjustment. However, little attention has been devoted to investigate the work outcomes of adjustment. It is only recently that researchers like Caliguiri *et al.*, (1999); Kramier *et al.*, (2001) and Takeuchi *et al.*, (2009) have explored job satisfaction, performance, commitment and assignment completion as possible outcomes. In general, research has shown that well adjusted expats show high job satisfaction, performance and are less likely to quit (Hechanova *et al.*, 2003; Shaffer and Harrison, 1998).

Since very few studies have looked into the challenges of managing people on construction related assignments (Santoso and Loosemore, 2013), the main purpose of the current study is to investigate the outcomes of cross-cultural adjustment in an under-researched sample of British Architectural, Engineering and Construction (AEC) professionals posted on international assignments by their parent company. Particularly because international construction projects are characterised by differences in cultural norms, regulations, routines, work cultures, institutional work practices, safety standards, language barriers, etc. (Chua *et al.*, 2003; Orr, 2005). Since cultural differences become apparent in every aspect of the business, in-depth understanding of the local environment becomes critical for both AEC professionals (Kangari and Lucas, 1997) and construction companies operating in international markets (Kivrak *et al.* 2010). The findings of this research will not only fill the existing knowledge gap but help AEC companies to understand what practical measures could be taken to support expatriate adjustment throughout the whole process to eventually predict effectiveness on international assignments. The current paper is a part of a larger study conducted by the authors. Therefore it will only concentrate on exploring the outcomes of expatriate adjustment. Previous papers by the same researchers have covered antecedents of adjustment.

LITERATURE REVIEW

Cross-cultural Adjustment

Socio-cultural adjustment deals with the ability to 'fit into' or negotiate the aspects of the host country (Ward and Kennedy, 1996). It is defined as the degree of psychological comfort an expatriate has with various aspects of the host country (Black, 1988; Oberg, 1960; Nicholson, 1984). Based on the cultural learning theory, it emphasises social behaviour and practical social skills which underlie the attitudinal factors (Black and Mendenhall, 1991; Furnham, 1993). To provide a comprehensive understanding of international adjustment, Black *et al.*, (1991) proposed a broad theoretical framework by integrating domestic and international adjustment literature.

The argument that they put forth was that though both domestic and international relocation involve a shift to unfamiliar locations the magnitude of ‘uncertainty’ is higher on international assignments as compared to domestic adjustment. Black *et al.*, (1991) made a distinction between three dimensions of adjustment, which include: General, interaction and work. General adjustment is defined as psychological comfort relating to living conditions, weather, food, transportation, recreation etc. in the host country. Interaction adjustment is defined as psychological comfort an expatriate experiences when interacting and communicating with host nationals. It is suggested that interaction is the most difficult of the three facets. Therefore, it is not surprising that many a times cultural interactions on construction projects lead to misinterpretations, confusions, conflicts thereby increasing the risk of disputes (Bu-Qammaz *et al.*, 2006). Finally, work adjustment involves psychological comfort in the new work environment, coping with different work values, expectations, and procedures. These three expatriate dimensions are well supported in literature (Takeuchi *et al.*, 2002) and have received empirical support from Shaffer *et al.*, (1999) and Parker and McEvoy (1993).

Expatriate Performance

‘Effective performance on a job is the attainment of specific results i.e. outcome required by the job through specific actions while maintaining or being consistent with policies, procedures and conditions of the organizational environment’ Boyatiz, (1982). In keeping with the above mentioned, Campbell (1999) defines performance as a function of knowledge, skills, abilities and motivation which is directed at role-prescribed behaviour. Similar to the concept of adjustment, job performance is relatively broad and multi-dimensional (Earley and Ang, 2003). In a comprehensive study Caligiuri (1997) suggests work performance on international assignment comprises of the following;

Technical performance - It includes those activities performed by individuals that support an organization's technical core by directly executing a technical process or indirectly by maintaining and servicing technical requirements (Borman and Motowidlo, 1993).

Contextual Performance - It is defined as ‘level of effectiveness in performing international aspects of the job beyond task specific duties’ which includes helping subordinates, being a good team player etc. (Borman and Motowidlo, 1993). Studies suggest that contextual performance supports organizational, social and psychological environment more than technical performance. Caligiuri (1997) further divided contextual performance into managerial, pro-social and expatriate specific categories.

Assignment Completion

Completion of the job assignment should be considered as the most basic criterion when assessing success of an expatriate (Black *et al.*, 1992). Success according to this criterion occurs when an expatriate stays until the assigned duration of his or her assignment (Caligiuri, 1997). Contradicting this assumption Harzing (1995) suggests that premature return is not the best measure of expatriate failure because; it is far more damaging for a company if an expatriate who fails to perform adequately stays until the completion of the assignment and, completion of an assignment does not mean the expatriate failure has been avoided. Thus, researchers encountering difficulties in assessing expatriate turnover have concentrated on intentions to remain on the job assignment, early return decisions and withdrawal cognition as outcomes of expatriate adjustment (Bhaskar-Srinivas *et al.*, 2005).

Job Satisfaction

It is defined as ‘a positive emotional state resulting from the appraisal of one’s job or job experiences’ (Locke, 1976). McCaughey and Bruning (2005) describe it as ‘the difference between an employee’s perception of what he/she expects to receive and what he/she actually receives at work’. Researchers in the field of psychology and sociology conceptualize job satisfaction as an emotional response towards various facets of one’s job as opposed to Lazear (2000) who considers it to be a unitary concept measurable in monetary terms. Job satisfaction has been conceptualized to have numerous facets ranging from five (Hackman and Oldham, 1980) to thirteen (Rice *et al.*, 1989). According to Nauman (1993) extrinsic and intrinsic distinction presented by Wiess *et al.*, (1967) is most appropriate conceptualization apt for studying job satisfaction of expatriates, since no best conceptualization of job satisfaction has emerged. Therefore the three facets of job satisfaction include;

Intrinsic Satisfaction - Derived from actually performing the job task and experiencing feeling of accomplishment (Wiess *et al.*, 1967).

Extrinsic Satisfaction - Derived from the rewards bestowed upon an individual by peers, superiors or the organization. It includes; remuneration, allowances for housing, travel, education etc. (Nauman, 1993).

General Satisfaction- It is an aggregate of satisfaction with various job activities or a combination of several measures of overall satisfaction.

RESEARCH METHODOLOGY

This research strives to provide a general overview of the experiences of British expatriates with an ultimate aim to provide AEC companies with few insights about how they can enhance assignment effectiveness. This study primarily focuses on British expatriates who have been extensively involved with international construction projects since the colonial times and still continue to be an under-researched sample. Qualitative research approach was believed to be most appropriate, since it emphasises “*on the ways in which individuals interpret their social world and also embodies a view of social reality as a constantly shifting emergent property of individuals’ creation*” (Bryman and Bell 2003). Since little is known about the sample under investigation, qualitative methods were employed to get an in-depth description of their experience (Mertens, 2005) and to understand the subtleties and complexity associated with outcomes of adjustment. Interview technique was deemed appropriate because it allowed the authors to explore an individual's opinion regarding the topic under investigation. Further, unstructured interviews were chosen to provide a thick description of the experience. Unstructured interviews were either conducted face-to face or video call via Skype VoIP (Voice over Internet Protocol). VoIP technology was used for interviews in those instances where it was difficult to conduct face to face conversations. The advantage of using the VoIP is that it offers easy access, speed and is low cost (Lin, 2004). Overall seven British expatriates i.e.6 male and 1 female were interviewed which lasted between 1 to 2 hrs. The respondents were stationed in six different countries which included China, Egypt, India, Tanzania, Mozambique and Saudi Arabia. The data collected was transcribed and analysed using cognitive mapping to elicit relevant themes. The analysis of interview revealed several major themes. The findings highlight the distinctiveness and uniqueness of each individual's assignment experience.

FRAMEWORK DEVELOPMENT AND DISCUSSION

A comprehensive review of extant literature supported by qualitative interviews with British expatriates, this study proposes a theoretical framework (Figure 1) which aims to propose various hypotheses to establish the relationship between cross-cultural adjustment, performance, assignment completion and job satisfaction. The following section will review the relationship between aforementioned constructs and provide elaborate explanation for the same.

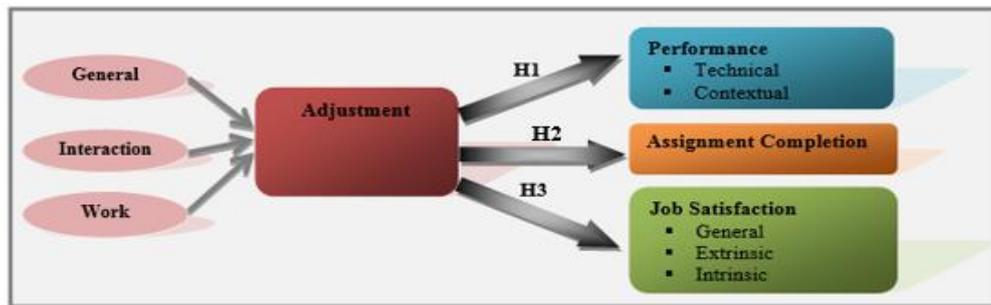


Figure 1: Theoretical Framework for outcomes of expatriate adjustment

The framework (Figure 1) highlights the pivotal role of expatriate adjustment. The main intention behind developing this theoretical framework is to assess the impact of adjustment on other expatriate outcomes to predict success on international assignments. This study utilizes the socio-cultural model of cross-cultural adjustment proposed by Black *et al* which has dominated the expatriation literature. According to SriRamalu *et al.*, (2010) adjustment is the primary outcome of an expatriate's assignment and a key determinant of expatriate success. During the interviews the expatriates were asked about their adjustment to host country culture. Majority noted that relocation to a foreign country meant that the expat and his/her family members were subjected to a variety of challenges associated with adjustment to a new and different environment. One of the respondents attributed adjustment to his motivation in this way;

'self motivation is essential, he's(expatriate) going to get motivation knocked out of him because of many obstacles that they are not used to, So you got to be self motivating and a strong character person willing to change and adapt'

Adjustment and Expatriate Performance

The relationship between adjustment and performance seems to be a logical assumption i.e. an expatriate needs to adjust in order to perform. According to Kraimer and Wayne (2004) an adjusted expatriate is well versed and maintains behaviours appropriate to the new environment, which in turn dictates secondary outcomes of performance and tenure intentions. Anecdotal evidence has suggested a positive relationship between expatriate adjustment and work performance (Aycan and Kanungo, 1997; Ones and Viswesvaran, 1997; Tung, 1981). Studies have clearly demonstrated that adjusted individuals grow to not only to enjoy their foreign assignments thereby completing their overseas contracts, but are also more productive in the process (Richardson *et al.*, 2006). Moreover, well-adjusted expatriates will have greater reserve of personal resources (time, effort and emotional investment) available to spend on behaviours that facilitate job performance (Shaffer *et al.*, 2001). During the interviews it was observed that expatriates with clear understanding of job responsibilities were productive and able to perform well. Whereas, the one's unable to deal with the transition felt completely exhausted, lost interest in completing the

assignment and yearned to return home consistent with the findings of Koteswari and Bhattacharya, (2007). To substantiate the intricate relationship between adjustment and job performance, the research framework proposes adjustment as a predictor of job performance. Consequently, the following hypothesis is proposed;

Hypothesis 1: Cross-cultural adjustment significantly influences an expatriate's performance

Adjustment and Assignment Completion

According to Earley and Ang (2003) expatriate adjustment, assignment completion and work performance are interdependent variables i.e. until and unless an expatriate adjusts to the new work place he/she cannot perform well and moreover one could expect them to return early even before the completion of the job assignment.

Hypothesis 2: Cross-cultural adjustment significantly influences an expatriate's intention to complete the assignment

Adjustment and Job Satisfaction

Primarily work related, job satisfaction has been studied as both, a predicted outcome and as predictor of cross-cultural adjustment (Black *et al.*, 1991). The present study views job satisfaction as an outcome of successful adjustment to overseas job requirements and from effective development of interpersonal relationships within the host country's workforce and customers, consistent with Shaffer and Harrison, (1998). Aryee and Stone (1996) suggest that an expatriate well adjusted to the various aspects of job requirements would derive satisfaction from the work experience. An experienced expat shares his satisfaction with the assignment as follows;

'I was very satisfied with the assignment result. We have prepared two contract documents, both have been tendered and awarded, the client was also satisfied with the result.. over the years I have developed an approach to working with overseas clients'

On the other hand, in another interview the authors observed that inability to adjust induced higher levels of stress and dissatisfaction with the project assignment. Since, job satisfaction is primarily work-related, general contention is that interaction and work adjustment may result in job satisfaction. But as suggested by Takeuchi *et al.*, (2002) there could be a spill over between general adjustment and job satisfaction i.e. expatriates experiencing adjustment difficulties and stress with the general environment in the host country, may carry over the frustration to work, negatively influencing satisfaction with their jobs. Hence it is proposed that;

Hypothesis 3: Cross-cultural adjustment significantly influences an expatriate's job satisfaction

CONCLUSION

The findings of the literature review and exploratory interviews with British expatriates suggest that adjustment has a deep influence on the effectiveness of the assignment, since only a well-adjusted international worker can operate in a completely integrated way within the host country (Schiuma *et al.*, 2006). These findings are also consistent with Shaffer *et al.*, (2001), Bhaskar-Shrinivas *et al.* (2005), Hechanova *et al.*, (2003), Shin *et al.*, (2007), Caligiuri (1997) and Kraimer *et al.*, (2001), who established expatriate adjustment as an important predictor of performance and intention to stay on the assignment. Additionally, this study

addresses the knowledge gap by including job satisfaction as the outcome of cross-cultural adjustment.

The current study contributes to literature on expatriate management within the AEC sector by presenting a framework that confirms the central role of cross-cultural adjustment as the predictor of work related outcomes. Therefore, it would be worth the company's time and expense to help expatriates develop the skills needed to interact and adjust (Van der Bank and Rothmann, 2006). Lacking foresight and appropriate strategies, organisations can hinder the effectiveness of the assignment by producing frustrated, disillusioned, discontented expatriate staff (Mammadov and Poss, 2010). Given the exploratory nature of this study coupled small sample size, the findings have limited generalisation. Therefore, future studies could be designed to quantitatively test the hypotheses and establish views of larger sample.

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DETERMINANTS OF SUCCESSFUL INTERNATIONAL EXPANSION OF CONSTRUCTION CONTRACTING FIRMS: A CASE STUDY OF PAKISTANI FIRMS

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International Business (IB) has generally examined international expansion of manufacturing firms, whereas services particularly the construction service sector has received little attention. This study has examined the firm-specific determinants (FSDs) and home country-specific determinants (HSDs) of Pakistani international construction contracting firms (CCFs). This study utilizes the mixed method approach i.e. integrating quantitative and qualitative methods. The data has been collected through the questionnaire survey, one-on-one interviews and company reports. The findings of the study show that an extensive harmony was found between the investigated firms' firm-specific determinants (FSDs) and the past studies. Investigated firms gave high competitive value to FSDs whereas they gave low competitive value to home country-specific determinants (HSDs). The findings of the study failed to support the HSD view of previous models as providing support to Pakistani international CCFs.

Keywords: competitive advantage, contracting, determinants, emerging economies, international expansion.

INTRODUCTION

Emerging economies' entry into the World Trade Organization (WTO) has sped up the process of liberalization, privatization and institutional reforms, thus pushing many firms from the developing world to internationalize in order to counter the intense competition at domestic and regional markets (Gammeltoft *et al.*, 2010). In the wake of globalization, firms are now exposed to newer challenges as they have to compete within ever changing and expanding marketplaces (Lavan and Murphy, 2007). These challenges bring new opportunities for the firms to reorient their business strategies and raise their competitive advantages.

Pakistan has been ranked as the top reformer in the ASIAN region and among the top ten reformers worldwide by the World Bank in year 2005. It is included in the Next Eleven (N-11) most important emerging markets. Construction sector is considered as one of the largest sectors in the development of Pakistan's economy. A number of Pakistani construction contracting firms (CCFs) are successfully providing services in the international markets and increasingly expanding their overseas operations though they have not received any academic attention yet (Maqsoom *et al.*, 2013). Constructors Association of Pakistan (CAP)'s record shows that around 126 Pakistani CCFs have been working in several regions including Middle East, Asia, America and

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Africa. The presence of Pakistani construction firms in such diverse regional markets show the potential which can be harnessed by building upon firm's own competitive strengths as well by increasing support of the home country. Therefore, this research examines the significance of firm's internal as well as the country level determinants in the expansion of Pakistani CCFs in worldwide markets.

Some studies like Dikmen and Birgonul (2003), Tseng and Kuo (2008) and Lee *et al* (2011) have looked at different aspects of multinational corporations from Asian developing countries, but ignored their competitive advantages which act as determinants. Hence, it is important to understand the relevant determinants within a firm and home country that formulate the competitive advantage of a firm and enable the firm to expand in to overseas markets successfully. The aim of the current study is to analyze the firm-specific determinants (FSDs) and home country-specific determinants (HSDs) that enable the Pakistani CCFs to expand internationally.

Further, the current research has used a combination of various relevant theoretical models that concentrate on the determinants for the international expansion of firms, instead of utilizing a single model approach as used by previous scholars (Seymour, 1987; Oz, 2001; Curevo and Low, 2003) to observe multinational construction firms of specific nationalities.

LITERATURE REVIEW

In order to expand in overseas, a firm needs to possess certain firm and home country related advantages in order to compete against the rivals in overseas markets (Kaleka, 2002). The earlier ones are advantages promoted within the firm whereas the latter are gained by fact of being a nationality of a specific country.

Firm-specific determinants (FSDs)

Firm-specific determinants (FSDs) are incorporated by the Resource-Based View and Eclectic Paradigm in their models under the cover of "*resources*" and "*firm-specific ownership advantages*" separately. The Resource-Based View model states that firm-specific resources which are non-substitutable, inimitable, rare and valuable are the sources for competitive assets (Barney, 1991). Sharma and Erramilli (2004) stated that firms can accomplish long-term goals and get competitive advantage over its rivals, if they contain an adequate amount of valuable resources such as assets and capabilities and use them efficiently. Hall (1993) states that firms' unique assortments of assets (e.g. land, technological equipment, reputation) and individuals that possess skills (e.g. managing people, marketing, communication) are source of competitive advantages in the global markets. Dunning (1977) recognized some of possible firm-specific ownership advantages as firm's technology and knowledge, proficient staff, physical assets and equipments, large financial capital and experience (both domestic and foreign). Hillebrandt *et al.* (1995) highlighted that the overseas reputation is vital for those firms which rely on repetitive business in an already defined market. Seymour (1987) by using Eclectic Paradigm realized that management expertise, technical knowledge, reputation and experience of foreign operations were British contractors' firm-specific ownership advantages. In examination of Singaporean firms, Cuervo and Low (2003) also used the Eclectic Paradigm and concluded that technology and knowledge, networks and reputation were their firm-specific ownership advantages.

Home country-specific determinants (HSDs)

Porter (1990) illustrates home country-specific determinants (HSDs) in detail by conceptualizing the assets using different categories in his Diamond Model. These categories include related and supportive industries (e.g. facilitation of executive and technical employees, cluster formation, sharing of activities and network setting), factor conditions (e.g. natural resources, labour, infrastructure, arable land and capital), the demand conditions (e.g. size, composition, pattern and growth) and environment for competition and firm strategy (e.g. home competition and organizational and managerial behaviour). Furthermore, Porter realizes that the international expansion of the businesses can be affected by two external factors i.e. the role played by government (e.g. to offer educational support, to make policy for capital markets, to create standards and to generate demands and services) and chance events (e.g. variations in exchange rates and production factors, wars and new creations). Rasiah *et al* (2010) stated that the support from the home government is a key factor which aids the international expansion of domestic firms. Oz (2001) with the help of Diamond Model realized that the international expansion of the Turkish construction firms was supported by the rapid growth of its markets. A group of competitive supplementary sectors, for example the construction materials industry, also promote internationalization. Political leadership and a multicultural workforce were identified as additional variables in Porter's Diamond Model by Abdul-Aziz and Wong (2010) in their study of international Malaysian housing developers. Dunning (1977) terms HSDs in his Eclectic Paradigm as "*home country-specific ownership advantages*". The Eclectic Paradigm states that the size and structure of the home industry may be included in the home country-specific determinants, which help to produce market knowledge, trained workforce and management expertise. Seymour (1987) identified consultants, domestic markets characteristics (e.g. size, growth) and support from the home government as home country-specific determinants of British contractors. While on the other side, according to findings of Cuervo and Low (2003), the potential to get sufficient supply of trained work force and financial funding were key home country-specific determinants of Singaporean construction firms.

RESEARCH METHODS AND PROCEDURES

Mixed method approach

A mixed method approach has been used for this research. This approach allows the researchers to combine the results of quantitative research (i.e., questionnaire survey) with qualitative (i.e. one-on-one interviews) to get more differentiable findings. The mixed method approach is supported for its potential to capture new comings, control inborn biases in the individual approaches and harmonize strengths (Maxwell and Loomis, 2003).

Construction Association of Pakistan (CAP) provided the mailing list of 126 Pakistani international CCFs. Also the chairman of CAP certified the research by way of a cover letter signed by him, thus providing the legitimacy to the study. The response rate in this study is 66.7 % as total 126 questionnaires were sent to the CCFs who have operated overseas and out of which 84 complete responses were returned.

Quantitative method – postal questionnaire survey

Keeping in view the research questions above a structured questionnaire was developed considering the factors as identified in the preceding discourse on firm-specific and home country-specific determinants. In order to ensure validity of the questionnaire, a combination of items developed and used by previous researchers on

internationalization of construction firms were adopted. Further, the questionnaire was pre-tested with the Chief Operating Officer of CAP and four executives responsible for business development in different international construction contracting firms in Pakistan. The structured questionnaire was then posted to the sample firms.

Questionnaire was divided into five parts and 27 questions. The first part included 3 questions related to the profile of the respondents. Four questions were asked related to the background of the firm which made the second part of the questionnaire. In the third part, two questions related to the international operations were asked. Open ended and multiple choice questions were designed to record the responses for these three parts of the questionnaire survey. The fourth part of the questionnaire included 9 items to get responses related to the firm-specific determinants. Finally, home country-specific determinants were observed through 10 different items. For the last two parts of the questionnaire, 5 point Likert response format was used with 1 representing strong disagreement to 5 representing strong agreement.

The data so collected was then analyzed using Statistical Package for Social Sciences (SPSS). With respect to internal consistency of the survey instrument, each factor's Cronbach alpha was greater than 0.7, corroborating the reliability of the items. Later, the responses were extrapolated based on the scale: 4.5-5.0 = very important, 3.5-4.49 = important, 2.5-3.49 = moderately important, 1.5-2.49 = less important, and less than 1.49 = unimportant (Kirby and Lebude, 1998; Abdul-Aziz and Wong, 2010).

Qualitative method – One-on-one interviews

In the questionnaire, the participant firms were requested for the interviews which were planned to start after the completion of questionnaire survey stage. Five firms' executives showed their consent to participate in one-on-one interviews. The use of one-to-one interviews allowed the researchers to pose follow-up questions, attain immediate feedback from the respondents and collect the additional information. Interviews were conducted in English language, however where the participants faced difficulty, local language was used for their comfort. Respondents were assured regarding keeping the respondent's and firm's identity confidential. Interviews were tape-recorded and the findings were later confirmed with the participants.

RESEARCH FINDINGS

The detail of the participating CCFs has been provided in Table 1. Seventy six of the surveyed firms (90%) were private CCFs whereas the rest eight firms (10%) were publicly listed. Primarily, Pakistani construction industry is dominated by the private sector. The surveyed CCFs were having specialization in multiple fields including building and civil, electrical and mechanical and petrochemical. Though 60% of the firms were having age more than 20 years, their year of establishment ranged from 1947 (since establishment of Pakistan) to 2007. Based on age of the firms, it can be found that these firms have been active in the construction industry of Pakistan for an average of nearly three decades (Range 5-64 years). It is to be noted here that the information provided below in Table 1 is until year 2012, as the survey was performed during 17 April 2012 to 11 July 2012.

Table 1: Profile of the surveyed CCFs

Characteristics	Frequency	Percentage
Respondent's designation		
Top management	64	76
Middle management	20	24
Firm's legal status		
Public listed	8	10
Private limited	76	90
Experience in the industry		
≤10 years old	12	14
11-20 years old	22	26
>20 years old	50	60
International experience		
≤5 years	40	47
6-10 years	13	16
11-15 years	13	16
>15 years	18	21

Source: Postal questionnaire survey

Firm-specific determinants (FSDs)

The statistical results mentioned in Table 2 reveal the level of importance attached to different firm-specific determinants (FSDs) by Pakistani CCFs. The lowest standard deviation exists in the top four ranked variables, proving the least difference of opinion among the respondents.

Interestingly, the variable to top the list is “*good reputation at domestic level*”. The frequency of domestic projects undertaken by majority of the Pakistani firms is often higher as compared to the international projects done. Hence, domestic repute of Pakistani firms matters a lot to the international clients to know their professional competency and efficiency at home. Interestingly, “*good reputation at international level*”, though still considered important, stood on the third lowest number during ranking. Many CCFs believed that their good domestic reputation when showcased to the foreign clients was appreciated and helped them win the overseas projects. During the interviews conducted to understand the ranking behaviour of FSDs, interviewees duly seconded this ranking and confirmed the higher importance of domestic reputation. In the words of one interviewee “*the first and foremost access in the international construction corridor is through contractor's reputation in the domestic market which travels in the international market paving the way for the contractor to internationalize its business*”. Another interviewee explained the importance of this variable in more meaningful way by saying “*domestic reputation comes from success history of contractor which in turn gives the contractor a confidence to take up the challenge of venturing in international market, after all moving a business in another country is not only costly but also riskier. Any contractor lacking the said confidence will lack the will of taking challenge in the international competitive market*”. The ranking of this variable at the top is the manifestation of the fact that those Pakistani

CCFs which prove their mettle at home have high chances to earn their fortune in international construction market.

Table 2: Firm-specific determinants (FSDs) of surveyed Pakistani CCFs

Variable	N	Mean	SD	Minimum	Maximum	Rank	Remarks ¹
Good reputation at domestic level	84	4.62	.582	3	5	1	Very important
Experienced and capable workforce	84	4.57	.590	3	5	2	Very important
Good contacts and networks in overseas	84	4.50	.634	3	5	3	Very important
Physical assets and equipment	84	4.36	.692	3	5	4	Important
Good contacts and networks in Pakistan	84	4.29	.742	3	5	5	Important
Advance technology and wide range of services	84	3.93	.867	2	5	6	Important
Good reputation at international level	84	3.83	.824	2	5	7	Important
Internationally experienced management	84	3.81	1.131	2	5	8	Important
Large financial capital	84	3.29	1.043	2	5	9	Moderately important

Note: ¹Means <1.49 = unimportant; 1.5-2.49 = less important; 2.5-3.49 = moderately important; 3.5-4.49 = important; 4.5-5.0 = very important

The second highest ranked FSD was “*experienced and capable workforce*”.

Experienced and capable workforce is an attribute of an organization which determines its professionalism and efficiency significantly. One of the interviewees interpreted the result as “*organization itself is only a name if experienced and capable workforce is subtracted from it. From the very first stage of technical and financial proposals up to the award of international contract, the rich human capital of the company act as an engine which drives the company’s vehicle of success. In international perspective these two dimensions become more critical as many countries try to bring their best at such international ventures making the competition tough and highly professional leaving a place only for those who are skilled, knowledgeable and able enough to convince their paymasters about the worthiness of their technical and financial proposals*”. One-on-one interviews brought forth that not all the investigated firms appointed their Pakistani executives for the foreign assignments. In some cases, only important technical managerial staffs along with two or three executives from the administration of firm were appointed in order to reduce the cost. The remaining construction workforce consisted of Pakistani and other low wage workers. In few countries of Middle East like Saudi Arabia, Bahrain and Oman, firms had to appoint and rely on the local workforce as it was the requirement of these countries.

“*Good contacts and networks in overseas*” was ranked at third highest position among the FSDs. Overseas contacts and networks reflect the technical, social, formal and informal networks (with host government, clients and other multinational firms) which helped in international expansion of Pakistani CCFs. It was identified that healthy networking and contacts across the construction supply chain are essential to make the business moves of the contractors financially viable. One of the investigated firms made its bid competitive by putting the comparatively low rates of concreting items which was made possible by the special rate quoted to contractor by the

concrete supplier because of an already existing network and relationship between the two companies. General Manager of an investigated organization reported that “*a Brazilian firm working in Qatar directly contacted the head of the business development department of his organization and expressed his willingness to make his organization part of the construction project. The business talk was initiated based upon Head business development’s prior contacts which ultimately led to the signing of the contract*”. General Manager of an investigated firm which had prior working experience with Japanese company asserted that “*possession of business contacts makes it possible to penetrate into the market facilitating the sustainability and further growth of the company; he further categorized the business contacts of the company as intangible assets and the absence of which could jeopardize the successful future of the company*”.

Five other variables were regarded as important by the investigated CCFs. These variables included physical asset and equipment, good contacts and networks in Pakistan, advance technology and wide range of services, good reputation at international level and internationally experienced management. “*Large financial capital*” was the only moderately important FSD ranked at the bottom. Some executives mentioned that to venture abroad large financial capital was needed, but others disagreed with this idea. This variable received the second highest standard deviation among the FSDs. One of the interviewee revealed that “*the importance of this variable floats as that of index point in securities’ market. It mainly depends on the project delivery system being used, mode of payment, advance payment by the client, the cash flow of an organization and also the severity of time schedule of the project, directly affecting the manpower and machine deployment requiring huge financials in short time*”. One of the firms got a contract which was partially on EPC basis and partially on traditional contracting requiring contractor to pull significant sum of money from its financial pool. Had it not enough money in its financial pool it would have lost the opportunity in spite of its technical expertise and experienced personnel. Two of the executives mentioned that they enter the markets through ‘agents’ and ‘brokers’ with minimal financial capital. Thus in their case, large financial capital was not needed as they only needed internally sound and reliable financial capital to operate overseas.

Home country-specific determinants (HSDs)

Regarding the home country-specific determinants (HSDs), respondents considered only two of the variables as important, while the remaining were regarded as moderately important and less important (Table 3).

“*Sufficient supply of trained workforce*” was regarded as the highest and important among the home country-specific determinants (HSDs). The manpower including both skilled and unskilled, required for typical construction projects is readily available and can be engaged in overseas projects. Pakistani workforce has a history of contribution to construction industry of Middle Eastern countries especially Saudi Arabia, Qatar, Oman, UAE and Bahrain, where thousands of craftsman and engineers have rendered their services. One of the interviewee informed that “*his firm hired its own country personnel in the head offices in Pakistan and mobilized the same individuals to serve at the regional offices in foreign countries along with hiring of other Pakistani nationals at overseas to work at operational levels*”. Further, it was identified from the interviews that sufficient supply of workforce from home country enabled CCFs to estimate precisely for salary expenses of the work force which is very important if

firm wants its cost estimates to be realistic. Deficiency of work force pushes firm to rely on work force of other countries on higher wages ultimately increasing actual expenses much more than planned. Therefore, more the domestic hiring more is the saving on expenses.

Table 3: Home country-specific determinants (HSDs) of surveyed Pakistani CCFs

Variable	N	Mean	SD	Minimum	Maximum	Rank	Remarks ¹
Sufficient supply of trained workforce	84	4.19	.804	3	5	1	Important
Good related and supportive industries	84	4.07	.808	2	5	2	Important
Multicultural workforce	84	3.45	.803	2	5	3	Moderately important
Respond to foreign competitors who came to Pakistan	84	3.33	1.052	2	5	4	Moderately important
Rapid economic development	84	3.24	.958	1	5	5	Moderately important
Small and sporadic market condition	84	3.19	1.018	1	5	6	Moderately important
Respond to Pakistani competitors who went abroad	84	3.12	1.152	1	5	7	Moderately important
Ease to get financial funding from local banks or government institutions	84	2.71	.944	1	5	8	Moderately important
Support from the home government	84	2.57	.966	1	5	9	Moderately important
Good political leadership	84	2.07	.677	1	3	10	Less important

Note: ¹Means <1.49 = unimportant; 1.5-2.49 = less important; 2.5-3.49 = moderately important; 3.5-4.49 = important; 4.5-5.0 = very important

The second highest ranked HSD was “*good related and supportive industries*” and was regarded as important by the respondents. The outputs of many industries served as a fuel for the CCFs venturing overseas. These supportive industries included mining, manufacturing, transportation, energy, banking, insurance and so forth. The interviewees of the investigated firms opined that the importance of the infrastructure which refers to “*good related and supportive industries*” is undeniable in the context of construction; and international construction being a subset of larger construction industry at home is strongly influenced due to these supportive industries. The growth of supportive industries helps construction industry to get nurtured professionally and to take on larger projects. One of the interviewees elaborated that “*with the passage of time, the enrichment of the technical pool of firm reaches the stage where the contractors are capable enough to venture abroad. Supportive industries have grown with time to support mega projects which have been executed in Pakistan including dams, motorways, high rise towers and real estate projects; the experience gained over the years has raised the level of Pakistani contractors enough to internationalize and compete in foreign market*”.

Seven variables were regarded as moderately important determinants for international expansion of Pakistani CCFs. These variables included multicultural workforce, respond to foreign competitors who came to Pakistan, rapid economic development, small and sporadic market condition, respond to Pakistani competitors who went abroad, ease to get financial funding from local banks or government institutions and support from the home government. The lowest ranked variable was “*good political*”

leadership” with lowest standard deviation among all the HSDs. It was rated as the less important variable. Pakistan is one of those countries where politics and democracy are still in their infancies and will take great deal of time to be stable and mature. Broadly, all the firms’ executives agreed that political leadership and government support didn’t contribute in promoting their construction business globally. Due to frequent toppling of democratic governments and disruption of political process, the political leadership has to go a long way to groom itself and stabilize the political institutions. Thus, it is easily comprehensible that “*good political leadership*” is not a significant determinant when it comes to Pakistani construction industry.

CONCLUSIONS

This study has tested the determinants of Pakistani international CCFs at firm level vis-à-vis at the home-country level and analyzed how they influence their process of international expansion. Pakistani CCFs rely more on their indigenous firm based advantages than the home-country level advantages. Due to instable political conditions, uncertainty in macro-economic indicators, lack of access to reliable credits from the financial institution of country and variations in government’s overseas employment policies, firms focus more on their own strengths. They develop their own domestic repute which helps them earn good name overseas. Pakistani CCFs develop their own professional ties across the border and enhance their professional capacity of their teams to make place in the internationally competitive construction markets. In the light of these findings it can be safely said that Pakistani international CCFs depend more on their own firm-specific advantages and keep building upon them according to international best practices learnt from global experiences. They rely little on the home country-specific advantages due to risks and uncertainties involved. Therefore, the theoretical framework for the home country-specific determinants (HSDs) argument is not validated by the current research, thus challenging the Eclectic Paradigm (Dunning, 1977) and Diamond Model (Porter, 1990).

There is limitation for this study that the nature of data collected through questionnaire is based on self-judgment of the respondents and the results may differ with reality. The obtained findings of this research should have managerial implications for international CCFs from Asian developing economies (like India, Iran and Bangladesh) who share the same profile in terms of economic development, geographical proximity and construction market structure. The useful insights of the research would provide practical assistance for the CCFs in order to enhance their competitive advantages and succeed in the global markets. The current findings would further enable the Government of Pakistan to provide a more stable political and macro-economic environment and supportive policies regarding labour, credit availability and liberal export so as to improve the international expansion of Pakistani CCFs.

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HEALTH AND SAFETY AND WELL-BEING

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SAFETY AND VOLUNTEER CONSTRUCTION WORKERS

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The construction industry is dangerous – 39 fatalities were recorded in the UK in 2012/13, with comparable and even larger figures reported worldwide. Yet every year, at least several hundred UK-based people take part in construction activities on a voluntary basis, examples being international development projects using ‘gap-year’ students and the substantial UK heritage railway sector that maintains its permanent way and civil engineering infrastructure using volunteers. Most of these volunteers have limited training and no technical qualification, whilst safety regulation frameworks range from being comparable to professional sectors to zero regulation in some international contexts. This research investigates how these volunteer workers construct safety in their volunteering environment. A series of unstructured interviews have been conducted with members of permanent way gangs at several UK heritage railways and with students who have taken part in development projects including the construction of housing and water infrastructure in Eastern Europe and Africa under the auspices of various charities. Taking a social constructionist perspective, the interviews were explored using discourse analysis to illuminate the master discourses of safety within this unique construction ‘industry’. Those with engineering or technical backgrounds developed more tangible constructions of safety, around risks and hazards, within their activities, yet volunteers without this knowledge also acknowledged this wider context of danger. Volunteers on overseas projects developed discourses of ‘difference’ between safety at home and safety outside of the UK; this discourse closely associated with negative practices overseas *yet also* with an acceptance of the inevitability of this context as part of their voluntary experience. Further work is proposed to determine whether these insights can contribute to appropriate management of safety in these contexts, relative to practice in the professional construction industry.

Keywords: development project, discourse analysis, heritage railway, safety, volunteer.

INTRODUCTION

The construction industry is recognised to be one of the most dangerous industries, exemplified by the number of accidents and injuries being higher than in any other land-based industry (European Agency for Safety and Health at Work 2004). As a consequence the industry has been subject to much research, with statistical data providing quantitative indices of the risks inherent in the sector; the latest figures in the UK showing 39 fatalities in the period 2012/13 (HSE 2014a).

As a result, a large amount of safety related literature has been compiled with the aim of recommending ways of improving safety in the construction industry, in order to

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reduce accidents and related incidents. However, investigations often focus on the salaried construction workforce, whereas non-salaried workers, volunteers in the sector, have not received the same attention.

Two areas of voluntary construction are explored here: heritage railways in the UK and civil engineering projects in developing countries. Within these sectors, the way the volunteers understand and relate to safety within the context of their work has been explored from a social constructionist perspective, in order to provide insight into what constitutes 'safety' in the voluntary sector of construction.

CONTEXT: VOLUNTARY CONSTRUCTION

There is a lack of research specifically focused on voluntary construction work and safety, despite the significant contribution volunteers make to this sector. Yet in order to sustain such a contribution, it is important to guarantee individuals' safety during their voluntary work, especially for those who carry out construction activities, with their proven high-risk profile.

The two environments chosen have very different contexts; whilst there is a legislative framework which covers the volunteers' health and safety on heritage railways in the UK, albeit with no actual definition or acknowledgement of volunteers within the law, no regulations exist that specifically cover volunteers who participate in construction projects abroad.

Heritage railways

There are over 100 heritage railways in the UK, and taking journeys on them is an increasingly popular activity, indicated by the growing number of passengers they convey (Heath 2013). In order to facilitate this, in 2013, 18,528 individuals were recorded to volunteer on heritage railways (HRA 2013), a proportion of which carry out construction work on the railways, vital for maintenance and to help ensure that the trains can operate safely. Construction work within heritage railways mainly involves track maintenance, ditching and vegetation clearance. Occasionally more significant projects are undertaken, for example platform construction or major track relays, which can involve large items of plant.

Legislation covering both the public and heritage railways in the UK, including applicable safety regulations is well-established. The Health and Safety at Work etc Act 1974 puts responsibilities on management to protect their workforce and others, as well as placing responsibility on individual workers for the care of their own health and safety. More specifically, The Office of Rail Regulation (ORR) further operates as an 'independent safety and economic regulator' (ORR 2014) which, following the Railways Act 2005, notably includes heritage railways (Butcher 2012). The ORR addresses health and safety of both the travelling public as well as railway workers (salaried and non-salaried) and ensures that those whose obligation it is to safeguard health and safety on the railways are fulfilling their duties and are otherwise held accountable for any safety shortcomings (ibid). Heritage railways must also comply with the Railways and Other Guided Transport Systems (Safety) Regulations 2006, again enforced by the ORR, which specifically defines work and voluntary work throughout, including the need for a Safety Management System, and to ensure that all staff, including volunteers, are adequately trained and possess the necessary skills for the work they are to undertake (ROGS 2006).

Whilst there is limited research around safety within the heritage railway sector and its volunteers, research has been carried out within the public rail industry, often as a

consequence of safety failures and serious railway accidents (HSE 2005). The Southall and Ladbroke Grove train crashes on the public railway, in 1997 and 1999 respectively, represent such examples and were fully investigated through several public inquiries. The investigations revealed that safety management, specifically safety culture in the industry, required improvement. The resulting 295 recommendations set "*necessary and challenging criteria to change the state of the railways*", with a particular focus on "*culture, safety leadership and health and safety management*" (HSE 2005, Section 3.1.3, p.5). Since these recommendations, the UK rail industry has been privatised, which led to many different franchisees, companies and sub-contractors gaining responsibility for the rail network. Whilst track maintenance has recently reverted to holistic control, separate sub-contractors remain responsible for sections of the public railway industry (ibid). In 2002 the HSC undertook an appraisal of the progress made since the recommendations and found that safety cultures across the UK railway industry were incoherent, with some companies having cultivated a 'positive' safety culture faster and more comprehensively than others (HSE 2002 and 2005).

Other research has focused on specific aspects of rail construction work, for example to ascertain "*why track workers sometimes behave unsafely and what factors within the IMC could be contributing to a negative safety culture and unsafe behaviour*" (Farrington-Darby *et al* 2005, p.41). This study identified the existence of a positive correlation between safety culture and major accidents on the railway, something also suggested by other work in this sector (c.f. Cooper 2000; Cullen 2001), as well as that carried out in the wider construction industry (c.f. Wamuziri 2008). Indeed, from his work investigating Ladbroke Grove, Cullen (2001) suggests that creating a 'positive' safety culture should be a key strategy for risk prevention and accident reduction, and all individuals within a rail organisation should participate in the process.

Volunteer projects overseas

Although the total number of volunteers participating on construction projects in developing countries is not documented, an indication of the scope can be gained by looking at just one established UK voluntary organisation, VSO (Voluntary Service Overseas), which identified 1,845 people volunteered abroad with them in 2012 alone (VSO 2013). Organisations such as Engineers Without Borders (2014) offer a wide variety of construction specific placements to engineering students and graduates to work in developing countries with a variety of aims, such as improving local infrastructure, developing water and electricity delivery systems or supporting local engineering education and knowledge.

Participation in such projects overseas is not subject to UK legislation, but rather the legislation of the country being volunteered in, and this can be very lacking. According to LaDou (2003), occupational health and safety laws cover only around one tenth of people in developing countries, and many major hazardous industries and occupations are omitted. In addition, it has been noted that the recording of accidents and fatalities is less rigorous, indeed that there could potentially be double the number of reported fatalities per year (Takala 2002). The lack of health and safety legislation, or indeed the lack of any enforcement or formal reporting within the paid work sector would suggest that there is little or no legislation covering volunteers.

Research of health and safety within this context is rare, although a relevant exception can be found in the work of Furber *et al* (2012), exploring the health and safety of community development projects in Ghana. Although Furber *et al* explored the socio-

cultural motivation factors behind the participation of local community members in construction projects, their illumination of the number of different pressures to conform to work perceived as hazardous by the participants is highly revealing, and suggests that this context remains the same for those participating on a voluntary basis, although the types of pressures to participate is are likely to differ.

METHODOLOGY

Ontologically grounded in relativism, and employing a social constructionist epistemology (Gergen 1999), no preconceived 'truths' regarding voluntary construction safety were brought to this study. Instead safety was considered as a social construction, built through the interactions of individuals, in this case volunteers, throughout their (working) time (Sherratt *et al* 2012).

A purposeful sample was taken, due to the timescales of the project. Three heritage railways in the UK were visited and 13 volunteers interviewed in total across these sites. The overseas project volunteers were identified through a snowball process (Walliman 2006 p.79), which resulted in seven volunteers from two voluntary organisations and four different projects, all construction based but differed in length, number of volunteers and location.

Whilst naturally occurring data would arguably be most valid for this study, the practicalities and ethical issues of its collection were deemed prohibitive. Consequently, unstructured interviews, or conversations (Potter and Hepburn 2005), were employed, used to explore the participants variable interpretive practices they employ to construct their versions of the social world (Potter and Mulkay 2007). All interviews were digitally recorded and transcribed as 'verbatim with dialect' (Gibbs 2007 p.14). The transcripts used the common notation of R for respondent and I for interviewer. These files were then managed and coded using NVivo 10 (Bernard and Ryan 2010; Creswell 2013) through a data-driven approach (Gibbs 2007) to reveal the dominant discourses.

It is through the analysis of such discourses that access can be granted to the socially constructed realities around safety. A discursive analysis tries to comprehend and understand the world, by examining its linguistic exchange (Sherratt *et al* 2012) and investigates how individuals 'build things in the world' by making use of language (Gee 2010 p.16). Discourse analysis accepts the notion that different understandings of the world exist, such as those around safety, which can be presented through discourses, and can thus be discovered through the analysis of language formed by different people (Paltridge 2006). Due to constraints of space, only the two most dominant, or master discourses identified within this work are presented below, drawing on representative extracts from the conversations to illustrate the analysis undertaken and how these discourses were formed and shaped by the data to illuminate understandings of safety within the voluntary construction sector.

FINDINGS AND DISCUSSION

'Professional' safety

The constructions of safety within the data were found to closely associate with the individual volunteer's own experiences and backgrounds. Those with engineering or technical backgrounds developed more tangible constructions of safety, around risks and hazards, within their activities, yet volunteers without this knowledge also acknowledged the wider context of danger although without recourse to formal safety

management practices. This discourse of 'professional safety' was drawn upon by both sets of volunteers.

Within the overseas project data, the discourse manifested from two alternate perspectives; consideration of the individual's own professional safety knowledge and comparable consideration with the knowledge of others. This can be seen in the extract below:

- R: ... sometimes it's argue to, it's hard to argue with them if you can't hammer a nail properly, that you should be doing something in a safe way.
- I: if the volunteers can't.. yeah
- R: as a volunteer, you're very much in, in, well they are responsible for you, they have the kind of position of power and authority

Here, the speaker is happy to make a judgement from their own understanding of what is a 'safe way', yet he does not position his own knowledge as able to challenge that of the 'professional' as constructed here, i.e. the person with the manual skills to 'hammer a nail properly'. This is an interesting shift from management taking the lead on safety; here professional safety is assigned to those physically carrying out the work, suggesting that, within this context, 'professional safety' is not restricted by the usual hierarchical constraints found on sites.

Here, the speaker draws on the discourse of professional safety to position himself in a passive place, in which he abstains from safety responsibilities by following the lead of the local workers. This is a recurring aspect of the discourse amongst the volunteer data, in which the knowledge and experience of the local workers supports 'unsafe' working practices, and thus volunteers abstain from safety responsibilities. The majority of volunteers in these projects all relatively young, many of them students, which may have considerable influence on this discursive development.

A further consideration can be identified in the way in which some volunteers position unsafe practices as negative to their own environments, whilst others draw on the discourse of professional safety to justify and validate unsafe working practices in this context, due to the value ascribed to the locals' knowledge and experience. This indicates a power relationship associated with the discourse, further illustrated by the speaker within the above extract. Although the local workers may not seek such responsibility, the speaker has assigned his own fate to them, despite the fact that he also ascribes them with negative considerations of safety. This resolution to context is also developed through the discourse of safety as different which is examined in detail in the next section.

Professional safety was the dominant discourse identified in the heritage railway data. Associated with this master discourse were constructs of the skills and knowledge (or lack of) that the individual volunteers brought to the railways from their professional backgrounds, as well as the way volunteers' professional backgrounds influence the 'roles' they are consequently allocated. An example of the former can be seen in the extract below:

- R: So, so that - we developed all that stuff ourselves. But I was just saying before then because I'm an operations manager in the aerospace industry, I'm -
- I: Yeah

R: I've, I've - this stuff's no bother to me ... I use my skills I've got and I transfer it across to the railway

The speaker here creates a direct association between his professional role in the aerospace industry and the work he carries out as a volunteer on the heritage railway, safety becoming an objective, mobile entity which can be transferred from one industry to the other. In contrast to the previous text from the overseas volunteers, there is a strong ownership of safety, the speaker personalising his involvement in safety and, along with others, taking responsibility for its management.

This aspect of the discourse can be associated with the type of volunteer predominantly encountered on the heritage railways, namely individuals experienced in their own professions, including many already retired. It is unsurprising that volunteers are inclined to transfer safety from a working environment they know well and to whose safety practices they are accustomed. Within this context, different professions were evaluated by the volunteers, and approval given for occupations that were seen as relevant to heritage railway work. Yet this wholesale construction of a 'mobile' safety contains inherent risks and flaws since every industry possesses its own particular set of risk and hazards, which is why, for example, the HSE provides separate health and safety guidance for different industries in the UK (HSE 2014).

The volunteers are potentially constructing an assumed reality of safety on heritage railways closely associated with their previous experiences, which is not necessarily consistent nor appropriate to the reality of railway practice. Indeed, within the texts, the volunteers also developed a minor discourse of 'safety as different' between heritage railways, which affirms the necessity for differential safety requirements between organisations of the same industry, *let alone* between different industries. There is a need for volunteers to acknowledge differences in safety practice between their own constructions and reality, and adjust accordingly. However if such differences are not acknowledged then, incongruously, it is possible that 'unsafe' behaviour occurs from those who are professionally knowledgeable about safety.

Professional safety was also drawn upon to influence the way roles were assigned within the heritage railway teams, as illustrated in the extract below:

R: uh ((name)) is the expert

I: OK

R: on the switches

I: so for everything someone - I mean how, how has everyone got their knowledge on this? Or was it just through -

R: ((name)), ((name)) with eh, eh ((acronym of freight operating company))

I: Ohhh

R: ((full name of freight operating company)), ((name)) was in charge

The above evolved from a question posed about who decides what and how things are to be done on the railway. The speaker responds through the identification of an individual, and draws on the discourse of professional safety to justify his attribution of 'expert' due to previous professional experience. Again, safety has been constructed in a way that allows it to be transferred between industries, here: one part of the public railway industry and the voluntary heritage railway industry. Through such associations, the speaker diminishes the existence of a difference in working practices

and safety between the paid public railway and the voluntary heritage railway, and strengthens the justification behind the discourse.

Throughout the heritage railway data, individuals constructed a close association between roles and past experiences, professional or otherwise, reaffirming a transferable construct of safety, potentially generating a management structure which is the product of transferred knowledge from other industries. However, such constructions also enable many of the volunteers to abstain from safety responsibilities themselves, assigning this charge to those with relevant professional backgrounds. Such abstention from responsibility is justified through the knowledge they presume others to have, often accepted on the individuals own cognisance. Potentially, such constructions are detrimental to safety in practice, both the shifting of responsibility for safety away from a holistic approach and its reliance on perceived competence and knowledge.

Safety as 'different' overseas

The master discourse identifiable in the overseas voluntary data was that of 'safety as different'. The volunteers constructed this difference in a variety of ways and at a variety of social levels; on both a personal level, often drawing on examples of incidents that had been witnessed, and on a national level, the latter often used to 'culturally' justify the unsafe actions of the local workers. This difference was juxtaposed with the volunteer's own understandings and experiences of safety in the UK through either their education or professional backgrounds, as the volunteer below illustrates:

- R: Well we, well we wanted to, to do it a different way. 'Cause we, we have a bit of experience, a few of us knew that this was not how things should've been done. It's just the people, the construction workers with us were used to cutting corners, taking those kind of risks.
- I: Mhh.. That's interesting
- R: And there's kind of a, there's a pressure on you then to take those risks.
- I: OK
- R: So we kind of mentioned it to them and they were like "*You know, this is how we have to do it*". Eventually don't want to lose time from working by having to argue with them or... especially if they speak a limited amount of English.

In this extract the respondent constructs safety through the discourse of safety as different. An example of when the speaker wanted to go about a task in a different way to that in which it was being performed is drawn upon to illustrate the difference to their own understandings. Yet the speaker is willing to justify and accept this difference as inherent in the context they have been placed in. The workers are more 'used' to unsafety than the speaker, although he does not blame or consider them responsible for this lack of safety, rather they are working in the same construction contexts of time and pressure as the speaker, which are used to justify the lack of ability for either workers or volunteers to develop safety within this context.

Safety as different is constructed as a fixed entity; the volunteers positioned it as an unchangeable context that was perpetuated by the local workforce, themselves unwilling to change, either in their actions or their own considerations of safety. The resolution of the speaker that this was "*how we have to do it*" is further justified by

language issues, notably as a lack on the part of the workers and not the volunteer, despite the non-English speaking country in which the work is being carried out.

Throughout the text, the speaker refers to himself in the plural 'we', bringing others into his understandings, but also enabling the avoidance of personal responsibility. This is found throughout the text, as although the speaker has positioned himself at the centre of the discourse, he does not want to associate himself with the unsafe practices taking place, the lack of action in terms of change, or the lack of ability to overcome any issues.

This develops notions of resolution, associated with the different context and its inflexible nature, and resulted in the volunteer's discourse of safety as different developing a facet of 'acceptance', as shown in the continuing talk of the same volunteer:

R: maybe they were fine with them but then when it came to volunteers like us, we might not have been as used to them.

Here, the speaker is further developing discussions around 'cutting corners' as common practice, but interestingly positions himself, identified as a volunteer, as 'not ... used to them'. Again, the speaker is resolved to the context in which he as a volunteer is being placed, constructing himself as 'other' to this environment.

The discourse of 'safety as different' was identifiable throughout the overseas volunteers' talk. It often originated at a general level around the safety standards of the host country, juxtaposed with UK safety practices to highlight difference, then developed more personal levels. Speakers often considered their own participation within this different context and throughout the texts an inevitability of negative safety practice was constructed; in some cases volunteers positioned their own safety compliance to these contextual levels, and a resolution that this context was unable to be changed formed could be identified as an inherent part of this master discourse.

In consciously possessing such safety knowledge, the volunteers are effectively revealing themselves to be in a position of safety conscientiousness, which is arguably tied to responsibility. The implication to practice therefore, is that they should try and ensure safe working practices are implemented, or at least improved to the safety standards with which they are comfortable. However, as the above analysis illustrates, although some volunteers considered change, the majority stripped themselves of these responsibilities by normalising the 'unsafe' ways of work, or even submitting themselves to these. In doing so the volunteers are effectively transferring all (safety) responsibilities to the local workers, with potential repercussions for their own safety and others participating in the work. The volunteers constructed a context in which safety is dependent on the environment in which it is being carried out, or more specifically dependent on the way people 'belonging' to that environment construct safety, which in turn determines the safety environment.

CONCLUSIONS

In exploring the discourses of safety within these two areas of voluntary construction, the two most dominant discourses, those of 'professional safety' and 'safety as different', were identified.

The discourse of professional safety was found within both environments, although associated with different constructions and applications. Within the heritage railway sector, professional safety created a mobile and transferrable safety drawn from

individuals' previous professional experience, in a wide variety of sectors, which was applicable and harmonious with railway construction work. Although this develops a strong personal association with and responsibility for safety in this context, there could be concerns with the suitability of such direct application, and indeed the potential for complacency in a very different industrial environment.

However, an alternative aspect of this discourse was also present, drawing on others' knowledge and competence to shift responsibility for safety from individuals, despite a lack of evidence or relevance of that knowledge to the context of the heritage railway.

Within the overseas volunteering sector, professional safety was again used to shift responsibility and ownership to those with professional credibility within the work context, and was often associated with a lack of professional knowledge, perceived or real, on the part of the volunteers.

Professional safety was also linked to the master discourse of safety as different overseas, through which the justification of working within unsafe environments was developed through its inevitability and inability for change. The role of power relations developed from the discourse of professional safety was influential in the resignation of the volunteers to this unsafe context: cause for concern given the number of participants in such overseas schemes and their potential exposure to health and safety risks.

Whilst less prominent discourses were identified within the texts that have previously been identified from similar work undertaken in the professional construction sector (Sherratt *et al* 2012), for example the discourses of safety as safe practice as considered against safety as work practice, and safety as PPE, the two master discourses developed here reveal potential issues significant to the voluntary construction sector. The considerations of professional safety, responsibility, ownership and resignation identified within this context have the potential to impact the safety of those participating in such voluntary ventures. It is suggested that these findings support the need for further work in this field, to develop further insight and potentially contribute to appropriate management of safety in these contexts, relative to practice in the professional construction industry.

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CONSTRUCTION WORKERS' VIEWS ON WORKPLACE DESIGN AND 'HEALTHY' AGEING

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With the recent abolishment of a retirement age we are seeing an increase in an ageing workforce. This can often be difficult to manage, particularly in tough working environments such as the construction industry. Construction and building trades are well known for being tough, heavy and manually challenging, which can prove difficult for the older worker to remain healthy in whilst also exacerbating the decline in physical ability seen in the ageing population. Construction workers are often faced with cold, dark, poorly ventilated working environments however, some organisations working in areas such as maintenance provide somewhat less harsh conditions, often with a slower pace of work in comparison to the building trades and industrial work. In this paper, findings from interviews with 74 construction workers will be presented. Workers came from a small maintenance facility, a medium-sized domestic new-build company and a large civil engineering company. In-depth semi structured interviews took place with participants aged from 18 to over 50 in their place of work, incorporating the Stage of Change questionnaire, Nordic Musculoskeletal questionnaire and the Work Ability Index. In this paper comparisons are made between working practices, cultures and attitudes in these three organisations. The aim of this research is to provide direction for better work place design using the experience, knowledge and ideas of construction workers by encouraging healthy ageing in the industry, facilitating healthier working behaviours and enabling positive change.

Keywords: ageing, culture, ergonomics, organisation.

INTRODUCTION

Construction is an essential worldwide industry, contributing nearly £90 billion to the UK economy and providing nearly 3 million jobs (Department for Business Innovation and Skills 2013). It is also renowned for being a tough, heavy industry to work in with workers often finding themselves in unforgiving environments which can be dark, damp, poorly ventilated and noisy. Heavy lifting, repetitive movements and awkward and cramped postures are commonplace which can lead to musculoskeletal problems later in life. Certain musculoskeletal disorders are more common in particular trades, such as lower back pain in roofers and floorers, back and knee pain for bricklayers and all body areas in scaffolders (Holmström and Engholm 2003; Boschman *et al* 2012). Musculoskeletal disorders can be debilitating and can cause severe pain to construction workers both in and out of work. This can be a particular problem if workers are self-employed or sub-contracted and not entitled to sick pay, causing them to remain in work whilst being in pain. In severe cases,

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musculoskeletal disorders can force workers into an early retirement, with as many as 63% having to retire due to medical conditions (Arndt *et al* 1996).

We are currently experiencing an ageing workforce; in the wake of a recession older workers are unable to retire early due to economic pressures and the recent abolishment of an official retirement age (BBC 2011). The harsh conditions found in construction can exacerbate the natural decline of ageing on the body; stamina and muscle strength are considerably reduced, injuries take longer to recover from, eyesight and vision deteriorate and hearing ability decreases, particularly in the speech frequencies (Larsson, Grimby and Karlsson 1979; Lemasters *et al* 2006; Chau *et al* 2004). These factors can potentially be problematic in construction, as older workers may not be able to see tripping hazards, hear instructions clearly or carry out work as quickly as younger workers. Despite this, older workers are highly valued in the industry and are considered to be experienced, dedicated and produce work of a high quality. However, these positives are outweighed by a negative perception that they are slow (Leaviss *et al* 2008). Many older workers have the desire to remain in work, having spent a large proportion of their lives in their trades (Leaviss *et al* 2008). However a more recent study found that despite being able to remain in work beyond the age of 65, workers are less willing to, due to being in awkward postures and suffering from musculoskeletal complaints (Hengel *et al* 2012).

More research is needed regarding working environments which facilitate healthy ageing and that can accommodate the needs of all workers in construction activities. The research presented in this paper is part of a larger project, funded by Age UK, investigating how construction workers can be part of this process to improve quality of working life using a participatory ergonomics framework. Health and safety is a well-rehearsed topic in construction, however amongst the many protocols and standards related to safe working on construction sites, there are fewer on health and well-being, which has been the case for many years (Gyi *et al* 1999). This is slowly beginning to change, with Dame Carol Black paying a large role in government reforms; *"a shift in attitudes is necessary to ensure that employers and employees recognise not only the importance of preventing ill health, but also the key role the workplace can play in promoting health and well-being"* (Black, 2008)

This paper presents the findings of an exploratory study investigating construction workers' views of the design of their workplace and health and well-being at work. Interviews were conducted with 74 construction workers from different organisations representing a number of different trades such as bricklayers, plumbers, electricians and carpenters/joiners. Comparisons are made between three different sized organisations, a small maintenance facility, a medium domestic build company and a large civil engineering company with sites situated in sewage treatment and railway. These findings are part of a larger project which will incorporate the workers' views and experiences using participatory ergonomics to improve health and well-being at work.

METHODOLOGY

In-depth semi structured interviews took place with a stratified sample of 74 construction workers. The aim of these interviews was to understand the breadth and depth of workers' knowledge about the design of their workplace and their health and well-being at work.

A range of ages were interviewed, in categories of under 25, 25-34, 35-49 and 50+. Project managers were approached through professional and personal contacts, who then selected appropriate and available English-speaking tradesmen. Trades of particular interest were those whose work included heavy lifting, twisting, turning and being in awkward and cramped positions for long periods of time. Demographic data was collected from the workers such as their trade, age range, employer and length of employment in the industry. A flexible interview schedule (table 1) was used to allow free discussion around a number of pre-determined topics including the participant's job, any issues they have and the personal protective equipment they wear. The Stage of Change questionnaire (Prochaska and DiClemente 1983; Whysall *et al* 2007) was used to facilitate discussion around ideas they have to make their workplace safer or more comfortable and quantitative data was collected using the Nordic Musculoskeletal Questionnaire (Kuorinka *et al* 1987; Sang *et al* 2010) and the Work Ability Index (Ilmarinen 2003). Issues raised in the interviews were evidenced by observations where possible, with photographs and videos being taken to triangulate the data.

Table 1: Flexible interview schedule

	Questions and issues
Demographics	Age range. Occupation. Time spent in employment
Their Job	Everyday tasks? Tools and equipment used? PPE requirements and usage? Location of job? Awkward/cramped positions? Use of chemicals? Is there dust, noise?
Ideas & Current Changes	Stage of Change (Prochaska & DiClemente 1983; Whysall <i>et al</i> 2007) What ideas do you have to make your job easier? To make the workplace better? New/different equipment? Flooring, lighting, PPE, talks, workshops, job rotation, micro-breaks, better facilities? What advice would you give to a younger worker? What would you do differently? E.g. Plasterer- how do you cope with the weight of the trowel and wet plaster? Electricians- what do you do about extra lighting in smaller areas? Bricklayers- what issues do you face with working outside? Weather? What is being done right now to make your job easier? Who comes up with these changes? Who is responsible for implementing and maintaining these changes? Are you using different equipment? Altering current equipment? Order of jobs? Wearing knee pads / particular gloves / other clothing modification?
Health (Quantitative)	Nordic Musculoskeletal Questionnaire (Kuorinka <i>et al</i> 1987; Sang <i>et al</i> 2010) Work Ability Index (Ilmarinen 2003)

FINDINGS

A total of 74 workers were interviewed (table 2); 28 from a small maintenance facility, 30 from a medium sized domestic build company and 16 from a large civil engineering company with sites based in sewage treatment and railway. Efforts were made to have an evenly stratified sample, however the outcome is representative of the peripatetic nature of construction; high numbers came from the stabilised maintenance facility which was based on one permanent site and from the medium domestic build company in which the researcher had personal contacts. The large civil engineering company had several management change-overs before data collection was possible. Interviews were conducted using a flexible interview schedule and were conducted in site offices. Interviews were recorded on a Dictaphone and took place after participants had read an information sheet and signed their informed consent. This study was approved by the University Ethics Committee.

Table 2: Age ranges of interviewed workers and the size of company they worked for

	Small	Medium	Large	Total
Under 25	3	6	1	10
25-34	1	7	4	12
35-49	6	11	7	23
50+	18	6	4	28
Total	28	30	16	74

Quantitative findings

As discussed, quantitative data was collected using the Nordic Musculoskeletal Questionnaire and the Work Ability Index and was analysed using IBM SPSS Statistics software.

From the Nordic Musculoskeletal Questionnaire, period (12 month) and point (7 day) prevalence of musculoskeletal symptoms were identified in specific areas of the body. The severity of these and whether the workers believed them to be directly related to their work was also recorded.

Workers from the small facility reported a higher number of symptoms in the wrists and hands (68%) and the knees (75%) in comparison to the medium and large companies. This may be related to the higher age range or number of plumbers interviewed within this facility. These workers also reported the highest point prevalence for these areas (43% and 39% respectively) and over half believed that these symptoms were a direct result of their work. This implies that many workers in this facility are continuing to work through their aches and pains. There were similar reports of lower back pain across all three organisations; 57% in the small, 55% in the medium and 63% in the large. In the large company, 56% of sufferers believed their work to be the direct cause of these symptoms. There was also a higher prevalence of symptoms in the elbows reported from the workers of the larger company (44%) in comparison to the small organisation (14%). Overall the wrists, lower back and knees were problem areas for workers in all size organisations, with a large number of these workers attributing these to their work.

Despite suffering with musculoskeletal symptoms, workers rated their work ability as high across all three companies. Using the Work Ability Index, they were asked to rate their current workability from 0 to 10, with 0 being completely unable to work and 10 being the best they've ever worked. The average rating for the small facility was 8.1, for the medium company, 8.9 and for the large company, 8.5. However these findings are likely to be subject to the 'healthy worker effect' where less healthy workers may have already left their jobs, leading to a skewed set of results (Stattin and Järvholm 2005).

Qualitative findings

The quantitative data was triangulated by collecting both observations on site where possible and qualitative data through in-depth semi-structured interviews. The interview data was coded and thematically analysed in QSR International NVivo software. During this analysis it became clear that the workers' experiences and ideas differed significantly between organisations.

Moving jobs

Many of the workers in the small maintenance facility had made the conscious decision to move there from other areas in the industry such as 'house bashing' or engineering with the view of taking a 'slower paced' job. Reasons for this included preservation of health as a result of damaged hearing or diabetes and 'getting out of the harsh conditions of the building trade'. A similar attitude was found in the younger workers of the medium size company, who openly spoke about not wanting to remain in their trades for a long period of time, instead wanting to own their own businesses or just "*get out of*" the industry.

Tasks

There was a variation of tasks reported by workers, both between and within the different organisations, with workers agreeing that each day's tasks depended on the demands of the job. Tasks in the maintenance facility appeared to be more similar on a day to day basis, such as "*very light work with small installation works*" and "*changing lamps, repairing sockets...fault finding*". The variation of tasks reported within the domestic company and the civil engineering company was reflective of both the many different trades working on the sites and the peripatetic nature of large construction sites. As the work moved forward on these building sites, the nature of the tasks changed. There were more references to heavy lifting and frequent use of machinery in comparison to the small facility, including wider discussion of materials used and the environment in which they have to work in. Workers in the small facility made frequent references to being in awkward and cramped positions due to having to maintain 'the voids' - spaces in the ceilings of old buildings. These awkward postures were also reported by workers in the large civil engineering company who were building trial holes in the ground on their site.

Pace of work

Workers from the small facility referred to their jobs as being safer and 'slower', particularly those who had previous experience in heavy industry. The overall opinion was that the employers of this facility prioritised health and safety over speed of production and that they were given all the time they needed to complete their jobs safely. Workers reported the difference between maintenance and their previous jobs, where they felt they were unable to 'waste time' on retrieving personal protective equipment from the van or take the time to consider the most comfortable way to do the job compared to maintenance where they felt they no longer needed to cut corners or rush their jobs. This was also viewed as having a positive effect on their health and well-being, as they felt the work was less physically demanding and as a result, they were not having to 'abuse their bodies as much'.

This was strongly contrasted with the workers of the medium domestic build company, who frequently reported feeling under a great deal of stress to complete their job in the allocated time frames. Workers within this company were on domestic build sites and had important deadlines to meet for paying tenants. These time pressures had an effect on their attitude towards health and safety, causing the workers to become less concerned about their well-being at work. There were reports of individual manual heavy lifting, which would normally be done by two people or with machinery, laying bricks in a way to increase production rather than to maintain health and comfort, with one worker stating "*you can't put the drill down...you gotta just keep going to earn more money*".

There was very little discussion of time pressures from workers in the large civil engineering company, however they were not working to such a strict timescale as they were working on a sewage treatment plant, digging large numbers of trial holes.

Employer relations

Relationships between the workforce and employers in the small maintenance facility differed significantly to those in the other two companies, whereby workers appeared to have a more direct relationship with their managers. Workers in the medium domestic build and civil engineering companies more commonly spoke to their supervisors rather than their overall employer. This was evidenced by workers in the small facility referring to their manager on a first name basis, whereas workers in the two larger companies referred to “*the employer*” or “*my company*”. The main reason for this could be attributed to the permanent nature of the maintenance facility, being situated on static site with the workers being paid a salary. In comparison, the peripatetic nature of the larger two companies meant that the main workforce was sourced from sub-contracting companies with workers moving on soon after project completion.

Using the Stage of Change questionnaire as a basis for discussion, it was clear that workers from the different sized organisations felt differently about the way their employers cared for them and had made changes. Overall workers in the small facility had a positive perception of their employers and felt that they had their best interests at heart. This was particularly the case for the older construction workers, who felt that they were really accommodated particularly when they were suffering with illnesses such as diabetes. When asked if their employers had made any changes to improve their health at work, a number of responses referred to the wide range of health and safety courses available to the workforce and being given as much time as they need to complete their jobs comfortably and safely.

Workers in the medium domestic build company were also asked if their employers had made any changes, however their responses centred around health and safety improvements, with no mention of any personal changes being made for the workers. Interestingly it was a supervisor of the bricklayers in this company who most openly talked about his experience of the culture of the building trade;

“[if you picked up blocks] properly it would take a day and they’d be building nothing...I’ve got to get a floor up today...it’s gonna fly up, so all corners are being cut...they’re [management] not interested, they don’t care about the health of them up there, all they wanna see is a measure and a pound note” (50+, bricklayer, medium company).

Responses from workers in the large company varied, with some workers referring to legislation changes as 'necessary' and therefore not being on a personal level, such as having to make changes 'just to cover them on insurance' and to 'tick boxes'.

These differences in relationships also affected the workers’ perceptions and openness to change within their company. Interestingly in the small facility, the close relationship between employer and workers was not indicative of a more positive reaction to change. In fact, this appeared to have caused more issues as some workers felt they were not being listened to by their manager. One issue raised by several workers was that of contracting on site - with the workforce being static and maintenance based, there was a great deal of ownership surrounding their work. However, management had increased the number of external contractors being bought

in, which had caused unrest within the internal workforce. Workers felt they were being forced to surrender ownership of their jobs, having to fix problems left by the contractors, with one worker stating *"they're not listening, I call it the FM Titanic 'cos we're pointing out that it's gonna fail but they're not listening!"*. Several workers reported a real need for apprentices to be enrolled in the company so that the older workers could pass down their knowledge and experience, with workers expressing their concern of the ageing workforce, many close to retirement with 'no-one coming up behind them'. Despite the considerable amount of communication between the workforce and management, this did not translate into the workers' understanding of the situation, leaving confusion and bad feeling about why changes were not being put into place. In the domestic build company, the main issue between workers and employers appeared to be related to money, particularly because the workers were on price. Workers felt that the main priority for their managers was to get the job finished on or ahead of time and that they were not concerned about their health and well-being. In the large civil engineering company, there were issues raised about the facilities, workers wanted hot running water and more toilet roll. Again, there was a dubious perception of these issues being not resolved due to a lack of communication between the workforce and the management, with one worker reporting an 'us and them' hierarchy.

Ideas for change

When workers were asked if they had any ideas for change in their jobs in order to make their work healthier or safer, there were large differences between the organisations. This was reflective of both the perception of their employers and also the sites on which they were working; hygiene facilities were an important factor for the workers from the large company, who were based on a sewage treatment plant whereas for the workers in the small maintenance facility, where the majority of the workers were over 50 and looking to retire, bringing in apprentices was an issue many of the workers felt strongly about.

Many of the workers from maintenance felt that changes were not necessary, as they already had good facilities with a large number of health and safety courses available to them. The main change workers wanted to see was the hiring of apprentices as previously discussed, with one worker also wanting more consideration given to older workers in terms of being placed on the rota for evening and weekend callouts.

Some workers in the medium domestic build company wanted a more personal emphasis on health and safety to be implemented, through encouraging workers to think about their own health in toolbox talks and by going on educational courses. Other workers had good ideas which they thought helped them work more comfortably, such as warming up and stretching before beginning a physically strenuous job and 'warming down' afterwards.

Most ideas from workers in the large civil engineering company were based around the need for better facilities, including more space for them to hang their personal protective equipment in the wet weather.

Although other changes were suggested such as making the tools lighter and using more electric, cordless tools, they were instantly dismissed due to the potential cost they could incur as the workers assumed that the company would not be willing to pay the extra money. Other ideas from workers were; worktables at the correct height for cutting materials, creating more durable, waterproof protective gloves and ways to

resolve the issue of goggles steaming up when they were worn at the same time as a dust mask, such as all-in-one breathing apparatus.

Limitations

Due to the time constraints of the study and the peripatetic nature of construction sites, the interviewed workers are not representative of the size or type of organisations worked with, particularly in the larger domestic build and civil engineering companies. There are multiple sites within these companies and only a small number were able to be visited throughout the time of the study, therefore these findings cannot be generalised to other companies throughout the industry.

The individual differences observed could also be due to the age and make-up of the workforce, with the small maintenance facility being typically made up workers over the age of 50. However, the views expressed by these workers in the small facility were also echoed by the younger cohort of workers, who had previous experience in larger companies. The workers in the medium domestic build company and large civil engineering company were mostly sub-contracted, meaning that they were not directly employed by the companies and their employment was of a temporary nature.

CONCLUSIONS

From the quantitative data it is clear that a number of workers in all organisations are suffering with aches and pains and that a high number of these are considered to be directly related to their job. Despite this, they are still keen to remain in work which is a finding supported by the qualitative interview data. Many workers in the small maintenance facility had moved from harsher, faster paced industrial work to 'slower' maintenance work in an attempt to reduce their aches and pains, suggesting that workers are considering their health and well-being at work and make changes to accommodate their abilities.

Communication is an essential factor for worker satisfaction and well-being, it is the quality of communication that is important and not just the quantity. It is also essential that managers and employers are aware of the smaller issues as well as the larger ones, which can improve quality of working life and in turn increase the work ability and productivity of their employees.

The range of both low cost ideas for change and longer interventions from construction workers in all companies demonstrate a good level of knowledge, creativity and experience of the industry. These findings suggest that the companies would benefit from a participatory approach, facilitating healthy workplace behaviours and design. This is supported by the high ratings of work ability, suggesting that workers are not only coming up with ideas and solutions, but that they are able to implement these and continue working.

The next phase of this research consists of presenting these findings to stakeholders within the industry including project managers, health and safety officials and occupational health professionals in order to investigate the opportunities and barriers for change in the industry. It is hoped that by using a participatory ergonomics approach, construction workers can contribute to healthy workplace design. This has the ability to improve the quality of working life for both younger and older construction workers alike. Methods such as 'train the trainer', where the knowledge comes from within the company, are hoping to be used, to ensure the experience of older construction workers does not go to waste; a method which has shown to be successful in previous research (Gyi, Sang and Haslam 2013). This research provides

a solid foundation for future investigation and can be used to provide guidelines for different size organisations when using a participatory approach to encourage healthy working behaviours in industry.

Acknowledgement

The authors would like to acknowledge Age UK's Research into Ageing Fund for sponsoring this research.

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EXPLORING THE INTERNAL DIMENSIONS OF WORK STRESS: EVIDENCE FROM CONSTRUCTION COST ESTIMATORS IN CHINA

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A recurring feature of modern practice is the stress placed on project professionals, with both debilitating effects on the people concerned and indirectly affecting project success. Cost estimation, for example, is an essential task for successful project management involving a high level of uncertainty. It is not surprising, therefore, that young cost estimators especially can become stressful at work due to a lack of experience and the heavy responsibilities involved. However, the concept of work stress and the associated underlying dimensions has not been clearly defined in extant studies in the construction management field. To redress this situation, an updated psychology perceived stress questionnaire (PSQ), first developed by Levenstein *et al* (1993) and revised by Fliege *et al* (2005), is used to explore the dimensions of work stress with empirical evidence from the construction industry in China. With 145 reliable responses from young (less than 5 years' experience) Chinese cost estimators, this study explores the internal dimensions of work stress, identifying four dimensions of *tension, demands, lack of joy* and *worries*. It is suggested that this four-dimensional structure may also be applicable in a more general context.

Keywords: work stress, perceived stress questionnaire, young cost estimators, exploratory factor analysis.

INTRODUCTION

Work stress has become an important concept in organizational management since the increased awareness of the prevalence of mental disorders such as depression in the 1980s (Tennant 2001). In the construction industry, because of the complexity and dynamic uncertainty of its projects, workers and professionals are frequently expected to confront and cope with stress (Ng, Skitmore and Leung 2005). In addition to concerns regarding the wellbeing of those affected, the study of work stress is especially important in organisational terms for the potential negative effects on production, such as safety incidents involving site workers, mistakes in professional services and reduced productivity.

Although identification and categorization studies of the causes of stress are not uncommon in the construction management field (e.g. (Leung *et al.* 2005, Ng, Skitmore and Leung 2005, Richmond and Skitmore 2006, Leung, Zhang and Skitmore 2008)), individual stress reactions, including stress assessment and emotional responses, have received little treatment to date. Additionally, stress reaction is widely regarded rather as a holistic concept with little investigation into the dimensions

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involved, raising consequential doubts over the veracity of the conclusions drawn in previous work.

Realizing a similar situation in psychosomatic research, Levenstein *et al* (1993) developed a 30 question perceived stress questionnaire (PSQ), validated with responses from 230 subjects comprising in-patients, out-patients, students and health workers. Pointing to some drawbacks existing in Levenstein *et al*'s PSQ, Fliege *et al* (2005) they used it in the German context with 650 subjects to conduct a principal component analysis (PCA), resulting in the identification of four dimensions of stress in terms of worries, tension, joy and demands, each represented by five questionnaire items (Fliege *et al*. 2005). However, this remarkable conclusion of exactly four dimensions with each containing exactly five items has yet to be replicated in any further empirical work.

Construction cost estimators, with huge responsibilities in construction projects, have been targeted as subjects in several previous studies (e.g. (Leung *et al*. 2005, Bowen, Edwards and Lingard 2012)). Since a further goal was to consolidate stress research in the construction industry by comparing the results with previous studies, cost estimators were used as subjects in this research. Our research, therefore, aimed to simultaneously explore the internal dimensions of stress in the construction industry context while testing the applicability of Fliege *et al*'s 4x5 structure to construction cost estimator stress. This was carried out with a sample of 145 predominately young (less than 5 years' experience) cost estimators working in the Chinese construction industry. As will be seen, four dimensions of tension, demands, lack of joy and worries are identified by Principal Components Analysis. A brief discussion is provided of the significance of the results in comparison with previous work and implications for future research, with the suggestion that the same four-dimensional structure may also be applicable in a more general context.

LITERATURE REVIEW

In stress related research, some studies have concentrated on external stressors or causes, some on subjective components such as anxiety and worries, and others on coping strategies (Levenstein *et al*. 1993). Although it is debatable that the measurement of stress should concentrate on those stressors or individual stress reactions including stress assessment and emotional responses in psychology research (Fliege *et al*. 2005), it is acknowledged that both approaches have their own advantages and drawbacks.

There are many studies relating to stressors. For example, job stress, in terms of job related tension, is evaluated by a 15 item inventory in Jamal (1984)'s exploration of the relationship between job stress and job performance. These stressors were categorized into four types, in terms of role ambiguity, role conflict, role overload and resource inadequacy. Most stress-related studies in the construction industry also concentrate on identifying and categorizing stressors. Leung *et al* (2005), for example, use causal structural modelling to examine the effects of stressors on stress, finding work overload, role conflict, job ambiguity, and working environment to be the most influential factors involved. Additionally, organizational support factors have been regarded as antecedents of stressors, with a few stressors (e.g. lack of autonomy) acting as mediators between organizational support and employee stress (Leung, Zhang and Skitmore 2008). Ng *et al*'s (2005) research on measuring the manageability of stress in relation to construction projects categorized 33 stressors into seven groups, in terms of works nature related stressors, work-time related

stressors, organisation policy related stressors, organisation position related stressors, situational/environmental stressors, relationship related stressors and personal stressors.

Negative effects of stressors occur when insufficient resources are available to cope with them (Cohen, Kamarck and Mermelstein 1983). The study of coping strategies is therefore another common topic. Aiming to help project participants better cope with stresses, Ng *et al* (2005), for example, conducted a questionnaire survey to measure the manageability of the stressors most confronted by construction project participants. Richmond and Skitmore (2006) also provide 14 stress coping strategies for 50 identified potential stressors by conducting interviews with IT project managers.

The influencing mechanism of work stress is not as easy to understand. Hon (2013), for example, examines the link between working-creativity-caused stress and service performance with evidence from 305 employees in 48 service organizations, finding co-worker support to be a significant moderator. When there is high co-worker support, higher stress leads to slightly better performance; but when co-worker support is low, higher stress leads to a much worse performance. Similarly, evidence from a survey of 306 nurses indicates that perceived social support from co-workers improves reported job performance and reduces reported job stress (Abualrub 2004). Interestingly, AbuAlrub (2004) also found a U shape relationship to exist in the job stress and job performance relationship, with respondents reporting moderate job stress believing their performance is worse than those reporting low/high job stresses. Jamal (1984), on the other hand, in analysing a sample data from 440 nurses working in Canada, proposes employee professional and organizational commitment as moderators in the stress-performance link, although this is only partially supported by the data. Because of the complexity in defining the role of stress and the little coverage of emotional stress reactions in construction research, therefore, it is of value to investigate its dimensions further to deepen our understanding of their interactions with external stressors.

RESEARCH METHOD

Perceived stress questionnaire

Fliege *et al*'s (2005) 4x5 PSQ was used as the main instrument in the study. After revisiting the results of Fliege *et al*'s factor analysis and considering the likely drawbacks and suitability of these items in the Chinese context, a modified 4x4 (four dimensions of stress, with each containing four items) version was conjectured for the Chinese cost estimator context. Also, while Fliege *et al*'s PSQ refers to the respondent as "you", we decided to address the respondent as "I" to make it easier for Chinese respondents to report more personal emotional reactions. Additionally, the four-scale questionnaire response format used in Levenstein *et al* (1993) was changed to a seven-point Likert scale format to elicit more finely grained information. Also, a "don't know" option, omitted from Levenstein *et al*'s and Fliege *et al*'s versions, was offered in the questionnaire as standard procedure for those unable to answer corresponding questions.

The main part of the questionnaire is presented in Table 1. According to Fliege *et al* (2005)'s categorization, Q1-Q4 belongs to "demands", Q5-Q8 belongs to "worries", Q9-Q12 belongs to "tension" and Q13-Q16 belongs to "joy". Q13-Q16 was reversed

in the analysis and named as AQ13-AQ16 indicating the “*lack of joy*” dimension consistent with Levenstein *et al*’s categorization.

Table 1: Perceived stress questionnaire

No.	Work stress	1-not at all to 7 very intensive	Don't know
Q1	I have too many things to do	1 2 3 4 5 6 7	<input type="checkbox"/>
Q2	I do not have enough time for myself	1 2 3 4 5 6 7	<input type="checkbox"/>
Q3	I feel under pressure from deadlines	1 2 3 4 5 6 7	<input type="checkbox"/>
Q4	I feel I am in a hurry	1 2 3 4 5 6 7	<input type="checkbox"/>
Q5	I have many worries	1 2 3 4 5 6 7	<input type="checkbox"/>
Q6	My problems seem to be piling up	1 2 3 4 5 6 7	<input type="checkbox"/>
Q7	I fear I may not manage to attain my goals	1 2 3 4 5 6 7	<input type="checkbox"/>
Q8	I feel frustrated	1 2 3 4 5 6 7	<input type="checkbox"/>
Q9	I feel tense	1 2 3 4 5 6 7	<input type="checkbox"/>
Q10	I feel mentally exhausted	1 2 3 4 5 6 7	<input type="checkbox"/>
Q11	I have trouble relaxing	1 2 3 4 5 6 7	<input type="checkbox"/>
Q12	I are hard to feel calm	1 2 3 4 5 6 7	<input type="checkbox"/>
Q13	I feel I am doing things you really like (R)	1 2 3 4 5 6 7	<input type="checkbox"/>
Q14	I am light hearted (R)	1 2 3 4 5 6 7	<input type="checkbox"/>
Q15	I feel safe and protected (R)	1 2 3 4 5 6 7	<input type="checkbox"/>
Q16	I am full of energy (R)	1 2 3 4 5 6 7	<input type="checkbox"/>

Translation and back translation

Because of differences in cultural backgrounds and languages, the translation of questionnaires from English to Chinese needs be carried out with care. To do this, the two-stage translation and back translation technique was adopted as used by Ding and Ng (2007) in their translated Chinese version of McAllister’s trust scale. The first stage involved the Chinese version of the questionnaire was translated by a bilingual PhD candidate with knowledge of PSQ, with the preliminary Chinese draft emerging after several subsequent rounds of discussions with a bilingual member of university academic staff. For the second stage, another pair of bilingual assistants (i.e. PhD student and academic staff) *without* prior knowledge of the PSQ English version of the questionnaire translated the Chinese questions back to English. The two English versions were then compared for significant inaccuracies (Table 2). The discrepancies found were then corrected to produce the final version of the questionnaire.

Table 2: Translation and back translations

No.	Final Chinese version	Back translation-1	Back translation-2
Q1	我有太多事情要做	I have a lot of things to do.	I have too many works to do
Q2	我感到留给自己的时间不够	I feel that I have limited time to myself.	I feel not enough time for myself
Q3	我感到来自截止日期的压力	I feel the pressure from deadlines.	I feel deadline pressure
Q4	我感觉自己很着急	I feel that I am in a hurry.	I feel I am in a hurry
Q5	我有很多担心	I have many worries.	I have a lot of concerns
Q6	我的问题似乎越堆越多	It seems that my problems are increasing.	My problems seem to be accumulating
Q7	我担心我不能实现我的目标（们）	I am afraid that I cannot achieve my goals.	I am concerned about not realising my objective(s)
Q8	我感到受挫与沮丧	I feel frustrated and depressed.	I feel frustrated and depressed
Q9	我感到紧张	I feel nervous.	I feel nervous
Q10	我感觉到精神上的疲惫	I feel mentally exhausted.	I feel mentally exhausted
Q11	我在放松身心上存在问题	I have some problems on relaxing my body and mind.	I have problem in physical and psychological relaxation I have difficulty in calming down
Q12	我很难冷静	It is hard for me to keep calm.	
Q13	我感觉我在做自己真正喜欢的事情	I feel I am doing the things that I like.	I think I am doing the work that I truly like
Q14	我很轻松	I feel relaxed.	I am very relaxed
Q15	我有安全感	I feel a sense of security.	I feel secure
Q16	我感觉充满能量	I feel that I am full of energy.	I feel energetic

Data collection and demographics

Due to the impossibility of covering all populations and the sensitive questions asked in the PSQ (Shi *et al.* 2014), a snowball sampling technique was used rather than delivery direct to companies. Since young cost estimators can become stressful at work due to a lack of experience, and five years' experience is generally acknowledged as the necessary time for practitioners to master skills in construction cost estimation (Skitmore *et al.* 1990), potential respondents were restricted to having less than five years' working experience. 145 valid responses were received. Of these, 75 (51.7%) respondents are male and 69 (47.6%) are female (1 missing data); 42 (29%) are younger than 25, 101 (69.7%) range from 25 to 34 and 1 (0.7%) from 35 to 44 (1 missing data); and for their highest educational level, 13 (9%) possessed diplomas, 110 (75.9%) a bachelor's degree and 22 (15.2%) a master's degree.

Data analysis

Data reliability

Cronbach's alpha is used to evaluate the internal consistency of the questionnaire items. The overall value is 0.884, with 0.847, 0.838, 0.790 and 0.749 for the "demands" (Q1-Q4), "worries" (Q5-Q8), "tension" (Q9-Q12) and "lack of joy" (AQ13-AQ16) dimensions respectively. Since all these values are larger than the 0.7 cut-off value, the whole and the parts of the questionnaire are considered to be acceptably consistent (Xiong *et al.* 2014). Since Cronbach's alpha value is affected by the length of the scale, the matrix of correlations of individual items is also examined for confirming scale reliability. With a mean of the absolute values of item-item

correlations of 0.326 (SD=0.185), the results indicate an acceptable level of reliability (Ding and Ng 2007).

Although the principal component analysis (PCA) deals well with non-normal distribution situations (Wang and Du 2000), tests on sample distributions are still useful to reflect information on the population distribution. The sample skewness and kurtosis statistics can be used to test the normality of distribution of variables and both should lie within the [-1, +1] interval (Hair 2006). Here, the skewness and kurtosis values of all 16 variables are within the range of -0.86 to 0.45 and -0.55 to 0.46 respectively, which indicates the normal distribution assumption implicit in PCA to be satisfied.

Validation

The PCA confirms the hypothesized four-dimensional structure of stress, with a 0.840 Kaiser-Meyer-Olkin measure of sampling adequacy higher than the the cut-off value of 0.5 (Hair 2006) and a highly significant $p < 0.0001$ for Bartlett's test for sphericity indicating that the items are suitable for factor analyses. The forced 4-factor solution applying varimax rotation, an widely applied orthogonal rotation method maximizing the sum of the variances of the squared loadings (Abdi 2003) and used in Leventin *et al* (1993) and Fliege *et al* (2005), explains 70.1% of the overall variance with component 1, component 2, component 3 and component 4 accounting for 37.9%, 16.6%, 10.2% and 5.4% respectively. The allocated components, means, standard deviations and communalities (h^2) of the items are summarised in Table 3. For clarity, only the highest factor loading of each item is shown.

Table 3: Principal component analysis with varimax rotation

Items	Components				Item parameters		
	1	2	3	4	mean	std dev	h^2
Q1		0.861			5.73	1.19	0.75
Q2		0.878			5.60	1.44	0.80
Q3		0.731			5.50	1.45	0.71
Q4		0.635			5.23	1.43	0.78
Q5				0.630	5.27	1.42	0.76
Q6				0.630	4.62	1.51	0.71
Q7				0.614	4.78	1.71	0.68
Q8	0.843				3.81	1.69	0.80
Q9	0.822				4.10	1.64	0.76
Q10	0.718				4.46	1.59	0.74
Q11	0.648				3.86	1.63	0.56
Q12	0.622				3.32	1.70	0.48
AQ13			0.591		3.43	1.37	0.42
AQ14			0.760		3.99	1.40	0.76
AQ15			0.843		3.52	1.42	0.75
AQ16			0.697		3.35	1.30	0.75

DISCUSSION

In stress related research, some studies concentrate on external stressors, some on subjective components such as anxiety and worry, and others on coping strategies (Levenstein *et al.* 1993), although there is no general consensus on their measurement.

In investigating the subjective components of stress for cost estimators, Fliege *et al.*'s (2005) 4x5 perceived stress questionnaire was revised according the expected circumstances in China to a 4x4 version and tested for identifying the dimensions of stress involved. With the exception of Q8 – “*I feel frustrated and depressed*” – the PCA supports the hypothesised 4x4 structure. This anomaly is discussed below in terms of the four dimensions involved, together with the relationship of the results with the findings of previous studies on stress emotional reactions,

The “tension” dimension, comprising Q8-Q12, explains the largest proportion of variance (37.9%) in the data, which is consistent with Jamal's (1984) view of job related tension being regarded as job stress. According to Fliege *et al.*'s (2005) original categorization, Q8 (“*I feel frustrated*”) is not included in this dimension but in the “*worries*” dimension. This may be due to Fliege *et al.*'s selection of 5 items from Levenstein *et al.*'s (1993) original 13 items for this dimension. If we carry out a semantic analysis between Q5-Q7 and Q8, however, it is easy to see that there are no words of “*worry*”, “*afraid*” or “*fear*” in Q8. Additionally, two Chinese words are used to represent “*frustrated*” exactly and they are back translated as “*frustrated and depressed*”. Therefore, it is reasonable to include Q8 in the “*tension*” dimension. Also worth mentioning is the slightly low communality value (0.48) of Q12 and a slight increase (0.009) of Cronbach's alpha value if deleted. This indicates an inconsistent understanding of “*calm*” by the respondents, possibly related to the fact that “*calm*” refers not only to “*not excited or nervous*” but also to “*reasonable and wise*” in the Chinese culture.

The “demands” dimension comprising Q1-Q4 explains 16.6% of the variance in the data. The Cronbach's alpha value is rather high (0.847) but would not increase if any item is deleted. According to Fliege *et al.*'s (2005) explanation, this dimension is actually an extra stressor dimension that is similar to the term “*overload*” mentioned in many stressor studies (e.g. Jamal, 1984; Leung *et al.*, 2005) and different in nature to the other three dimensions.

The “lack of joy” dimension, comprising AQ13-AQ16, explains 10.2% of the variance, and has an acceptable Cronbach's alpha value of 0.749, but would be increased a little (by 0.007) if AQ13 was deleted. Additionally, the communality of AQ13 is comparatively low (0.42), indicating some confusion among respondents when answering Q13 (“*I feel I am doing the things that I like*”), which is similarly reflected in Levenstein *et al.*'s (1993) factor analysis results where the factor loading on this item in the “*lack of joy*” factor is also comparatively low.

The “worries” dimension, comprising Q5-Q7, explains 5.4% of the variance, and has a high Cronbach's alpha value (0.803) that would not increase if any item was deleted. The issue of Q8 is discussed above. To remain in the “*worries*” dimension, the wording of Q8 needs to be changed to such as “*I am afraid of/fear frustration*” with a greater emphasis on “*worries*”.

Investigating the differences among variables is a very informative way to understand multi-attributes of the sample. As shown in Table 3, items under “*demands*” sub-dimension among participants have comparatively high mean values than items in

other dimensions, indicating these young cost engineers experience a general “overload” feeling. The average value of this sub-dimension (5.52) is higher than that (4.13) of the “work overload” feeling among their counterparts in Hong Kong according to a 7 point Likert scale survey by Leung *et al* (2005). Additionally, Leung *et al* (2005) found that “work overload” factor is the most predictive stressor of stress of construction cost estimators in Hong Kong. This difference may be related to the extensive construction work that needs to be done to cope with the rapid urbanization in Mainland China, where the sub-sector of construction cost consultancy reached 80.685 billion RMB and 237,100 employees in 2011 after a 10% annual increase rate for several years (Shi *et al.* 2014). With such a fast increase in workload and employees, therefore, it is not surprising to find that current employees experience high “demands”. According to results shown in Table 3, young construction cost estimators also experience intense “worries” but with a little less “tension” and less still “lack of joy”.

CONCLUSIONS

The applicability of Fliege *et al*'s (2005) revised perceived stress questionnaire is tested and confirmed. Some critical issues are mentioned and discussed concerning the potential for the questionnaire to be applied in understanding the stress of workers and professionals in more general context and explore interactions of these sub-dimensions with stressors in the construction research. Since the hypothesised 4x4 structure of stress is supported with empirical evidence from young Chinese construction cost engineers, the topic would benefit from further research in general treating stress as a multi-dimensional concept.

ACKNOWLEDGEMENT

The authors would like to thank Dr. Mei Li and Mr. Xin Hu for the translations and the respondents of the survey for their contribution and support. The first author is financially supported by a QUT HDR Sponsorship from the research project “*Hosting, Maintenance and Further Development of the BER – Cost Analysis Model*” funded by the Commonwealth of Australia represented by the Department of Education.

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WORKPLACE STRESS IN THE CONSTRUCTION INDUSTRY: AN EXPLANATORY MODEL

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The construction industry is noted for high levels of occupational stress, particularly among professional workers. Using data from 676 architects, civil engineers, quantity surveyors, and project and construction managers responding to an on-line survey in South Africa, an integrated conceptual model of occupational stress is proposed. Structural equation modeling is used to test the model iteratively. The results of the final model indicate that: psychological, physiological and sociological strain effects are the terminal consequences of occupational stress; organizational climate is largely determined by gender and job demand, control and support; age, gender, control and organizational climate are predictors of discrimination; psychological distress is predicted by age, job demand and control factors, and organizational climate; sociological stress is determined by age, job demands, discrimination and psychological distress; and age, and sociological and psychological stress effects manifest themselves as predictors of physiological stress effects. Construction employers should regularly review workload allocations, empower employees, foster a supportive work environment, conduct stress appraisals, and hold stress management workshops.

Keywords: construction professionals, predictive modeling, workplace stress.

INTRODUCTION

The U.S. National Institute for Occupational Health and Safety defines workplace stress as “*the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker.*” Occupational stress is associated with low productivity, high absenteeism and poor job performance (McShane and Von Glinow, 2005). Construction is a high-risk industry for work-related stress (Love *et al.* 2010), characterized by long work hours (Van Wanrooy and Wilson, 2006) and interpersonal and inter-role conflicts (Loosemore and Galea, 2008). Recent research has explored occupational stress experienced by construction professionals in South Africa, focusing on the relationship between occupational stress and job demand, control and support factors; the effects of occupational stress; the coping mechanisms adopted by professionals in an attempt to mitigate the effects of stress; and the role of harassment and discrimination as work-related stressors. Data from 676 respondents to an on-line

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survey of architects, engineers, quantity surveyors, and project and construction managers are used to investigate occupational stress phenomena. Earlier papers, based on this dataset, have reported on the comparative levels of self-assessed job stress and job demand, control and support (JDC/S) factors; the comparative relationship between job stress and harassment and discrimination at work; stress, strain effects and coping mechanisms; and predictive regression modeling of stress as a function of JDC/S factors (see Bowen *et al.*, 2013). This paper, drawing together the disparate *foci* of the earlier papers, reports the application of structural equation modeling to posit an integrated model of occupational stress among construction professionals.

BACKGROUND TO THE STUDY

Job demands are quantifiable features of work, including time pressures and workload, while job control is defined by Karasek (1979: 290) as “*the extent to which employees have the potential to control their tasks and conduct throughout the working day*”. More recent adaptations of Karasek’s JDC model of occupational stress have incorporated workplace support as a resource that, together with control, can mitigate the extent to which job demands induce harmful effects in workers (Schaufeli and Bakker, 2004). The Job Demands-Control-Support (JDC-S) theory of occupational stress (Schaufeli and Baker, 2004) thus states that jobs that are high in demands, low in control and low in workplace social support are experienced as the most stressful and produce the most damaging health impacts.

Work generally takes place within organisations and these differ in the attitudes and behaviours they elicit in people (Sharma, 2013). Organisational climate can be described in terms of the values of a particular set of characteristics (or attributes) of the organization (French *et al.*, 1985). Thompson *et al.* (1996) found that stress and strain conditions were significantly less favourable in organisations with a negative organizational climate (characterised by employee perceptions of high compliance expectations, lower individual recognition and supervision, and lower employee autonomy) compared to organisations that were not so characterised. Such negativity can manifest in discrimination and harassment.

Discrimination in the workplace includes sexist or racist ‘put downs’ and unfair treatment by employers, supervisors or co-workers (Caplan *et al.*, 2009).

Discrimination at work is more serious than general ‘daily hassles’ because it threatens a person’s goals and sense of value as a person (Landry and Mercurio, 2009), and impacts negatively on job satisfaction (Ensher *et al.*, 2001) and mental health (Hoobler *et al.*, 2010). Harassment can be sexual or ethnic or based on points of difference between people, such as language, religion or sexual preference (Schneider *et al.*, 2000). Both discrimination and harassment are significant workplace stressors. All work stressors lead to strain effects.

Occupational stress exhibits strain effects in physiological, cognitive, emotional and behavioural ways (Blaug *et al.*, 2007). Physiological strain effects include sleep disturbances, headaches, gastrointestinal upsets, increased ill-health, and loss of libido. Psychological effects may be emotional (e.g., anxiety, depression); intellectual (e.g., loss of concentration, lack of motivation); or behavioural (e.g., substance misuse, absenteeism, poor motivation). The sociological effects of occupational stress may include marital discord, withdrawal, and the inability to manage one’s personal life. These are adaptive behavioural responses to stress.

Adaptive behaviours for coping with occupational stress include taking physical exercise, engaging in hobbies, socialising with family and friends, engaging in various

forms of entertainment, and seeking support from supervisors, co-workers and others. Maladaptive (or escapist) coping behaviours include the consumption of nicotine, alcohol and other (recreational) narcotics (see Moisan *et al.*, 1999). Research also suggests significant differences between the coping mechanisms utilised by men and women (Gianakos, 2002).

Few research findings explore the symptomatic relationship between the psychological, physiological and sociological effects of stress and JDC/S factors, organisational climate, harassment and discrimination at work, and the coping response mechanisms they adopt. This study attempts to address that shortcoming by proposing an integrated occupational stress model for construction professionals, and testing it mathematically using survey data.

RESEARCH METHOD AND QUESTIONNAIRE DESIGN

Primary data collection

An on-line questionnaire survey was administered to registered architects, civil engineers, quantity surveyors, and project and construction managers in South Africa. The item catalogue included: demographic details; self-assessed levels of occupational stress; a range of job demand, control and support issues; organisational climate; experiences of workplace harassment and discrimination; responses to psychological, physiological, and domestic/social (sociological) strain effects; and coping mechanisms. The catalogue of questions drew on the work of Haynes and Love (2004), Leung *et al.* (2005), Lingard and Francis (2009) and Love *et al.* (2010). The same questionnaire was used for all participating professional groups, and tested through a pilot study. Participants self-selected themselves by accessing the survey on-line at a given URL. Compulsory professional registration provided acceptable proxies for the populations of each profession. However, as the sample is self-selecting, care is needed in generalising findings. The responses (676) represent 7% of the total professional population. They comprise 269 architects, 168 engineers, 179 quantity surveyors, and 60 project and construction managers. Since many in the latter group hold dual registration in another discipline, their representation in the response sample is actually likely to be higher. The overall response rate is not considered unusual for web-based surveys of this nature.

Data validity and factor variables

Given the self-reporting survey measurement method adopted, the findings may have the potential risk of common method variance and the validity of data may be questioned. However, it should be noted that the question response Likert scales were adopted from survey designs reported in the extensive stress management and construction literature. The response sample size militates against data validity concerns, as do the significance values for the correlations between variables. The Cronbach's alpha for each variable summation scale (reported below) ranges from 0.69 to 0.89, indicating good to excellent scale reliability (see Table 1). The original dataset was subjected to missing value analysis involving the detection of anomalies. Eighteen anomalous cases were identified. Thereafter, listwise deletion was applied to the remaining 658 cases, resulting in 405 cases without anomalies or missing data. The remaining dataset is adequate for modeling purposes.

Demographic characteristics

Age is measured in seven discrete categories: under 25; 25-29; 30-34; 35-39; 40-44; 45-50; and over 50 years. Ethnicity data is captured in terms of the following

classifications: African; 'Coloured' (mixed race); Indian (Asian); and 'White'. However, the first three groups are combined as 'Black' in the statistical analysis and modeling, to improve cell count sizes.

Workplace stress

Participants are asked to assess their own perceived occupational stress (OS) levels on a 1 – 10 scale, ranging from 1 = minimum (*'feeling little or no stress'*) to 10 = maximum (*'highly stressed'*). No intermediate scale intervals are defined.

Job-related factors

Questions relating to *job demands* ask how frequently respondents experience working to tight deadlines (D1); how often they work long hours (D2); if they feel that they have inadequate time to balance work and family responsibilities (D3); and if they have to work harder than others to 'prove' themselves (D4). Each item uses a 5-point frequency response scale (1= *'most of the time'*; 2= *'frequently'*; 3= *'sometimes'*; 4= *'seldom'*; and 5= *'never'*). Item D4 permits the additional option of 6= *'not applicable'*, to cater for sole practitioners and other instances in which this condition would not apply. In addition, participants are asked to indicate the number of hours worked per week (D5) on a scale with seven 5-hour intervals ranging from: 1= *'31-35 hours'*, to 7= *'exceeding 60 hours'*. Exact items are shown in Table 1. Responses to each of the five demand factors were first examined as individual indicators of workplace demands of the job. Thereafter, a *job demand scale* was computed by summing all item responses in the direction of greater job demand. All demand factors, except hours worked per week, were reverse coded for this purpose. Scale scores thus represent the sum total of the endorsed items (range 5-27; with 27 representing the highest level of job demand). The job demand scale score is internally consistent ($\alpha = 0.63$). The internal consistency was improved by the removal of variable D4 (need to 'prove' oneself) ($\alpha = 0.75$), resulting in the scale score range 4-22. Similarly, factor scales were also computed for the other job-related factors: job control; job support; organizational climate; harassment; discrimination; drug usage; psychological symptoms; physiological symptoms; and sociological symptoms (see Table 1).

Table 1: Job-related category factors

Factor	Alpha	Sub-variables (survey questionnaire catalogue items)
Job Stress (OS)	-	-
Job Demands (Range 4-22)	0.751 (with D4 removed)	Need to work to tight deadlines (D1) (<i>reversed</i>) Need to work long hours (D2) (<i>reversed</i>) Inadequate time to balance work and family responsibilities (D3) (<i>reversed</i>) Need to work harder to 'prove' oneself (D4) (<i>reversed</i>) [Subsequently removed]
Job Control (Range 4-20)	0.796	Typical hours worked (per week) (D5) Control over work-place tasks (C1) (<i>reversed</i>) Control over pace of work (C2) (<i>reversed</i>) Control over work environment (C3) (<i>reversed</i>) Imbalance exists between work-place responsibilities and authority (C4)

Job support (Range 4-20)	0.779	<p><i>Manager support:</i></p> <p>(a) Manager makes life easier (S1) (<i>reversed</i>)</p> <p>(b) Manager helps in difficult situations (S2) (<i>reversed</i>)</p> <p><i>Colleague support:</i></p> <p>(a) Colleagues make life easier (S3) (<i>reversed</i>)</p> <p>(b) Colleagues help in difficult situations (S4) (<i>reversed</i>)</p>
Organisation (Range 7-35)	0.703 (with OG3 removed)	<p>Honestly say what I think and get things off my chest (OG1) (<i>reversed</i>)</p> <p>Argue frequently with line managers, colleagues or clients (OG2)</p> <p>Kept busy and occupied by job demands (OG3) (<i>reversed</i>)</p> <p>[Subsequently removed]</p> <p>Given opportunities to improve or perfect skills (OG4) (<i>reversed</i>)</p> <p>Fairly compensated for the work done and hours worked (OG5) (<i>reversed</i>)</p> <p>Certainty regarding job stability in the industry over the next few years (OG6) (<i>reversed</i>)</p> <p>Certainty regarding job promotion opportunities in the construction industry (OG7) (<i>reversed</i>)</p> <p>Confidence in ability to secure a new job (if lost job) within a short period of time (OG8) (<i>reversed</i>)</p>
Harassment (H1 – H16) (Range 0-16)	0.749	Perceived <i>harassment</i> of a sexual nature, or based on language, race, religion, gender and / or sexual preference – by line manager or colleagues: H1 H2 H3 H4 H5 H6 H7 H8 H9 H10 H11 H12 H13 H14 H15 H16 (<i>all reversed</i>)
Discrimination (DS1 – DS20) (Range 0-20)	0.715	Perceived <i>discrimination</i> in terms of salary or job security, based on language, race, religion, gender and / or sexual preference: DS1 DS2 DS3 DS4 DS5 DS6 DS7 DS8 DS9 DS10 DS11 DS12 DS13 DS14 DS15 DS16 DS17 DS18 DS19 DS20 (<i>all reversed</i>)
Drug usage (Range 3-18)	0.698 (with SU4 removed)	<p>Extent of consuming alcoholic drinks (SU1) (<i>reversed</i>)</p> <p>Units of alcohol consumed per week (SU2)</p> <p>Number of cigarettes smoked per day (SU3)</p> <p>Use of illegal substances over the last 12 months (SU4) (<i>reversed</i>)</p> <p>[Subsequently removed]</p>
Psychological symptoms (in the last 12 months) (Range 8-40)	0.851	<p>Felt tense at work due to job-related issues (PS1) (<i>reversed</i>)</p> <p>Felt angry at work due to job-related issues (PS2) (<i>reversed</i>)</p> <p>Felt unhappy and / or depressed at work due to job-related issues (PS3) (<i>reversed</i>)</p> <p>Felt satisfied with the way a task is performed (PS4)</p> <p>Felt depressed about circumstances at work (PS5) (<i>reversed</i>)</p> <p>Lost self-confidence (PS6) (<i>reversed</i>)</p> <p>Felt you played a useful part in projects in which you were involved (PS7)</p> <p>Received adequate acknowledgement or appreciation for good work (PS8)</p>
Physiological symptoms (in the last 12 months) (Range 6-30)	0.796	<p>Experienced changes / disturbances to usual sleeping habits / patterns (PH1) (<i>reversed</i>)</p> <p>Felt (unexplained) symptoms of nausea or stomach disorders (PH2) (<i>reversed</i>)</p> <p>Experienced headaches (PH3) (<i>reversed</i>)</p> <p>Found it difficult to concentrate for a long period of time (PH4) (<i>reversed</i>)</p> <p>Communication with colleagues frustrates you or leaves you with feelings of being misunderstood (PH5) (<i>reversed</i>)</p> <p>Difficulty in relaxing after hours (PH6) (<i>reversed</i>)</p>
Sociological symptoms (Range 3-15)	0.892	<p>Stress at work puts a strain on family life (SE1) (<i>reversed</i>)</p> <p>Stress at work puts a strain on social activities (SE2) (<i>reversed</i>)</p> <p>Stress at work puts a strain on social relationships (SE3) (<i>reversed</i>)</p>

DATA ANALYSIS

Bivariate correlations

Significant correlational relationships were found between perceived occupational stress (OS) and psychological strain effect ($r=0.670$, $p<0.001$), physiological strain effect ($r=0.671$, $p<0.001$) and sociological strain effect ($r=0.714$, $p<0.001$) (results not depicted here). Given the strength of these relationships, the three strain effect conditions are adopted as concurrent or surrogate indicator measures of stress. The relationship between factors was explored using Pearson's correlation coefficients (not shown here). The findings show that the three strain effect conditions are significantly (either positively or negatively) correlated with gender, age, work experience, job demands and job control, organisational climate, and harassment and discrimination (but not with ethnicity or job support). These patterns of correlations support more detailed analysis, first using multiple regression to model physiological, psychological and sociological strain effects, respectively.

Multivariate analysis

For the multiple regression modeling, preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity, and heteroscedasticity. A multiple regression was performed to examine the determinants of *physiological strain* in occupational stress, using the same set of independent variables (not shown here). The overall model is significant ($F=14.911$, $p<0.001$), explaining 29.4% of the variance in the physiological strain effects of stress. In this case, age ($p<0.050$), job demands ($p<0.001$) and organisational climate ($p<0.001$) are found to be significant independent determinants of physiological strain effects of occupational stress. Similarly, to determine the *psychological strain* effects of stress, a multiple regression was conducted with age, ethnicity, experience, job demands, job control, job support, organisational climate, harassment and discrimination at work, and substance usage being entered as independent variables (not shown here). The overall model is significant ($F=36.687$, $p<0.001$), explaining 50.7% of the variance in psychological strain effects. However, only age ($p<0.050$), job demands ($p<0.001$), job control ($p<0.001$), and organisational climate ($p<0.001$) are found to be significant independent determinants of psychological strain effects of occupational stress. Finally, to determine the *sociological strain* effects of stress, a multiple regression was performed using the same set of independent variables. The overall model is significant ($F=25.225$, $p<0.001$), explaining 41.4% of the variance in the sociological strain effects of stress. For this model, age ($p<0.050$), job demands ($p<0.001$), organisational climate ($p<0.001$), and discrimination at work ($p<0.001$) are found to be significant independent determinants of sociological strain effects of occupational stress (not shown here).

A four-part *conceptual model*, based on the literature review and the statistical analysis, is posited. Firstly, demographic (age, ethnicity, gender and experience) and workplace (job demand, control and support) factors are seen as predictors of the organisational culture, itself comprising harassment, discrimination, and the organisational climate. Secondly, the strain effects (psychological, physiological and sociological) experienced by construction professional participants are seen as being determined by the organisational culture; itself determined by demographic and workplace factors as noted above. In turn, the extent of use of alcohol and tobacco (substance use) is seen to be predicted by the three strain effects. In essence, in the conceptual model, substance use is posited as a terminal outcome of occupational stress. This model provides the starting point for structural equation modeling.

Structural equation modeling

Structural equation modeling (SEM), using Amos 22.0 for Windows, was used to delineate two structural equation models. Nine fit indices were applied to determine the degree of fit of the structural equation models. The development of the final SEM model occurs in three iterations: conceptual model; Model 1; and Model 2 (final model). Only the final model is discussed here. The fit indices of the various models are shown in Table 2. The final model is depicted in Figure 1.

A path diagram (not depicted here) was compiled to represent the conceptual model. The fit indices (Table 2) show that the ethnicity and harassment factors violate the normality assumption and are thus omitted from subsequent modeling. In line with the conceptual model, Model 1 (not shown here) models the stress-related determinants of substance use. The pathways from the three strain effect factors to substance use are *not* significant, and substance use is thus omitted for Model 2. Model 2 (the final model) models the determinants of strain effects, and displays the following fit statistics: $\chi^2 = 42.189$ with $df=24$ and a χ^2/df ratio of 1.758 (below the recommended threshold of 2.00); GFI=0.982; AGFI=0.949; CFI=0.991; IFI=0.991; REMSEA=0.043 (all well within accepted tolerances); and Hoelter=349, which exceeds the 200 cases recommended threshold. An assessment of normality test reveals no transgressions. Model 2 is considered well-fitted to the data.

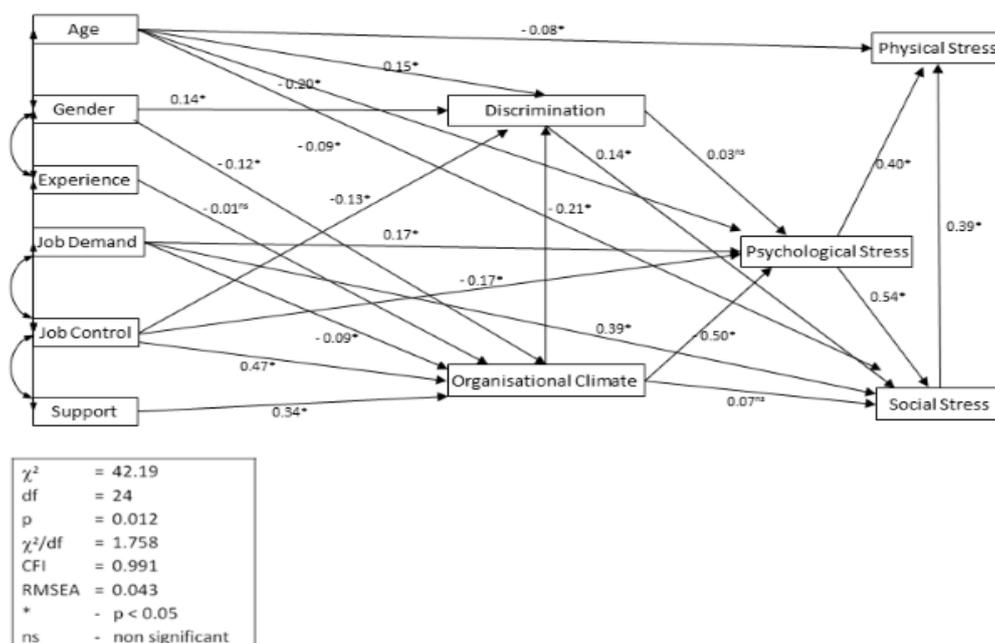


Figure 1: Modeling determinants of strain effects – Model 2 (Final)

Table 2: Fit indices of the occupational stress structural equation models

Model	χ^2	df	p	χ^2/df	GFI	AGFI	CFI	IFI	REMSEA	Hoelter
Conceptual Model	120.0	5	0.00	2.14	0.96	0.92	0.97	0.97	0.053	251
Model 1	53.48	3	0.01	1.67	0.97	0.94	0.98	0.99	0.041	349
Model 2 (Final)	42.19	2	0.01	1.75	0.98	0.94	0.99	0.99	0.043	349

Note: χ^2 = Chi-square; df = degrees of freedom; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; CFI = comparative fit index; IFI = incremental fit index; REMSEA = root mean square residual; and Hoelter = critical N (CN) index.

DISCUSSION

Several significant predictive pathways are identified in the SEM (see Figure 1). Firstly, gender is significant in predicting perceptions of organisational climate ($b=-0.122, p<0.010$) and discrimination at work ($b=0.135, p<0.010$). Female construction professionals are more likely than males to experience a less supportive organisational climate and more discrimination at work. Subsequent field research interviews, conducted to address the absence of female construction managers in the original survey response, support this finding, particularly for female professionals working on construction sites, where reported issues include the provision, adequacy and cleanliness of female toilet amenities, and less willingness on the part of male artisans to accept instructions from a female supervisor. These findings align with those of Bowen *et al.* (2008) in respect of quantity surveyors.

Job demand ($b=-0.090, p<0.050$), control ($b=0.471, p<0.010$) and job support ($b=0.340, p<0.010$) factors are predictive of perceptions of organisational climate. Construction professionals who experience lower levels of demands, and higher levels of control and support are more likely to experience a better organisational climate. Long hours and tight deadlines are considered endemic job demands in the construction industry, but must be operationally justified if their magnifying effect on employees' physiological strain is to be mitigated. Greater flexibility in job allocation processes; improving staff supervision; and encouraging more collegial support will not only yield efficiency dividends but will also lead to a better organizational climate. Blaug *et al.* (2007) argue the positive effect of primary organizational measures to prevent occupational stress; improving the organizational climate is one way to implement them.

Age ($b=0.148, p<0.010$), organisational climate ($b=-0.208, p<0.010$), and control ($b=-0.126, p<0.050$) are predictive of discrimination at work. Older construction professionals, working in less supportive organisational climates, and experiencing lower levels of control at work, are more likely to experience greater discrimination than younger professionals working in supportive environments and enjoying higher levels of control. This suggests that the effectiveness of any stress 'conditioning' (i.e., where tolerance of the strain effects has gradually built up over time in the face of continuing exposure to workplace stressors) is likely to be of limited duration. This finding aligns with Gilbert (2010).

Psychological strain effects are predicted by age ($b=-0.204, p<0.010$), job demands ($b=0.166, p<0.010$), control ($b=-0.170, p<0.010$), and organisational climate ($b=-0.497, p<0.010$). Younger construction professionals, experiencing higher levels of job demands in less supportive organisational climates and having low levels of control, are more likely to report higher levels of psychological strain than their older counterparts. It may be hypothesized that the stress arising from a need to prove themselves, uncertainty about their place and 'fit' in the organisation and uncertainty about what they can reasonably expect by way of support from the organisation, may all lead to higher psychological strain outcomes for young construction professionals. Similar findings are reported by Leung *et al.* (2005).

Physiological strain effects are predicted by age ($b=-0.076, p<0.050$), psychological strain effects ($b=0.404, p<0.010$), and social / domestic strain effects ($b=0.391, p<0.010$). Younger professionals, experiencing higher levels of psychological and social strain, are more likely to suffer from physiological strain effects than older

professionals experiencing lower levels of psychological and social/domestic strain (see also Leung *et al.*, 2005).

Social/domestic strain effects are predicted by age ($b=-0.087$, $p<0.050$), job demands ($b=0.390$, $p<0.010$), discrimination ($b=0.138$, $p<0.010$) and psychological effects of stress ($b=0.538$, $p<0.010$). Younger professionals, experiencing high levels of job demand, higher levels of discrimination at work, and more severe psychological effects of stress, are more likely to display social strain effects than older participants who have not experienced similar high job demands, lower levels of discrimination at work, and lower levels of psychological stress effects. Explanations may include the demands of families and young children (compared to the potentially quieter lives enjoyed by older 'empty nesters'); the social expectations of peer groups; the effects of 'conditioning' among older professionals or their greater experience with appropriate coping mechanisms. These findings support those of Lingard and Francis (2009).

This study offers some new and interesting findings. Firstly, it reaffirms the prominence of job demand and control factors as workplace stressors, together with job support as a mitigator. Secondly, it shows that age is an important factor in the strain effects of occupational stress among construction professionals. Thirdly, female professionals are likely to have more negative perceptions than males with respect to the organizational climate of the construction industry.

CONCLUSIONS

Data were gathered from construction professionals and a conceptual model of workplace stress posited. This model, comprising demographic factors, job demand, control and support factors, harassment and discrimination at work, organisational climate, and psychological, physiological and sociological strain effects, initially proposed substance use as the terminal consequence of job stress. Structural equation modeling was then used to test the conceptual model. The initial proposition was not supported and a different model formulated.

The results indicate that: (1) psychological, physiological and sociological strain effects are the terminal consequences of occupational stress, not substance use (2) employees' perceptions of organisational climate are largely determined by gender and job demand, control and support factors; (3) age, gender, and perceptions of job control and organisational climate are predictors of workplace discrimination; (4) psychological distress is predicted by age, perceptions of job demand and control factors, and perceptions of organisational climate; (5) sociological stress is determined by age, perceptions of job demands, and experiences of discrimination and psychological distress; and that (6) age, and sociological and psychological strain effects manifest themselves as predictors of physiological strain effects (the manifest symptoms). The complexities of organizational climate, and the ways in which it is perceived by employees, are likely to be highly nuanced. The organisational climate derives from how employees perceive their working environment, not from the experiences they bring to it. Employers should understand the effect that occupational stress has on their employees and implement strategies preferably aimed at prevention. These might include regular reviews of workload allocations, empowering employees, fostering a supportive work environment, conducting stress appraisals, conducting stress management workshops, and facilitating stress counseling where warranted. SEM has yielded valuable insights into the relationships between work stressors and their strain effects, the age and gender of construction professionals, and the strength of these associations. This is the contribution of the research.

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WE WILL FORCE YOU TO BE WELL: POSITIVE LIBERTY, POWER AND THE HEALTH AND WELLBEING OF CONSTRUCTION WORKERS

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The UK construction industry has long championed changes and developments in work practices that reduce and avoid negative impacts on worker health and wellbeing. More recently however, approaches have shifted to consider the worker beyond the workplace, and now seek to improve health and wellbeing in worker 'associated lifestyles', as crystallised in the UK Department of Health's Responsibility Deal Construction Pledge. Yet such an approach is a fundamental challenge to construction workers' liberty, and questions the status of the individual and their autonomy. It can also be seen as an exercise in paternalistic or pastoral power, and consequently a constraint of personal freedoms. Whether this next step in corporate social responsibility is a purely philanthropic quest, seeking to improve individuals own health and wellbeing, or a step towards the creation of a more perfect workforce, one that does not become ill or operate at any less than maximum performance, such an approach brings benefits not only to the workforce but also to those who benefit from what they produce. As companies become more economically powerful than countries, such governmentalisation of corporate powers must be considered. The exercise of this power should be questioned, and the agendas, issues, conflicts and interests behind such approaches fully illuminated and explored. Grounded in a Critical Discourse Analysis (CDA) of the press release of the UK Pledge, a Foucaultian exploration of the power relations in play within this context has been developed. Steven Lukes' three dimensions of power are considered alongside positive liberty, revealing potential concerns for workers health and wellbeing in terms of their fundamental autonomy, and an increasingly controlled relationship between productive activities and power relations.

Keywords: autonomy, health, positive liberty, power, wellbeing.

INTRODUCTION

The UK construction industry has a relatively poor record in terms of the health and wellbeing of its workforce. There were an estimated 74 thousand total cases and 31 thousand new cases of work-related ill health, and an estimated 818 thousand working days lost due to ill health in the period 2011/12 (HSE, 2014). Construction industry diseases include vibration white finger, occupational deafness, dermatitis, many different lung diseases and the largest instance of occupational cancers within all UK industry, due mostly to past exposures to asbestos and silica (HSE 2014).

It would therefore seem highly appropriate that 'health' is becoming as important as 'safety' within construction management, and in autumn 2013, the UK Government's

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Department of Health (2013a) launched the 'Responsibility Deal Construction Pledge'. The Construction Pledge forms part of a wider governmental initiative covering all industries, with the core commitment to "... *actively support our workforce to lead healthier lives*" (DoH 2013b). As a consequence, the Pledge does not just seek to encourage health management within construction work, but rather seeks to improve worker wellbeing beyond work into their "*associated lifestyles*".

There are several key issues to be unpacked here. Whilst the involvement of governments in the lifestyles of their electorates raises certain questions of power, autonomy and personal freedoms, the passing of this pastoral role to corporations is arguably cause for serious concern. Within the ever growing context of corporate social responsibility (CSR), and as companies become more powerful than countries, it must be remembered that organisations ultimately seek productivity and profit. A healthy workforce operating at maximum productivity may indeed benefit the worker, but it will also certainly benefit those who control such production. Any philanthropic gloss, whether government applied or not, should be chipped off, and the agendas, issues, conflicts and interests behind such approaches fully illuminated and explored.

METHODOLOGY

This study is grounded in social constructionism, seeking to examine the discourses that are central to all human activity (Potter and Hepburn 2008) and used to construct our social realities. Whilst various approaches to discourse analysis have been identified (Wetherell *et al* 2001), it is also accepted that discursive work can often blend with and move between them, along what is known as the discursive continuum. Indeed, Gergen and Gergen (2003) have described discourse analysis as a very flexible approach, with no rigid set of assumptions that must be adhered to.

For this study Critical Discourse Analysis (CDA) was used to unpack the Department of Health's Pledge press release, to examine the processes and functions of the discourse (Gergen 2009), whilst also enabling power relations to be highlighted through the analytical process (Fairclough and Wodak 1997). This approach, developed from the micro structures of the text itself, shifted between micro and macro perspectives (Van Dijk 1997) to allow the larger linguistic and social structures within social life related to this reality to be explored (Burr 2003). Consequently the wider contexts of concern, those of freedom, power and production could be explored in depth, drawing on Foucault's (1982 [2002]:342) concept of power relations, as well as Lukes' three dimensions of power (2005) and other theoretical positions (Berlin 1958), ultimately '...linking the specific text with the underlying power structures in society through the discursive practices which constitute and are constituted by the text' (Ness 2010:483).

Grounded as it is in relativist ontology and social constructionist epistemology, this study obviously makes no claims to objectivity. Indeed, given the subject matter such an approach would risk the legitimisation of the very power structures it seeks to explore (Ness 2010). Rather the explication of the analysis alongside considerations of theory, enables the reader to make their own judgements of the validity, and indeed the relevance and utility of this work.

Due to constraints of space, and concessions to the rationality of argument, literature, theory, findings and analysis have been interwoven to develop the main body of this paper as a coherent whole. Quotations in double speech marks have been taken from

the Pledge press release itself, and this document is subsequently referred to as 'the Pledge'.

ANALYSIS AND DISCUSSION

Construction Health

Health is a contentious issue. It does not meet specific criteria; simple absence from illness is insufficient within wider considerations of wellbeing, mind as well as body, and indeed the state of 'healthier'. Unsurprisingly, within the Pledge a state of health is not defined, rather the wider discourse of health within the Pledge associates variously with the industry, its sites, the individual and the UK economy.

The health of the UK construction industry is negatively positioned alongside other industries, with *"a higher prevalence of poor health and wellbeing compared to other sectors"*. This industry level consideration is supported by the aim *"to make building sites healthier places to work"*, seeing the existing state of sites as unhealthy or not as healthy as they could be. Health is constructed as something lacking within the construction industry and its places of work, yet the practical context of construction work is rather superficially considered. Negative influences on *"better health"*, namely the *"difficult and demanding environments"* and the *"conditions of work"* are not associated with any management, ownership or legal responsibility. Indeed, the only acknowledgement of law within the Pledge is found within a soundbite from the Chair of the Responsibility Deal Health at Work Network, that some construction workers *"face particular and well known workplace hazards against which there are strict safeguards"*. Yet this is followed by a *"but ..."*, which again makes recourse to working conditions and so reduced the impact and effectiveness of these legal safeguards to actual work practice.

The UK Construction Worker

Within the Pledge, two very different UK construction workers can be identified. The first, limited to a soundbite from Tommy Walsh, *"Britain's favourite builder"*, is *"... just as likely to go down to the gym as they are to go to the pub after work"*. The second, more prominent within the Pledge can be taken from its title *"Britain's beefy builders say bye bye to baring bottoms"*. To brush over the patronising alliteration within this description, the Pledge makes further reference to the *"bottom baring, overweight builder"*, although concedes that this *"... image... "* is *"... being replaced by workers who are hands-on well-oiled machines."* Yet such delayed juxtaposition does not dismiss the initial and socially familiar negative stereotype of the UK construction worker, who then lingers in the background throughout the Pledge.

Despite the construction industry still retaining a reliance on manual labour (HSE 2009), the fact that a large amount of construction work requires certain levels of physical fitness is not considered. Within the Pledge, health for the individual involves being in *"better shape"*, a consideration more closely associated with the physical than the mental aspects of wellbeing, and something potentially more relevant to office workers than construction operatives, who are in the majority on their feet and moving throughout the working day. The body over the mind is also prioritised in the *"Health at Work Network collective pledges"*, all-industry commitments to health. These collective pledges focus on illness, *"risk of heart disease, type 2 diabetes and certain cancers"* and seek to help the individual *"improve their health and live well for longer"*.

Surprisingly, the Pledge does not position the construction worker as the architects of their own health. Again, only acknowledged within the same soundbite from Tommy Walsh, that "*there's loads more workers and their companies can do*" does the worker gain an active role in their own health. Given the highly autonomous nature of a widely self-employed workforce who enjoy the freedom construction work brings (Polesie 2010), such limited acknowledgement of their participation in their own health seems incongruous. Indeed, the Pledge does not linger on construction workers as individuals, but rather they are incorporated into an amorphous "*healthy workforce*" which avoids illness, and is therefore able to work and produce consistently for the benefit of corporations, industry and the UK economy.

Indeed, the Pledge emphasises that "*almost two million working days were lost due to sickness on construction sites across Britain last year ...*". This use of a statistical trope is familiar within discourses of health and safety, but in this context it also supports the construction of health as simply the ability to be present and participate in work.

Paternalism and Pastoral Power

The dominant discourse within the Pledge associates health with industry and industry organisations, with companies "*making the health of their staff a priority on their sites*", notwithstanding the legal framework already in place to ensure and enforce precisely that. However, within the Pledge health is not restricted to the legally controlled workplace, but is also articulated within the construct of "*public health*", associated with the desire for the industry's "*workforce to lead healthier lives*". This links to Victorian concepts of philanthropy, paternalism and moral direction grounded in religion, closely associating with the contemporary concept of Corporate Social Responsibility (CSR).

Health is therefore constructed beyond the workplace, and the "*support*" and "*care*" for the workforce's lifetime health becomes the responsibility of their employer. The stereotypical construction of the "*bottom-bearing, overweight builder*" seemingly provides straightforward justification for this wider philanthropic approach. Workers cannot look after themselves, they are fat and unable to wear trousers correctly, and so must be looked after by their companies, even when not at work.

More complexly, notions of paternalism and pastoral power (Foucault 1982) can be drawn upon to explore the rationalisation behind this simplistic construction. Berlin (1958:18) suggested the concepts of 'higher', ideal and rational, and 'lower', impulsive and uncontrolled selves. He argued that this kind of language led to the rationalisation and justification of '*... coercing others for their own sake ...*' towards goals that they '*... would, if they were more enlightened, themselves pursue, but do not, because they are blind or ignorant or corrupt.*' In ascribing 'real' or 'true' interests to construction workers, decisions can then be made to guide them for the 'better'. For example, Lukes (2005: 82) identifies various 'welfare interests', including health, and proposes that their status as an interest does not always derive from desire, but that any '*... conditions that damage your health are against your interests ... even if you actively seek to promote them*'.

Concepts of irrational interests are also linked to human fallibility and self-control, towards what Thaler and Sunstein term 'sinful goods' (2008:80) such as "*... smoking, alcohol and jumbo chocolate doughnuts*", all of which can be linked to the negative health descriptions found in the Pledge. Indeed, Thaler and Sunstein suggest that irrational interests often arise from 'busy people trying to cope in a complex world in

which they cannot afford to think deeply about every choice they have to make' (2008:40). This is reflected through the discourse of health within the Pledge, reinforcing the need for "*support to promote better health*", to the extent of taking decisions out of workers' hands through "*healthier staff restaurants*" to "*tackle obesity*". In constructing the construction worker as unhealthy, the Pledge positions corporations as necessary instruments in "*getting construction workers and staff in better shape*".

Yet as Foucault identified, issues around health are highly complex and '... all uniform, rational modes arrive very quickly at paradoxes' (1983 [2002:378]). Although as Young (1986) stated, 'to be less than fulfilled is surely sometimes better for a person, where fulfilment brings in its train premature death', people continue to operate in ways that are not, rationally, in their best interests. It is this construction of the worker that is found in the Pledge, the "*overweight builder*" who does not realise his true interests because "*many construction workers do not have ready access to the kind of general support to promote better health that is available to other working people*". This highly simplistic, and somewhat patronising rationalisation justifies the wider discourse of workers' health as the responsibility of others, their employer corporations and government.

Such constructs also arguably objectify workers, turning them into true human 'resources', that can be stacked alongside the plant and materials on sites, requiring maintenance and fuel like the excavators and dumpers. As Berlin noted, such paternalistic manipulation '... is to deny their human essence, to treat them as objects without wills of their own, and therefore to degrade them' (Berlin 1958:22). This also raises issues of the ownership of such 'commodities' and the contract of work itself, an analysis of which is beyond the constraints of space allowed here.

Young (1986) identified two types of paternalistic approach; strong and weak. Strong paternalism is intervention to protect a person, whether their consent to this protection is given or not, and this often manifests through law. Yet within the Pledge, representation or support from strong paternalistic perspectives is notably absent. Praise for organisations "*making the health of their staff a priority on their sites*" rings somewhat hollow when considered alongside the Health and Safety at Work Act 1974, which rather clearly states that this is not actually a voluntary situation - they should be doing so as a matter of course. This construction of health management as an option negates the influence of the legal framework, and constructs those companies involved as considerate when in reality they are only compliant.

The paternalistic discourse found within the Pledge is weak; it assumes an ignorance or defect in the decision-making capabilities in the workforce, which may or may not be present. Young (1986:64) suggests that whilst strong paternalism results in law, something notably lacking within the wider discourse of the Pledge, there are also potentially concerns with weak paternalism. This this has the potential to '...open(ing) the gates to invasive intrusions ...', identifiable here as the involvement of those motivated by production and profit.

Worker Autonomy and Freedom

Paternalism and pastoral power also have implications for worker autonomy and freedom, and as such have been severely criticised; Berlin cites Kant, who famously stated that 'paternalism is the greatest despotism imaginable' (1958:22), whilst Foucault sought specifically to challenge 'a certain modern version of enlightenment, made up of morally and intellectually validated schemes of social improvement'

(Gordon 2002:xvii). Paternalism follows the basic presumption that those '... who allow themselves to be injured or harmed are, in doing so, not consenting freely and knowingly' (Young 1986), yet such an approach also contains potential '... threats to the individual and his [sic] liberties ...' (Foucault 1979 [2002:298]).

Most notably, Isaiah Berlin (1958:18) explored this relationship in detail, suggesting that paternalism draws on the fundamental assumption that an individual's 'true' interests '... must be identical with his freedom, the free choice of his 'true' ... self', and therefore it is clearly justifiable through paternalistic measures to 'force them to be free' (Curtis 2007). Yet equating what people would choose if they were something they are not, with what they actually seek and choose is what Berlin describes as a '... monstrous impersonation ... at the heart of all political theories of self-rationalisation' (1958:18). Within the Pledge, the workers are constructed as making poor choices, resulting in their current health issues, and the choice for health is normalised within the discourse. Despite the evident choices made by the workers, and their choice to have such choices, the Pledge self-rationalises thereby restricting worker freedoms; seeking to force them to be well.

This follows Berlin's concept of positive liberty - that to be free people must be coerced into their 'true' choices, and assumes that '... freedom is not freedom to do what is irrational, or stupid, or bad' (1958:32). Although workers' best interests may indeed correlate to improve health as defined within the Pledge, they may also wish to enjoy 'sinful goods', to make irrational decisions or choose something unhealthy. Within the wider picture such 'bad' choices may even form respite from the restrictions of work on their lives, allowing them to make some of the few remaining autonomous decisions available within our society. As Lukes (2005:36) suggests, any challenge to the 'accepted' definition of health actually shifts the best interests of the workers to the exercise of their own autonomy. Within the Pledge, the workers' ownership of their own health is notable in its absence from the discourse, "*industry has come together with the Department of Health to tackle the issue head on*", and the active participation of the workforce in their own health is not a consideration.

Through positive liberty, paternalistic approaches are often justified as supporting the freedom of the workers, although as Berlin also noted, those who seek to implement this form of freedom also want '... authority ... placed in their own hands' (1958:51). Within the Pledge, the power to determine good health is taken by the government and industry, leaving the workers' voices unheard and fundamentally challenging their individual freedoms.

Legitimation of the New Shepherds

However, the curtailing of individual worker freedoms through paternalistic corporate control of health is not so baldly explicit within the Pledge itself. Rather, subtle shifts in power relations have enabled the legitimisation of new industry shepherds.

As noted by Foucault, '... power relations have been progressively governmentalised, that is to say, elaborated, rationalised and centralised in the form of ... state institutions' (Foucault 1982 [2002:345]). That the government has permission to implement laws around health and safety within the construction industry demonstrates an accepted strong paternalistic exercise of power. The role of the Department of Health as instrumental in the initiation of the Pledge adds authority to its implementation, and the weak paternalism exercised within.

Yet through the close association of the Department of Health with industry, more subtle forms of power have shifted between the two. In the partnership of the Pledge, construction companies have tacitly gained the same authority and responsibility as the Department of Health, further emphasised by their active role in the Pledge and their unquestioned ability to *"play their part in improving public health"*. This invokes Luke's third dimension of power, normalising industry involvement in public health and granting permission to action in areas previously restricted to government bodies, who had gained their permission through development of knowledge, experience and elected right.

The Pledge further identifies the *"potential for businesses ... to make a significant contribution to improving public health"* ascribing corporate involvement to philanthropy, further legitimising participation but also challenging questions of interests; to contribute is not to take or exploit. The construction companies themselves are institutionalised; their identification as *"... household names ..."* that *"... have developed health and well-being programmes for all the workers on site"* creating an association with reputation, stature and investment, and the consequential validation of their involvement. Indeed, the findings of Thaler and Sunstein (2008:11) may also support such corporate institutionalisation, as they suggested that '... some people will happily accept (influence from) private institutions but strenuously object to government efforts to influence choice with the goal of improving people's lives ... (and) worry that governments cannot be trusted to be competent or benign.' The Pledge's link to an industry that the workforce itself forms part of, adds validity to their involvement whilst diffusing concerns around interests.

Within the Pledge, the power of the new shepherds is explicitly exercised through corporate management control. Despite the paternalistic discourse of health throughout the Pledge to *"further help its workforce to lead healthier lives"*, the collective pledges are themselves tools of managed surveillance and control of personal choice. Although cloaked in notions of pastoral care, Lukes' second dimension of power can be identified; the decision for workers' participation in these practices is made without question or choice, normalising detailed levels of corporate management investigation into the personal lives of individuals. Given that the findings of such *"health check tools"* may reveal issues that directly affect an individual's ability to work, or even their future longevity, such information further commodifies the worker, a resource to be objectively evaluated for its potential outputs.

Productivity and Profit

Foucault (1982[2002:339]) observed the disciplining of societies since the 18th century, which did not result in more obedience, but that '... an increasingly controlled more rational, and economic process of adjustment has been sought between productive activities, communication networks and the play of power relations.' This has also been suggested by the analysis carried out here; control of health has been passed unquestioned to the controllers of production, who have now been granted the power to manage and control worker health even beyond the workplace.

Indeed the discourse of health as an economic factor can be identified throughout the Pledge, the philanthropic gloss tarnished somewhat by the close associations of the *"health push"* with the *"productivity and prosperity of businesses and the wider economy."* Whilst it could be suggested that the workers interests should be

prioritised, and to some extent the prominent discourse of paternalism within the Pledge supports this construct, the positioning of "*their health and wellbeing (as) ... crucial to our economy as well as to themselves and their families*" does not place their interests first within the wider context. Rather the mechanisms of productivity are the primary interest here, the individual's health only a secondary support to that higher function.

Indeed, the Pledge constructs an Orwellian image of workers as "*well-oiled machines*". The aim of health, and arguably life itself, has become the maximisation of operations and efficiency at work. Health is equated with attendance, participation and productivity, and can be extrapolated to the corporate interests of increased outputs, turnover and profits.

Yet the neat alignment of these rationalised interests of workers' good health with those of commercial corporations adds a new dimension to the Marxist struggle between those who control production and those who provide the labour for that productivity, and raises questions of what reciprocal benefits a leaner, more efficient workforce can expect as they increase productivity through health.

The CSR Illusion

In the contemporary construction industry, the growing area of CSR forms the perfect obfuscator for the implementation of the Pledge; commercial gain subsumed by philanthropic concepts of care and support, seemingly justified by straightforward paternalistic intentions and fully supported by benevolent clients and public sector organisations.

The normalisation of employer responsibility and control of worker health beyond the scope of the workplace forms an inherent part of CSR, organisations proudly promoting their activities to support worker health and wellbeing (Rawlinson and Farrell 2010). A fundamental assumption that the workforce should be glad to participate in various health management programmes and schemes exists within the industry, as illustrated by the lack of any promotion of participation within the Pledge itself.

Yet interests are assumed where they should be challenged. Although the individual's interests of health may align to those put forward by their employers, it is a fallacy to suggest that there is significant freedom of choice within such a prescribed framework of surveillance and environment of control. For example, knowledge about health is positioned through "*health checks*" as beneficial, to help individuals "*improve their health and live well for longer*". This raises fundamental questions about the harsh realities of life; whether it is better to meet death one morning as a surprise or to watch him slowly walking towards you over the horizon. Many people many not wish to know the latter, it may not be within their 'real interests' at all. Consequently, it must be remembered that responsibility to the social only operates within the boundaries of the corporate interest, which is more concerned with output, workload capacity and productivity than the holistically worthwhile nature of workers lives.

Another concern around the growth of "*healthy lifestyles*" under CSR clearly illustrated in the pledge, is the lack of recourse to the legal frameworks that have developed over years to ensure organisations provide workers with certain levels of care. Many health issues in the construction industry are the result of poor industrial practices and management, yet to shift perspective from the worker at work to the worker in their whole life means a change in consideration in the ownership and

management contexts of health issues. For example, the incorporation of smoking into a workers health profile could potentially change the liability for any future lung disorders, whether the company paid for correctly face-fitted dust masks or not.

A lifestyle approach to worker health makes those workers with poor health lifestyles outside of work potentially vulnerable to 'blame the worker' situations, as identified when behavioural based safety launched in the USA. In that instance, criticism was made that such programmes focused on worker unsafe behaviour, rather than potential hazards and unsafe conditions in the workplace (Frederick and Lessin, 2000). As with behaviour based safety, it may be of greater benefit if the industry starts to practically address health management issues within work, rather than grandly promoting the pastoral care of their workforce whilst away from site.

CONCLUSIONS

Put harshly, the Responsibility Deal Construction Pledge press release portrayed the UK construction industry workforce as fat ignoramuses with poor trouser skills, in need of considerable pastoral care to avoid killing themselves with fry-ups and fags. The one voice to challenge this within the Pledge was that of Tommy Walsh, the only participant to identify himself as a part of the construction workforce.

The real interests of construction workers are likely to be a balance of good health and work, but what this comprises should not be dictated by government, much less commercial organisations with vested interests in worker output. The provision of suitable mechanical means for lifting should always be prioritised over any encouragement of the development of the muscles needed to do it manually.

As this brief analysis has shown, the Pledge does not prioritise the practical health of individual workers whilst on sites, rather they are considered in the widest possible terms of their contribution to work, the industry, its corporations and the wider UK economy. This raises issues of autonomy and liberty, and identifies a significant yet subtle shift of paternalistic power from government to those with more mercenary goals at heart. Against the context of growing activity around CSR, and the wider governmentalisation of corporations within our society, questions have been raised which demand further consideration and research.

This paper forms the starting point for a project to continue to explore the shifting rationalisation of health and safety management within our industry, the growing influence of CSR, and how the employment of power and normalisation has been implemented, especially within such seemingly altruistic ventures.

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CARTOONS ON OCCUPATIONAL HEALTH AND SAFETY: SEMIOTIC ANALYSIS OF WORKERS

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Construction industry is at the top rankings in developed and developing countries in terms of occupational deaths and injuries. This shows that legal regulations themselves could not decrease occupational accidents. In decreasing such incidents, the perception of the society on workers, who are a part of occupational health and safety issue, has an important indicator. Therefore, in this study, it was aimed to present the perception of the society on the responsibility of workers for occupational health and safety through cartoons. For this objective, seven of cartoons exhibited in International Construction Accidents Cartoon Contest held in Turkey were examined through semiotic analysis methodology. As a result, occupational health and safety perspectives of different countries in terms of cultural and geographical background were exposed by means of cartoons from these countries. It was observed that workers in China and in Greece share the same problems such as lack of attention and responsibility, although these countries are quite far from each other geographically and culturally. Similarly, cartoons from Turkey and Russia emphasize the extremely dangerous nature of construction works. In addition, contrary to other countries, workers in Turkey and in Greece wear casual clothes instead of overalls. All of these findings clearly indicate that construction-based occupational health and safety perceptions of countries do not change significantly and that cultural and economic differences between countries do not seem to be an important driver in this regard. Consequently, these results can have a function in guiding workers and worker unions to revise and manage the general perception of the society about them.

Keywords: cartoon, occupational health and safety, semiotic analysis, worker.

INTRODUCTION

Because of highly dangerous working conditions in the construction industry as listed at the top levels in occupational health and safety (OHS) statistics of developed and developing countries, legal regulations themselves are not adequate to reduce the number of occupational accidents. Toward this aim, it can be a better and sustainable solution to attract attention of the society at the macro level. In this regard, cartoons have impressive functions to attract society's attention through their entertaining and catchy messages. They are significant humour elements, directing the society and reflecting its perception. According to Sani *et al.* (2012), cartoons are very effective mediums in setting agenda of the society. In this context, cartoons can be basically used to identify the society's point of view to the "worker" image in occupational incidents.

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In this study, it was aimed to identify the perception of the society on the responsibility of workers for OHS through cartoons. For this objective, seven of cartoons exhibited in International Construction Accidents Cartoon Contest held in Turkey were examined through semiotic analysis methodology. The fact that these cartoons have different contents and are from various countries, each of which has a different cultural and economic background, has led to evaluate different perspectives. The semiotic analysis process was basically carried out in three stages: (i) discourse analysis, (ii) narrative analysis, and (iii) basic (logical – semantic) analysis. Using this methodology, the society's perception on the responsibility of workers in work accidents was revealed through cartoons in the present study.

SEMIOTIC ANALYSIS METHODOLOGY

In recent years, academic studies about cartoon analysis have prominently increased. Cartoons have often used in social sciences as a persuasive method for individuals and society. In this study, cartoons were analysed qualitatively using semiotic analysis method. In this analysis, systems and implications of signs are interpreted. In the academic literature, there are several studies that have made cartoon analysis using this method (Morris 1991, Morrison 1992, Warburton and Saunders 1996, Shultz and Germeroth 1998, Brilliant 2000, Everaert-Desmedt 2003, Schwartz and Rubinstein-Ávila 2006, El-Arousy 2007, Jackson 2008, Tsakona 2009, Schreier 2010, Mahmood *et al.* 2012, Sani *et al.* 2012). However, there has been no scientific research analysing OHS-related cartoons specifically. This evidence shows the originality of the present study.

On the other hand, in the literature there are two studies on visual warning materials used in construction sites, although they did not examine OHS-related cartoons specifically and did not employ semiotic analysis method. In fact, these researches are noteworthy in this domain of the literature in terms of their significant conclusions. Bust *et al.* (2008), one of them, explored how visual representations, including cartoons, can communicate critical OHS information in a construction context. They stated that visual materials for safety cautions are easy to understand for workers and have potential to develop OHS applications. Similarly, Hare *et al.* (2013) studied on communication with migrant workers. They investigated how pictorial aids can communicate simple hazards and controls, and how such images can be used during safety training, particularly for migrant workers and those new to construction. As a result, they found out that visual materials facilitate the communication with migrant workers and thereby decrease potential OHS problems.

Semiology investigates the signs in the written communication. Its purpose is to examine a meaningful communication activity. During the in-depth analysis, interpretation processes or compilation methods of signs of such an activity are revealed. The semiotic approach includes some decoding activities such as investigation of visual scanning direction of an image, interpretation of a text, and evaluation of intonation. Hence, semiology investigates visual presentation of information (Raskin 1985).

As in this study, cartoons can be analysed through the following five information sources respectively:

1. Situation, including situations, places, time, objects, participants, and activities, presented in the humorous text.

2. Language, which is responsible for the exact wording of the humorous text and for the placement of functional elements that constitute it (i.e., the distribution of information along the text and the position of the punch line and/or the jab lines).
3. Logical mechanism, presenting the distorted and playful logic that causes the script opposition.
4. Target, involving the people, groups, or institutions, ridiculed by humour (Tsakona, 2008).
5. Script opposition, which is the necessary requirement for humour. A humorous text is fully or partially compatible with two different and opposed scripts. Raskin (1985) identifies three basic types of opposition between the 'real' and 'unreal' situations evoked by the overlapping scripts of a humorous text: actual – non-actual, normal – abnormal, and possible – impossible.

ANALYSES OF CARTOONS

In this study, seven of more than five hundred cartoons exhibited in International Construction Accidents Cartoon Contest held by Anadolu University (AU) in Turkey in 2011 were chosen and examined through semiotic analysis method. These seven cartoons were chosen among the cartoons criticizing workers for incidents. Moreover, in order to increase cultural and economic diversity, a special attention was paid to choose cartoons from countries which have different levels of development. In addition, in order to provide easy communication between cartoonist and readers and to deliver the same message to people from different countries easily, non-verbal and time-independent cartoons were taken into account. These seven cartoons were analysed according to their countries as follows.

Turkey

A cartoon from Turkey was given in Figure 1.

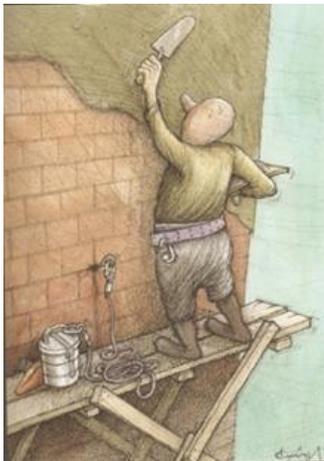


Figure 1: Cartoon by Kursat Zaman, reproduced by permission of AU.

Situation: A plasterer working at height ties the security belt to his lunch box instead of himself.

Language: Working at a high place is described through scaffolding and the space in the background. Lack of safety precautions are symbolized through worker's daily clothes and jerry-built wooden scaffolding without railing. Despite the high risk of falling, worker prefers using the belt for his lunch box to using it for himself. Lunch box and bread are metonymies and represent financial difficulties of the worker.

Logical mechanism: The humour means is the exaggeration logic.

Target: Considering the position of the worker, the construction industry and employers are criticized. Because of financial difficulties and the fear of unemployment, workers force to endanger their lives and to ignore their health. The main themes in the cartoon are the need for improvement of working conditions and workers' rights and the need for better control of OHS precautions in the industry.

Script opposition: The normal – abnormal contrast is represented through tying safety belt to a worker – tying safety belt to a lunch box.

Belgium

A cartoon from Belgium was given in Figure 2.



Figure 2: Cartoon by Norbet Van Yperzeele, reproduced by permission of AU.

Situation: A worker draws aside his meal because a worker is falling from stairs on his meal.

Language: Stairs, partial worker image, and the out-of-hand trowel represent that a worker is falling from a high place. Both the horizontal line from cup to covering and the position of sitting worker's arms show that he draws aside his meal to protect it from the falling worker. Helmet and overalls are metonymies and represent OHS precautions. Unexpected reaction of the sitting worker to the falling worker is emphasized by his facial expression of displeasure. This denotes that the incident is usual and gives him discomfort instead of fear.

Logical mechanism: The humour is made by exaggeration and habituation logics.

Target: It is OHS practices in the industry. Especially, the falling incidents are criticized.

Script opposition: The actual – non-actual contrast is represented through being scared of seeing a falling person – showing displeasure while a person is falling.

Macedonia

A cartoon from Macedonia was given in Figure 3.



Figure 3: Cartoon by Jordan Pop Iliev, reproduced by permission of AU.

Situation: A worker at a high place hangs on to a brick to not to fall and waits for help from the other worker.

Language: The skyscraper and flying birds at the background and the close cloud indicate that workers are at a high place. Workers' overalls, shoes, and helmets are metonymies and represent OHS precautions. Lines over the left hand of the hanging worker show that he waves his hand to ask for help. The other worker coming to help is anxious and tries to give a helmet to the hanging worker. However, it is an unexpected move to give a helmet to a person who is about to fall. Here, it is emphasized that the personal protective equipment (PPE) is not adequate to avoid accidents and that accurate information on OHS should also be given to workers.

Logical mechanism: The humour is made by misapprehension, failing, and ignorance.

Target: It is OHS practices in the construction industry. The message is that if PPE is not used properly, it will be useless.

Script opposition: The normal – abnormal contrast is represented through giving a hand to a person who is about to fall – giving a helmet to a person who is about to fall.

China

A cartoon from China was given in Figure 4.

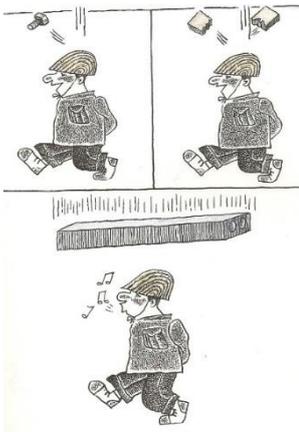


Figure 4: Cartoon by Zhang Xin Hua, reproduced by permission of AU.

Situation: The cartoon consists of three parts. The first two parts show that the helmet of worker saves him against small falling materials. However, in the last part, worker faces a danger in which a helmet cannot protect him.

Language: Cartoon has been drawn in the direction of reading from left to right. Although there is no number on the parts, their orders can be estimated by the habit of reading from left to right. In other cultures where the habit of reading is from right to left, their orders can be estimated by means of sizes of the falling materials. Thin vertical lines denote that materials are falling. Worker's facial expressions and the broken materials show that the falling materials did not hurt him. In the last part, worker's mouth shape and musical notes indicate that the worker is self-confident because of the past two experiences even if the falling material is big and heavy.

Logical mechanism: The humour is made by over-confidence and analogy logics.

Target: It is workers. Besides all OHS precautions taken, workers themselves should pay significant attention to potential risks in job-sites.

Script opposition: The possible – impossible contrast is represented through being protected by helmet against small falling materials – being protected by helmet against all occupational incidents.

Greece

A cartoon from Greece was given in Figure 5.



Figure 5: Cartoon by Grigoris Georgion, reproduced by permission of AU.

Situation: A worker, who has built a swing between two incomplete columns, is observed by another two workers with usual glances.

Language: It is clear swings are entertaining tools and for use in free-times. Helmets of two people at the foreground denote that they are workers. In addition, their daily clothes and the scattered bricks show that OHS precautions were not taken adequately in site. Lines on these workers' faces indicate that they are middle-aged and experienced employees. Given their facial expressions, they observe the other worker with usual glances.

Logical mechanism: The humour means is the logic of bringing contrasts together.

Target: It is workers. The message is that workers should avoid making unnecessary activities in site even if they do not seem to be dangerous actions.

Script opposition: The normal – abnormal contrast is represented through obeying OHS precautions – behaving improperly against OHS precautions.

Italy

A cartoon from Italy was given in Figure 6.



Figure 6: Cartoon by Zaza Leonardo, reproduced by permission of AU.

Situation: While a worker has lunch at a high place, sausages fall from his sandwich and hit another worker's head.

Language: Sausage is used as a metaphor to represent the falling objects and unexpected events. Although helmet, overalls, and shoes symbolize OHS precautions taken, the worker sits on a steel beam at height as a contradiction. In fact, this represents dangerous working conditions in site. Wheelbarrow, bricks, crane, and bucket show that the incident occurs in a construction site.

Logical mechanism: The humour means is the exaggeration logic.

Target: It is the construction industry. According to the cartoon's message, it is necessary to be ready and careful against unpredictable incidents.

Script opposition: The possible – impossible contrast is represented through a worker who is not injured by a falling sausage – a worker injured by a falling sausage.

Russia

A cartoon from Russia was given in Figure 7.

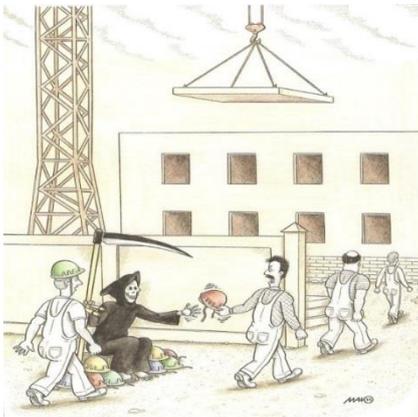


Figure 7: Cartoon by Alexander Markelov, reproduced by permission of AU.

Situation: Workers give their helmets to the angel of death.

Language: Crane and the hanging material symbolize potential risks in the construction site. Lines around the worker's hand show that he gives his helmet to the angel of death, and the lines around the worker's mouth denote that he talks to the angel of death. Helmets in different colours, on which the angel of death sits, indicate that all workers give their helmets before accessing to site. Helmet is a metonymy and represents OHS precautions. The message in the cartoon is that the results of occupational incidents may be fatal without taking OHS precautions.

Logical mechanism: The humour means is the exaggeration logic.

Target: It is workers since their improper actions can lead to fatal incidents.

Script opposition: The normal – abnormal contrast is represented through workers wearing their helmets while accessing to site – workers taking off their helmets while accessing to site. Also, the actual – non-actual contrast is represented through the fact that the angel of death is out of this universe – the fact that workers are talking and delivering their helmets to the angel of death.

DISCUSSION

Considering seven cartoons in this study, three cartoons (Turkey, Belgium, and Macedonia) are about falling from height, three (China, Italy, and Russia) about falling materials, and the remaining one (Greece) about off-the-job actions in site. This shows that these are among typical reasons of accidents in the construction industry.

In the sample of Turkey, despite the high risk of falling, a casual-dressed worker, who works on jerry-built wooden scaffolding, prefers using a belt for his lunch box to using it for himself. This indicates that construction workers in Turkey have serious financial problems and prioritise economic safety than OHS. Therefore, they ignore fatal working conditions.

The cartoon from Belgium shows that occupational incidents by falling from height are very frequently encountered in this country. An eating worker's reaction of displeasure to a falling worker reflects that this kind of incidents is common in Belgium. Another remarkable issue is that the falling worker has basic PPE such as helmet and overall. However, he does not have a safety belt, although it is a must for those who work at height. Even in a developed country like Belgium, the procurement and usage of PPE are questionable.

The cartoon from Macedonia is a sample which stresses both the importance of OHS trainings and workers' responsibilities on them. OHS trainings are compulsory by law and must be provided by the employer. Also, workers must behave according to these trainings. In the cartoon, a worker tries to deliver a helmet to a worker hanging at a high place. This clearly shows the lack of OHS trainings and the related knowledge. Similarly, in the samples of Turkey and Greece, workers do not behave according to OHS trainings. However, in Turkey the reason of this mistake is financial difficulties while in Greece it is the worker's irresponsible behaviour.

Cartoons from China and Greece illustrate workers' irresponsible behaviours in job-sites. Chinese worker's incautious actions to the falling materials lead to a serious incident at last. Although there is no occupational incident in the sample of Greece, it is implied that a worker's careless behaviour can cause safety problems. These two samples indicate that workers in China and in Greece share the same problems such as

lack of attention and responsibility, although these countries are quite far from each other geographically and culturally.

Given the cartoon from Italy, it is observed that unexpected events may cause occupational incidents in construction. It is an exaggeration that a worker may be hurt by a piece of sausage. However, this metaphor emphasizes that unexpected events may lead to unpredictable results. According to the cartoon's message, workers always have to be careful and on the alert against occupational incidents and follow work instructions in site exactly.

The sample of Russia is about workers' improper acts with safety precautions in site. In the cartoon, workers give their helmets to the angel of death while entering to the construction site. This emphasizes the vital importance of PPE and its proper usage. Through helmets, problems experienced in the use of PPE are told to readers. As a conclusion, without PPE, workers in the construction industry are very prone to fatal incidents.

Considering the samples of Russia, Italy, and China, incidents by falling items can occur in two different ways. The first one is the ignorance-focused incidents. In China, PPE is not adequate to protect workers against occupational incidents. Despite all precautions taken, workers themselves should pay significant attention to potential OHS risks. The second one is the attention-focused incidents. In Italy, it is necessary to be ready and careful against unpredictable incidents. In contrast to these two samples, the cartoon from Russia reflects a different approach to safety precautions. It stresses that safety precautions and PPE can be efficient only when workers follow the given instructions and behave carefully in site.

CONCLUSIONS

In the construction industry, occupational incidents and OHS-related problems show similarities in different countries around the world. It was observed that workers in China and in Greece share the same problems such as lack of attention and responsibility, although these countries are quite far from each other geographically and culturally. The finding that worker in Turkey ignores fatal working conditions is very similar to the finding that lives of workers in Russia are in a serious danger. In addition, contrary to other countries, workers in Turkey and in Greece wear casual clothes instead of overalls. This reflects these countries' points of view to the OHS issue. Also, in most of the cartoons, helmet was used as a metonymy for OHS precautions. According to the cartoons, different countries have common OHS problems: (i) unexpected events, (ii) careless actions, and (iii) ignorance may cause occupational incidents. The common theme in cartoons was "*falling from height*". This shows that such accidents are among the most common incidents in industrial practices as well. All of these findings clearly indicate that construction-based OHS perceptions of countries do not change significantly and that cultural and economic differences between them do not seem to be an important driver in this regard.

Consequently, these results can have a function in guiding workers and worker unions to revise and manage the general perception of the society about them. This can be performed by depicting the results properly in workers' trainings that can be organized by unions, universities, or the related public institutions. In other words, such cartoons can be used in OHS trainings of workers owing to their impressive functions.

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HEALTH AND SAFETY PRACTICES ON CHRISTCHURCH'S POST-EARTHQUAKE REBUILD PROJECTS: HOW RELEVANT IS HEINRICH'S SAFETY PYRAMID

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Health and Safety is at the forefront of the construction sector projects in New Zealand particularly as the post-earthquake rebuild gets underway in Christchurch. Health and Safety best practice on all project sites needs to be constantly reviewed, updated, and implemented to reduce on-site accidents. The research investigated whether Heinrich's (1931) Safety Pyramid was relevant to Christchurch's post-earthquake rebuild projects in the civil construction sector. The selected literature specifically focussed on publications that involved or reviewed the validity of Heinrich's Safety Pyramid. Archival accident data in New Zealand for the year ending June 2103 was reviewed and to complement this data a questionnaire was prepared, and distributed to one hundred construction personnel working on civil construction rebuild projects in Christchurch in the latter part of 2013. In addition, semi-structured interviews were subsequently conducted with five selected personnel including project managers, supervisors and labourers. The reviewed and collected data were analysed with the resultant finding that Heinrich's Safety Pyramid was still considered to have relevance for safety practices on Christchurch's post-earthquake rebuild projects in the civil construction sector.

Keywords: Christchurch, civil construction rebuild, health and safety, Heinrich pyramid, post earthquake.

INTRODUCTION

Health and Safety New Zealand

The New Zealand Government is currently reviewing the Health and Safety system in New Zealand. Funding for an additional \$37 million over four years is being provided to help change the system by strengthening the approach and increasing frontline Health and Safety inspectors. This funding will also support targeted Health and Safety initiatives. The Government has set a minimum 25% reduction in workplace serious harm accidents and fatalities by 2020 and an interim target of a 10% reduction by 2016. In addition there is an independent task force reviewing whether the current Health and Safety systems in New Zealand are the optimal systems and will recommend any improvements.

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Rationale

According to the Canterbury Rebuild Safety Charter (2011), it is estimated that 1-2 construction workers may die each year from the re-build of Christchurch city if current statistics are any indication. This would cost over \$80 million in Accident Compensation Corporation (ACC) costs and 600,000 hours of lost time. This would put added pressure on the re-build that is avoidable. Steps are being taken to find ways of reducing these potential statistics. In early 2013 Christchurch accounted for half of all of the serious injuries reported in New Zealand. This research investigated a theory and tool that has been in use by companies to monitor and measure Health and Safety and accidents in particular on construction sites for many years, the Heinrich (1931) Safety Pyramid. Health and Safety training for the majority of workers completing the post-disaster civil construction re-build in Christchurch use accident pyramids to illustrate accidents from near misses to major incidents. Near-miss reporting is considered critical to Health and Safety success. Establishing whether the Heinrich Safety Pyramid was still relevant in the post-earthquake civil construction rebuild would inform decisions regarding Health and Safety policies in New Zealand.

LITERATURE REVIEW

In 1931 Herbert Heinrich wrote a book that became the foundation for Health and Safety regulations and culture throughout the construction industry worldwide. The work entitled 'Industrial Accident Prevention' described Heinrich's research into accidents as a result of working for 'Traveller's Insurance', and identified why and how industrial accidents occur, and could have been prevented. The findings were based on the analysis of 5000 cases of closed-claim-file insurance records of industrial accidents and company records. Heinrich's book introduced the ratio 1-29-300 which identified that in a unit group of 330 similar accidents, 300 will produce no injury whatsoever, 29 will result in only minor injuries and 1 will result in serious injury" (Heinrich 1931). This ratio became known as Heinrich's Triangle, or Heinrich's Pyramid. The three main statements underlying the Heinrich Triangle /Pyramid (1931) are summarised as:

1. A stable ratio of minor incidents (no injury), to moderate to major injuries following accidents,
2. The investigation of minor/no injury accidents provides valuable information to prevent further accidents,
3. Changes in the frequency of minor injuries cause a proportional change in harm.

The injuries resulting from accidents were placed in the following categories:

1. Major injuries -any case reported to insurance carriers or to the state compensation commissioner. This would be the equivalent of the New Zealand department of Labour (formally Occupational Safety and Health).
2. Minor injuries -a scratch, sprain, or cut. These incidents would commonly be termed a first-aid case.
3. No injury accidents -an unplanned event involving the movement of a person or an object, or substance (slip, fall, flying object, inhalation), and having the probability of causing personal injury or property damage, now referred to as a 'near- miss' (Heinrich 1931).

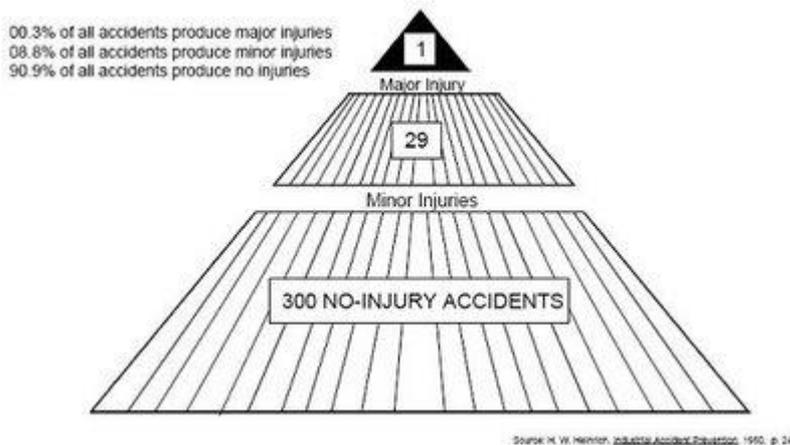


Figure 1 Heinrich's Safety Pyramid.

The ratio and categories are used widely throughout construction and other safety sectors. “*Heinrich is credited with bringing attention to workplace safety and focusing on the human element of safety*”, (Collins 2011).

One of the most important principles of Heinrich’s original pyramid is that fatalities cannot occur without a foundation of less severe incidents. That means that an increasing number of non-serious accidents will eventually mean that more serious accidents or major accidents will occur. This is the theory/ principle being reviewed in this research, with the question: Is Heinrich's Safety Pyramid still relevant in today’s construction sector health and safety environment on the Christchurch post-earthquake civil construction rebuild projects?

The reviewed literature clearly supported, or did not support the continued relevancy of the Heinrich's Safety Pyramid. McCaughey *et al.* (2010), and Klienfdorfer *et al.* (2011), stated that “*just because you have a good safety record does not mean that you are safe*”. Complacency seems to be a major concern as safety managers and on-site workers seem to relax more once the companies safety record has a high standard. ”

Gallivan *et al.*, (2008). disagreed with Heinrich’s theory that “*introducing measures to reduce the incidence of minor incidents will not inevitably reduce the incidence of major incidents*”, and further stated that, “*any safety policies based on the assumption that the Heinrich ratio is true needs to be rethought*”.

Smith (2006) questioned the way safety is measured, stating that “*it is impossible to measure the effectiveness of proactive methods of safety management*”. Reactive statistics (feedback received on an introduced system/product), are given bad press because they are seen as measuring failure. Smith (2006) believed that there are several advantages to reactive statistics versus proactive statistics (data collected via interviews with potential users of a system/product):

Proactive statistics are a measurement of fact, are specific, quantifiable, and can be used as a benchmark performance indicator compared with other companies, either within the same sector or industry wide. Proactive statistics allow accurate re-tracing of multiple casual events to pinpoint the times and places where effective interventions could have been made (Smith 2006).

An article written by Krause (2011) entitled, 'Where to now?' highlighted research that showed a reduction in minor injuries does not necessarily produce a reduction in serious injuries and fatalities. Krause (2011) further stated that, “*this contradicts a*

decade old paradigm in the safety community which has held that reductions in minor injuries produce proportional reductions in serious injuries”.

A number of safety managers continue to support Heinrich’s work and still use his Safety Pyramid for example, Paradies (2012) wrote the article 'Does the safety pyramid still exist?' Paradies noted that even though several safety managers were discrediting the pyramid, that the ratio should not be taken so literally, and should instead focus on the underlying theories, and that *"the focus of resources must be kept on minor problems that could lead to major accidents, and to stop wasting time on 'paper cuts' "*. Gamble and Proctor's Port Ivory Study (2012), revealed a close similarity to Heinrich’s model, and even though Heinrich’s original pyramid has been adapted over time, the Safety Pyramid is still considered to have relevance for today's health and safety managers. "

“Heinrich’s triangle became the foundation on which many of today’s industrial accident prevention programs are built and perhaps the most important lesson learned from this foundational work is that the path that leads to the prevention of accidents resulting in major injuries, lies in investigating all accidents, including no-injury accidents” (Collins, 2011).

To conclude, Heinrich (1931) described two approaches in accident prevention and that both are required: 'an immediate approach' - the control of personal performance and the environment, and 'a long-term approach' involving training and education. Heinrich also noted that, *“accident prevention is both a science and art, and that a strict concentration on mathematical formulas and models do not create a safe environment”* (Heinrich, 1931).

RESEARCH METHOD

A multi-method approach was used for this research as it afforded collecting, analysing and integrating data from several sources. The three methods selected were post-earthquake accident archival data, questionnaires and subsequently selected semi-structured interviews, with five selected civil construction personnel.

Firstly, a statistical analysis of SCIRT's (Stronger Christchurch Infrastructure Rebuild Team) accident data was undertaken to find if there was any correlation between Heinrich’s Safety Pyramid and the recorded accidents in post-earthquake civil construction rebuild projects. SCIRT, an alliance of the 5 top civil construction companies, undertook to fix all of the damaged infrastructure in Christchurch city from the February 2011 earthquake. Archival data involving all accidents, including near-misses, gathered since the post-earthquake rebuild began was accessed and reviewed. The archival data was recorded and filed using only accident data; as no personal information was obtained nor recorded. This accident-data-only approach was used extensively in papers that were discussed in the literature review, including Heinrich (1931), where only quantitative data from insurance claims was utilised. For this research, qualitative data was collected using questionnaires and semi-structured interviews to attempt to answer questions focussed on participants' opinions and details that the archival accident data could not show.

Surveys in the form of questionnaires were handed out to a participant sample of 100 personnel in the civil construction sector in Christchurch. Questionnaires comprised a combination of multi-choice and open-ended questions. This method helped establish how participants perceived the Safety Pyramid, and gathered data that complemented the archival accident data to provide information on the relevancy of the Safety

Pyramid in Christchurch's post-earthquake civil construction rebuild projects. 69 completed questionnaires were returned from a range of participants operating at all levels and roles in civil construction. All of the questionnaires were filled in on-site at weekly safety meetings. Semi-structured interviews were subsequently conducted with five selected civil construction personnel -a Project Manager; an Engineer; a Supervisor; a Foreman and a Labourer, using 5 questions that resulted from the themes and topics identified in the analysis of the questionnaire responses.

DATA FINDINGS AND ANALYSIS

Major Accidents	33
Minor Accidents	147
Near miss Incidents	654
Safety conversations	70,692

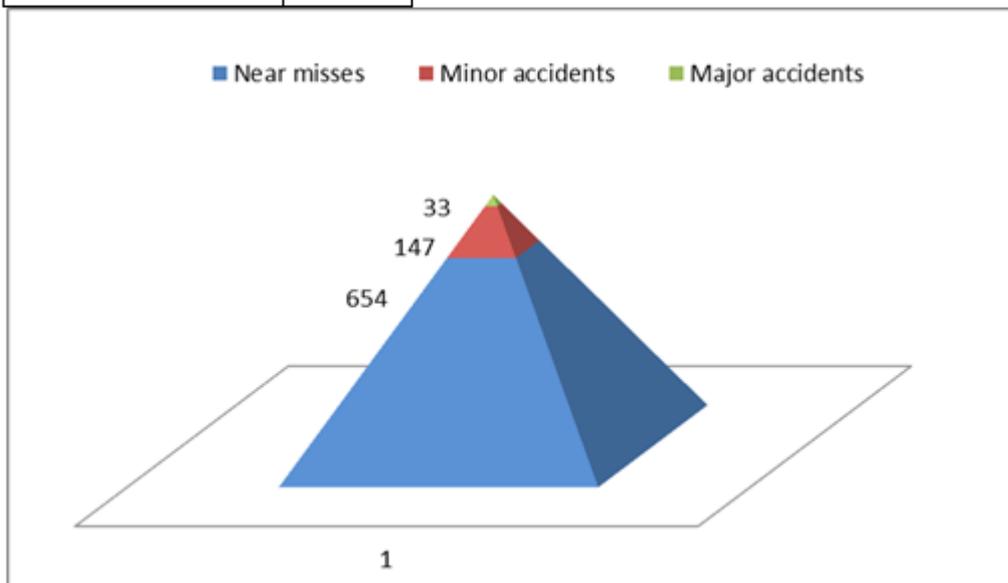


Figure 2 Christchurch's Civil Construction Rebuild Archival Accident Results for the year ending June 2013 (SCIRT).

Of note in reference to Figure 2 above, was that some of the companies involved in the SCIRT alliance recorded significantly less minor accidents, than others in the alliance. Overall though, the ratio for Christchurch's post-earthquake civil construction rebuild was 1-5-20, identified as one major accident to five minor accidents to twenty near miss incidents whereas Heinrich's ratio was 1-29-300. This demonstrates that there were significantly more major injuries in Christchurch's civil construction rebuild projects than when Heinrich (1931) first established that ratio.

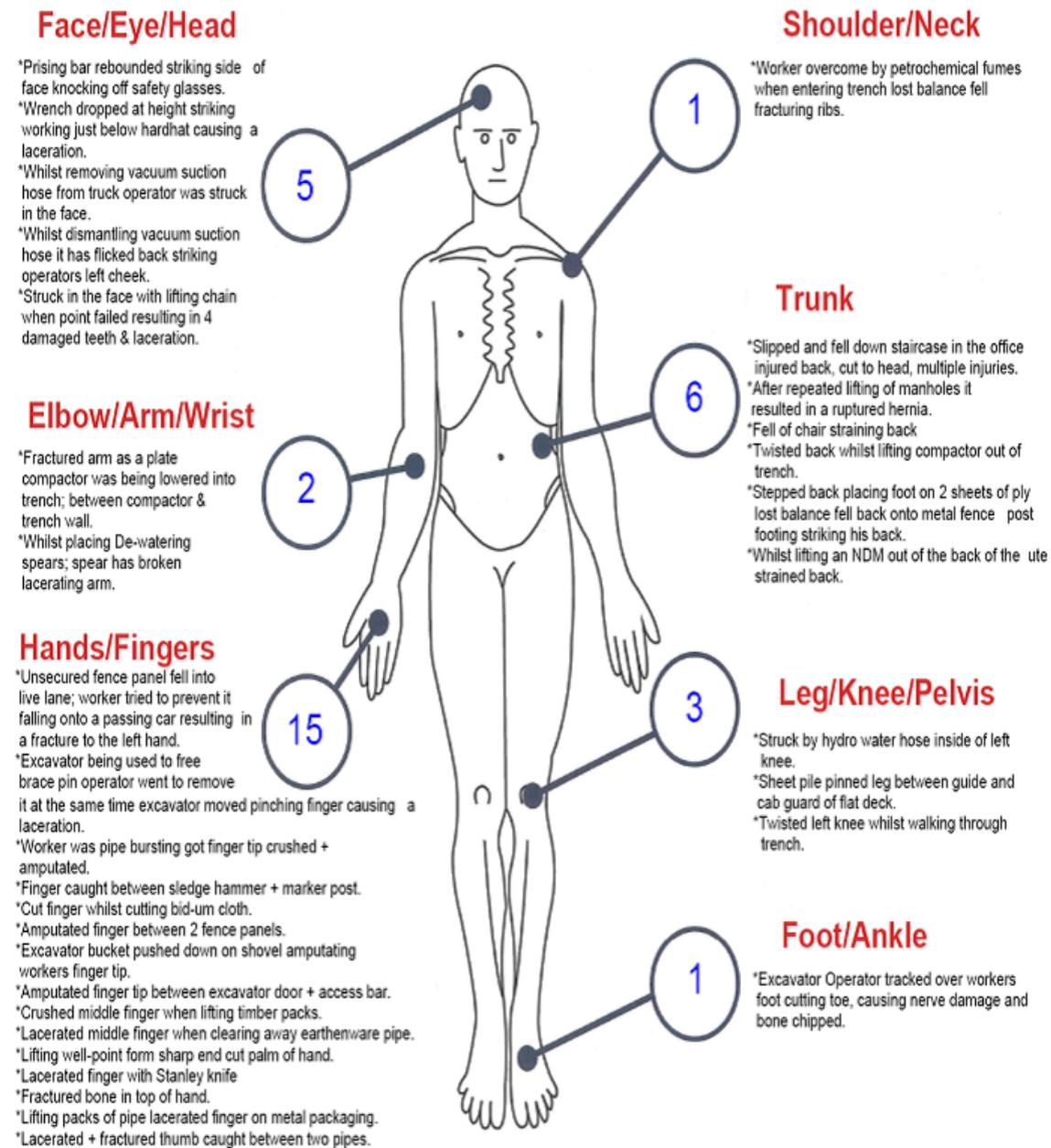


Figure 3 Civil Construction Post-Earthquake Christchurch Major Accidents.

Heinrich (1931) was using accident data from insurance claims that were gathered over a wide range of industries. It is not unusual that civil construction would realise a lower ratio, as construction has always been a sector with a high rate of accidents. However, as at June 2013 no fatalities had occurred in Christchurch's post-earthquake civil construction sector rebuild, and that some of the major injuries were just classed as minor injuries. A few of the more serious injuries such as finger amputations definitely fell into the 'major' category. Given that first-aid type injuries were not always recorded, this could have had an affect on the actual results. However, as noted by Heinrich(1931), only the recorded data can be used. Adding the 70,692 safety conversations to the Safety Pyramid may be of use to civil construction in Christchurch, but as a comparison to Heinrich's Pyramid it was not relevant, as no such data was collected on or around 1931. Heinrich's Pyramid referred to major, minor or no injuries, whereas results for this research were listed under major, minor or near-misses (the name also used for the no-injury' category). Smith (2006),

observed that *"there are advantages in measuring proactive statistics"* (data collected via interviews/market research surveys), *"rather than just reactive statistics"* (data collected/received once product/service used), *"even though proactive statistics are harder to compare."*

Table 1 Questionnaire Matrix Findings

Question 1. Do you recognise any of the safety pyramids shown below?	Yes 91% No 9%	A very good result with 91% recognising the pyramid which helped with the rest of the survey.
Question 2. Do you believe that you make use of the safety pyramid as part of your health and safety in your company?	Yes 53%, No 22%, Unsure 25%	Surprisingly only 53% say they use the Safety Pyramid. Most use it as a 'tool' to help explain 'safety' to others.
Question 3. Do you agree that reducing near misses will in turn reduce major accidents?	Strongly Agree 39%, Agree 53%, Unsure 4%, Disagree 3%, Strongly Disagree 1%.	Stopping accidents at their 'root cause' was a major theme. 'luck will run out' was another.
Question 4. Do you participate in near-miss reporting?	Always 58% Sometimes 39% Never 3%	97% do take part in near-miss recording, a good sign that the message of it's importance is getting through.
Question 5. Have you ever had or seen a near-miss and not recorded it?	Yes 39%, No 61%.	Unfortunately there can still be improvement in the amount of near-miss reporting as 39% do not do it enough.
Question 6. If yes, please explain the near-miss and why not recorded ?		Outside of work and a long time ago were common answers.
Question 7 Have you experienced a near- miss that could have been a major accident?	Yes 54%, No 46%.	Shows that there are a lot of times that a near-miss could have been a major accident of even a fatality.
Question 8. If you witnessed a large site- safety fence fall over from the wind but did not hit anything. Would you consider this a near-miss?	Yes 88%, No 12%.	Most agreed the scenario offered the opportunity to harm someone, so it was considered a near-miss.
Question 9. If an excavator bucket swung around and brushed against your clothing. Would you consider this a near-miss?	Yes 90%, No 10%.	Even more agreed that this was a near-miss with a few thinking that it was an incident.
Question 10. If you are not wearing the correct PPE for a task, for example, not having your safety glasses. Do you consider this a near-miss?	Yes 45%, No 55%.	Only half considered this a near-miss, as most explained there was no incident that took place.
Question 11. Do you agree that the target of zero-harm is achievable?	Strongly Agree 1%, Agree 25%, Unsure 22%, Disagree 45%, Strongly Disagree 7%.	Only 26% believed that zero- harm is achievable. Most however said we must try to achieve zero-harm.

The analysis of the 69 questionnaire response revealed that the majority of the companies' safety managers still use near-miss reporting and the Heinrich Safety Pyramid to aid their Health and Safety practises. However, near-miss reporting did not appear to accurately reflect the number of actual near-misses that occurred according to the participants. There were a range of reasons as to why these near-misses were not always reported, including being too busy on-site to fill out the paperwork, not wanting to get others in trouble with the boss for example. This might be one of the reasons why the SCIRT civil construction rebuild Safety Pyramid was dissimilar to Heinrich's (1931).

However, the majority of participants agreed that reporting near-misses, and working to reduce them will in turn reduce the more serious accidents. A few participants acknowledged using the Heinrich Safety Pyramid subconsciously despite not specifically setting out to.

Utilising potential scenarios in the questionnaire established that not all employees were aware of what actually defined a near-miss that should be reported. Respondents further identified other technicalities that might have meant that a situation/event changes from being a near-miss, into an incident report. The target of 'zero-harm' is still a long way off according to the majority of respondents, but a large percentage also agreed that this must be a target goal as anything less is unacceptable.

As illustrated in Table 2 below, zero-harm whilst being a target goal, is hard to achieve when there are continual changes amongst team members on-site, all with differing levels of safety awareness, despite standard safety inductions for all new staff. The supervisor for example, noted that *"once there are no accidents for a while, people start to become complacent and the chance of a serious accident increases"*.

A common response from the interviewed participants was that workers have differing views on what constitutes a near-miss. Many feel uncomfortable about reporting near-misses for fear of getting a workmate into trouble, or simply forget to report most near-misses, believing that only major near-miss accidents need to be reported.

Table 2 Interview Matrix Findings

	Project Manager	Engineer	Supervisor	Foreman	Labourer
Q1 Why do you think your company's personnel feel that zero harm is not achievable?	Human error	You have to allow for stupidity	We may get close but will never have zero	Dumb moments	There are always idiots, accidents happen
Q2 Why do you think some near-misses are not recorded on project sites that you are familiar with?	Misunderstanding of what a near-miss is	Getting someone into trouble	Too busy to do all the required paperwork	Forget a lot	Getting themselves or someone else into trouble
Q3 Do you feel that the way forward is concentrating on major accidents or near-miss injuries, and if why?	Major accidents	Combination of both	Both but more major accidents	Combination of both at same time	Major accidents
Q4 If you organise the induction for new staff, would you use the Safety Pyramid to illustrate near-miss reporting. If so why/why not?	Yes valuable tool	Yes easy to use	Yes and able to demonstrate visually	No. would use real life scenarios	Yes was clear to understand
Q5 Are your company definitions of near-miss reporting clear to staff? Please explain your definition of a near-miss.	Clear. Something that could have hurt you but did not	Clear. An accident that could have hurt someone	Clear. A situation that may have been an accident on another occasion	Unclear. Some people are a bit lazy	Unclear. New people unsure

There were positive responses from 4 of the participants that the Heinrich Safety Pyramid is a valuable visual graphical tool at the induction of new staff, as it is easily understood. The participants noted that the Safety Pyramid helps reinforce how serious near-misses actually are, and that it is frequently under-used. There was also agreement amongst the majority of the selected interview participants that the way forward involves a concentration on reducing both major and minor accidents. There was also agreement that all near-miss accidents need to be reported, going forward, in order to reduce major accidents, and the overall number of on-site civil construction accidents in Christchurch. This was a useful result given the focus of the research being to establish how relevant Heinrich's Safety Pyramid is to Christchurch's post earthquake civil construction rebuild health and safety practises.

CONCLUSIONS

The objectives of the research were to establish the continued relevancy of Heinrich's Safety Pyramid to safety practices on Christchurch's post-earthquake civil construction sector rebuild projects, and to identify whether the near-misses recorded were an accurate reflection of what was actually happening on-site. The relevancy of the Safety Pyramid results were divided in the literature review findings, with approximately fifty percent supporting the pyramid, and fifty percent not supporting the original Heinrich's Safety Pyramid's use. The questionnaire results were mixed but revealed that the majority of the companies' safety managers still use near-miss reporting and the Heinrich Safety Pyramid to aid their Health and Safety practises. However, near-miss reporting did not appear to accurately reflect the number of actual near-misses that occurred according to the participants. There were a range of reasons as to why these near-misses were not always reported, including being too busy on-site to fill out the paperwork, or not wanting to get others in trouble with the boss for example. Four of the five selected interviewees believed that targeting both major and minor accidents and reporting all near-misses was equally important. The 69 /100 personnel surveyed demonstrated that a significant majority believed that the Safety Pyramid was relevant in today's health and safety practises in Christchurch's post-earthquake civil construction rebuild. There was significant support from those surveyed with the questionnaire, and those interviewed for the use of the Safety Pyramid as a tool to visually demonstrate how near-miss reporting can reduce major accidents by attending to the hazard before it results in an accident. Overall the findings positively supported the premise that Heinrich's Safety Pyramid continues to be relevant for safety practices on Christchurch's post-disaster civil construction rebuild projects.

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VALIDATION OF CONSTRUCTION SAFETY EQUILIBRIUM MODEL ON HIGH-RISE BUILDING CONSTRUCTION PROJECT IN THAILAND

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Construction work involves a lot of work processes which are subjected to change according to project-specific requirements and context. These changes can cause accident hazards which require workforce management to balance task demand with worker capability. This research proposed the construction safety equilibrium model which was based on the car accident model. This study investigated the factors that influence task demand and capability, and also determined the weight of each factor by the Analytic Hierarchical Process via interviewing construction safety experts. The 15 accident case studies of workers who worked in high-rise building construction projects were applied for validation of the model. The research came up with two results: 1) the highest weight of the main factor of task demand contributed to the work behaviour factor and rule of safety was the most weighted sub-factor; for capability, the dominant main factor was the human factor and frustration was the highest weighted for the sub-factor; and 2) the average task demand level and the average capability level of the sample group was 1.99 and 1.77 of 3.00 point scale. These scores reflect the work that workers were performing when the accidents occurred were too difficult and did not match their capabilities according to the principle of construction safety equilibrium.

Keywords: capability, construction safety, safety equilibrium, task demand.

INTRODUCTION

The construction industry has a large number of activities with complex processes which affect the high risk of accidents. The record of occupational injuries in Year 2011 by Thailand Social Security Office (2011) found that the construction trade occupied third place in work-related fatalities with the number of 87 fatal injuries from a total of 590. For an international view, the construction industry in the United States accounted for 738 fatal cases from a total of 4,693 fatal cases and was ranked second for the highest number of fatal work injuries (BLS, 2011).

Other interesting information from the Bureau of Labour Statistics (2011) identified falls from a higher level accounted for 553 fatal work injuries, and in the construction trade, falls are the most frequently occurring types of accidents resulting in fatalities (Hinze, 1996). Research by Haslam *et al.* (2005) referenced statistics which stated that the construction industry accounted for 31% of all work related fatalities in 2002/03 of which 46% were caused by falls. For decades, high-rise building construction workers have worked in one of the highest-risk workplaces in Taiwan, more than 150 high-rise

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Sooksil, N and Benjaoran, V (2014) Validation of construction safety equilibrium model on high-rise building construction project in Thailand *In: Raiden, A B and Aboagye-Nimo, E (Eds) Procs 30th Annual ARCOM Conference, 1-3 September 2014, Portsmouth, UK, Association of Researchers in Construction Management, 371-379*

building construction workers are killed in workplaces annually, representing one-fourth of the work-related death toll in Taiwan (Hsu *et al.*, 2008).

Human resource is the main workforce needed in the construction trade to accomplish its target. Most successful projects have effective human resource management to deal with dynamic circumstances in the project, these environments created several of the risks that are confronted. Thus, worker management tools would be useful for assigning the right resource to the right task concerning safety and efficiency.

The present paper proposed the construction safety equilibrium model between task demand and worker capability, investigated the factors which influence task demand and capability and found the weight of each factor by Analytic Hierarchical Process, and lastly, validated the proposed model with a construction worker sample group who have been injured during the operation of the task.

FUNDAMENTAL OF CONSTRUCTION SAFETY EQUILIBRIUM MODEL

The literature review began with the study of the Fuller (2005) traffic collisions model which explained the principle of a car accident. Afterward, Mitropoulos and Cupido (2009) applied the Fuller (2005) theory in the construction trade. Finally, an investigation of the factors that are related to the construction safety equilibrium model by Haslam *et al.* (2005), research which found the causal factors of 100 case accidents.

Traffic collisions model

With regard to traffic accidents, the Task Demand-Capability Interface (TCI) model (Fuller, 2005) provides a new conceptualization of the process by which collisions occur. As shown in Fig. 1, at the heart of the TCI model is the relationship between the task demand and the capability applied to achieve a safe outcome while driving the vehicle. When the task demand is less than capability, the driver has control of the situation. Whereas, when the task demand is greater than the applied capability, the result is loss of control, which may result in a crash (or may not, if there is a compensatory action by others).

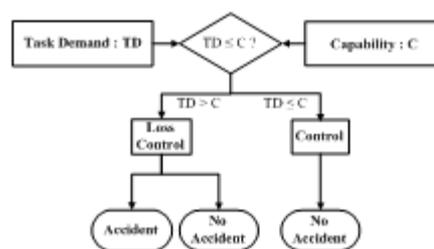


Figure 1: The Task Demand -Capability Interface model (adapted from Fuller, 2005).

In the experiment, the volunteers have to assess both task difficulty and statistical risk directly by viewing video sequences of roadway segments, filmed from the viewpoint of the driver, and travelling at different speeds. Participants were required to rate each sequence for task difficulty and for statistical risk of collision. The result from the study found that speed is the driver's choice to control the difficulty level and balance the task demand with driver capability.

Applying Fuller model on construction trade

Mitropoulos and Cupido (2009) applied traffic collision principles in construction accident occurrence. The component of Task Demand and Capability described below.

Task Demand

Task demand can identify the level of task difficulty to accomplish the production task under various circumstances and try to avoid the hazards. The greater the task demand is the greater likelihood of error and loss of control of the process.

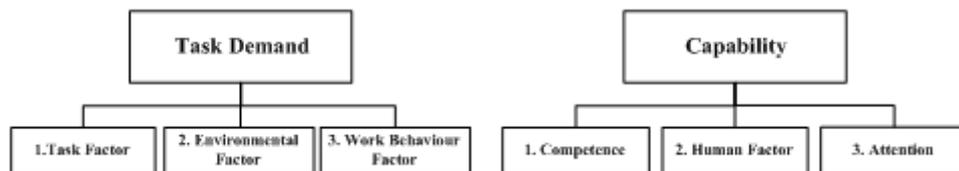


Figure 2: The factors of Task Demand and Capability (adapted from Mitropoulos and Cupido, 2009).

Fig. 2 groups task demand factors into three categories: (a) Task factors; (b) Environmental factors; and (c) Work behaviours. For example, the task demands for a crane operation depend on task characteristics (type of load, distance and angle, blind lift), environmental factors (soil stability, wind, visibility, proximity with power lines), and work behaviours (such as speed or other tasks that the operator may perform).

Capability

The applied capability determines the ability to deal with the task demands, and depends on: (a) The competency of the worker(s), including work experience, training, skill and physical condition; (b) Human factors that can reduce competency, especially four key factors related to accidents: rushing, fatigue, frustration, and satisfaction; and (c) The level of attention given to the task and the hazards. Attention is a limited resource - multiple task demands (due to task complexity) reduce the attention to any single demand, and distractions can divert the attention from the task or the hazards.

Furthermore, Mitropoulos and Namboodiri (2011) assessed the task demand by The Task Demand Assessment: TDA, which is a new technique for measuring the safety risk of construction activities and analyzing how changes in operation parameters can affect the potential for accidents. TDA quantifies the “*task demand*” of actual operations based on characteristics of the activity and independent of the workers’ capabilities. The task demand reflects the difficulty to perform the activity safely. The paper presents the findings from the initial implementation of TDA and demonstrates its feasibility and applicability on two different operations: a roofing activity and a concrete paving operation. It displays how the TDA method can compare different production scenarios and measure the effect of production factors on the accident potential. Unfortunately, this paper did not investigate the capability assessment for both operations.

From those details, it proves that the Fuller principle can be adapted to the construction industry. However, the investigation of the capability assessment and identification of factors related with task demand and capability are essential.

Causes of construction accidents

Haslam *et al.* (2005) presents overview findings from Loughborough University and the UMIST (2003) full research report which studied the casual factors of construction accidents. Based on a focus group of a variety of stakeholders in the construction trade to discuss and propose the root causes of accidents, the report detected the main causes of 100 incidents and assessed the possibility of consequences impacting each incident. They claimed that more than one-third was judged to have had the potential to result in a fatality, while more than two-thirds could have led to a serious injury. Levels of involvement of key factors in the accidents were problems arising from workers or the work team; workplace issues; shortcomings with equipment (including PPE); problems with suitability and condition of materials; and deficiencies with risk management. Meanwhile, they proposed a hierarchy of causal influences in the construction accidents model as well.

From that point of view, the author categorized each factor that influences task demand and capability into the construction safety equilibrium model which will be discussed next.

MODEL DISCUSSION

After reviewing the background model which involved safety equilibrium and influence factors of construction accident causes, a construction safety equilibrium model is proposed based on Fuller (2005) TCI model with the principle of "The accident won't occur, if the task demand is not greater than worker capability at that moment in time " as Eq.1

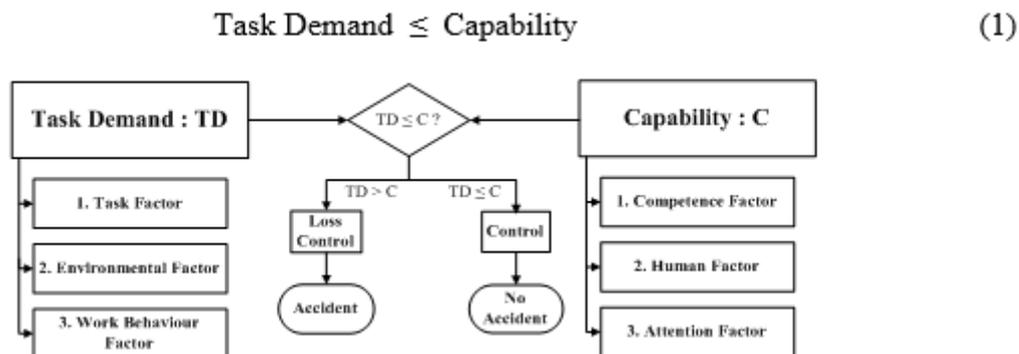


Figure 3: The Construction Safety Equilibrium Model between Task Demand and Capability

And whenever the task demand exceeded capability, the result is loss of control and accident occurred. This means that the task is too difficult for the worker to handle. Whereas, when the task demand is less than the capability then that task is controlled and the worker can perform that task easily. As shown in fig.3.

The Construction Safety Equilibrium Model is comprised of task demand and capability with the 6 main factors from the Mitropoulos and Cupido (2009) research. For sub-factors, the author synthesized from Haslam *et al.* (2005) and Loughborough University and UMIST (2003) exploration and grouped these sub-factors into categories as show in fig.4.

This model assesses both task demand and capability into quantitative terms for the macro level of high-rise construction project in Thailand, contrasts with Mitropoulos and Namboodiri (2011) research that tried to quantify only the task demand of actual

operations based on characteristics of the activity and independent of the workers' capabilities.

WEIGHTING FACTORS

All factors were included in The Construction Safety Equilibrium Model; therefore, giving weight to each factor which can then be used to generate quantitative safety indices. The weighted factors generated by the implementation of a multi-attribute decision making tool to draw knowledge from experts in the field. Shapira and Simcha (2009) is one of the sample researches that adopted Analytic Hierarchical Process (AHP) for a decision making tool to elicit knowledge from experts and formalize it into a set of weighted tower crane safety factors. Construction equipment and safety experts were interviewed and led through the AHP process to provide their assessments on the relative importance of safety factors obtained in an earlier study. The AHP process is provided the weight for each safety factor and is shown the dominant factors that are vital for focusing.

The AHP process (Saaty, 2008) has been used for weighting each factor by interviewing 5 construction safety experts in high-rise construction projects. These 5 experts had a cumulative 55 years in their current (2014) positions, with an average of 11 years, and three of them had shared a total of 45 years' experience as senior safety officers. They were all experienced in high-rise building construction projects in the domestic area. All of them expressed their opinions and experiences through interview forms and the conversations between the participants and author were recorded.

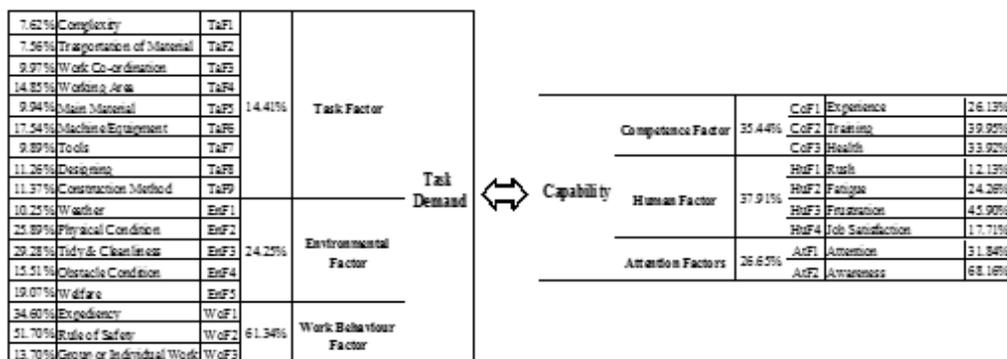


Figure 4: The factors of Task Demand and Capability and weighted of each factor.

The data was analysed and the results were verified by measuring Consistency Ratio (CR), which is a tool for controlling the consistency of pair-wise comparisons. The final weighted factors are shown in figure 4.

VALIDATION OF THE MODEL

In order to validate the application of the construction safety equilibrium concept to the construction safety trade, the author validated the model by applying it to a sample group of 15 incident cases (non-fatal cases due to the need of receiving information directly from the victim). These 15 injured workers held a variety of positions at the worksite. Six of them were employed as carpenters and the rest were employed as masons, safety crew members, levellers, foremen and hoist operators. Four of these victims held Cambodian citizenship. The investigation used a designed interview form and a voice recorder along with the interview process by individual case. The participants were asked to consider the accident situation and describe the task demand and their capabilities.

Task demand level

Table 1 indicates that the average task demand level of the sample group was 1.99 out of 3.00 which is over a half and as such is considered a difficult task to perform.

Table 1: Valued of each factor of Task Demand

Task Demand Factors	Task Demand																				
	14.41%									24.25%											
	Task Factor									Environment Factor											
Frequency	Ta1	Ta2	Ta3	Ta4	Ta5	Ta6	Ta7	Ta8	Ta9	En1	En2	En3	En4	En5	En6	En7	En8	En9	Wb1	Wb2	Wb3
Complexity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation of Material	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Work Organization	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Working Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Job Material	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substandard Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tools	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Designing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction Method	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weather	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Job's Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Machine Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Welfare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygiene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
State of Safety	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Language of the Work	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average Task Demand Level	1.99																				

The rule of safety was the highest sub-factor at 0.634 or 31.81% of the average task demand level and proved that the task demand level or difficulty level of the entire sample group depended on project safety rules. As some of the projects abandoned rules of safety (not behaving under the rules) then there was a consequence of a higher level of task difficulty. All workers started to be more aware of the risk when completing a task. Another dominant sub-factor that impacted the task demand (22.73%) was expediency, working at a faster rate made the work more difficult. With regard to the traffic accident principle by Fuller (2005), it was found that drivers adjust their speed based on task difficulty. The transportation of material was the less affected sub-factor with only 1.10%.

Capability level

The average capacity level of the sample group was 1.77 and lower than the average task demand by 0.22 as shown in table 2. The explicit evidence indicates that at the time of accident, task demand was greater than worker capability

Two sub-factors which have a high potential level of affecting worker capability were frustration and awareness. According to information from the interviews with the sample group, in most cases they were worried about their own problems and not aware of the risks involved. These two sub-factors decreased worker capability according to the Hinze Distraction Theory (1996).

Table 2: Valued of each factor of Capability

Capability Factor	Capability									
	25.44%			27.91%				16.65%		
	Competence Factor			Human Factor				Attention Factor		
	24.12%	1.02%	10.32%	12.12%	14.24%	6.22%	17.71%	1.14%	41.14%	
	Openness	Training	Health	Stress	Weight	Personality	Job Satisfaction	Attention	Awareness	
Frequency	CoF1	CoF2	CoF3	HuF1	HuF2	HuF3	HuF4	AtF1	AtF2	
Low	1	7	8	0	4	4	2	0	2	4
Medium	2	4	6	15	10	11	12	12	12	9
High	3	4	1	0	1	0	0	2	0	0
Average Each Sub Factors	1.50	1.52	2.00	1.50	1.72	1.50	2.12	1.57	1.60	
Factor Weight	0.092	0.162	0.120	0.066	0.092	0.176	0.067	0.085	0.182	
Value (x Factor Weight)	0.167	0.217	0.240	0.082	0.159	0.215	0.145	0.128	0.291	
Average Capability Level	1.772									

Comparing task demand level with capability level

Table 3: Comparing Between Task Demand Level and Capability Level of each incident

Accident Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
Task Demand Level	2.29	1.67	2.23	1.69	2.22	1.90	2.11	2.08	2.18	1.92	1.98	2.02	1.88	1.85	1.90	1.99
Capability Level	1.33	1.63	1.69	1.86	2.14	1.50	2.09	2.00	1.59	1.70	1.91	2.00	1.77	1.68	1.68	1.77
Difference	0.96	0.05	0.53	-0.17	0.08	0.40	0.02	0.08	0.59	0.22	0.02	0.02	0.12	0.17	0.23	0.22

Referring to table 3, the average task demand level and average capability level of the sample group was 1.99 and 1.77, respectively, with a difference of 0.22. According to the principles of construction equilibrium, these figures show the tasks that the workers were doing at the time of the incident were too difficult for them to achieve. Except in the 4th case, the task demand level was lower than the capability level by -0.17. In this case, miscommunication during conversation via interpreter should be the main cause of error.

The widest gap between the task demand level and capability level was the 1st accident case with a difference of 0.96. In this case, the victim was a young outside labourer with no previous experience and had been recently hired before accident.

The 7th, 11th and 12th accident cases occupied the least difference between the task demand level and capability level by 0.02. These circumstances were nearly balanced for both sides, but working negligently or loss of attention to work can initiate the accident.

CONCLUSION AND DISCUSSION

This research proposed the principle of the construction safety equilibrium, and investigated factors and reflected weight factors in the model, then validated the presented model with a sample group. Conclusion and discussion follow.

Weighted factors

The sample group insisted that work behaviour factors were the major factors affecting the task demand level rather than task factors or environmental factors. This result contradicted Loughborough University and UMIST (2003) research that found task factors such as design or construction methods were the main root causes of accidents.

Human factors seem to have more weight than the competence factor; this is reflected in the situation of a skill shortage in the workforce in the Thailand construction trade and being replaced by non-work experienced labourers from neighbouring countries.

Equilibrium of Task Demand and Capability

The 15 cases of accidents were a sample group for the research and have a task demand and capability level of 1.99 and 1.77, respectively. The sample group responded that the tasks were too difficult for their capabilities, and this resulted in accidents. The rule of safety and expediency were the sub-factors that most influenced the task demand level to reach the maximum 3 point scale. On the other side, reduced worker capability depended on frustration and awareness sub-factors.

Overall, the 15 accident cases corresponded with the principles of the construction safety equilibrium that the author proposed. The case of the task demand being lower than worker capability means the worker can perform the task without any accidents and also means that the task is too easy and can be improved for higher productivity.

LIMITATION AND FUTURE STUDY

The weight of each factor represented opinions from only 5 construction safety experts, which is probably not representative of the entire construction industry. Other representatives from the construction sectors and qualified experts have to be added.

Referring to surveying period, the rating scale of each factor needs more clarification and the addition of the exact meaning of each rating level (low, medium and high). The author has to repeat the question and explain the meaning of the rating system several times.

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UNDERSTANDING THE ROLE OF LOCAL SAFETY GROUPS IN MANAGING SAFETY PRACTICES BETWEEN MICRO CONSTRUCTION FIRMS AND PRINCIPAL CONTRACTORS

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Construction projects incorporate the input of a range of tradesmen and different sized firms, ranging from micro to large organisations. Working practices of micro construction firms are carried out in an informal manner while larger organisations tend to adopt more formal on-site management techniques. Many micro firms seek to develop long-term relationships with large principal contractors and a major strain on their relationships stem from the difference in safety management techniques they employ. Faced with a fundamental shift in their style of safety management, workers of micro construction firms must successfully negotiate this challenge. Against this background, records from the Health and Safety Executives show year on year reductions in accident and incident rates in the East Midlands, an indication that the safety practices on projects are being implemented more effectively. Some of this success has been attributed to the efforts of local safety groups, such as Nottinghamshire Occupational Safety and Health Association (NOSHA). As such, it is important that the interdependencies between large principal contractors and micro firms, and the role that safety groups such as NOSHA play in managing this relationship are better understood. This paper presents interviews conducted with some members of NOSHA. This is the first of two phases of empirical work. The roles that the members of the local safety group perform have been found to go beyond simply promoting safety awareness and safety knowledge on site. They have been found to help in conflict resolution among the various construction parties. Such practices help create a harmonious working environment and subsequently lead to long-term working relations.

Keywords: micro firm, informal practice, subcontractors, safety group.

INTRODUCTION

The need for improvement in safety practices and safety cultures on construction sites will always exist as long as the well-being of workers is at stake in the industry. Essentially, every construction firm, whether large, medium, small or micro receives encouragement from policy makers and other practitioners in the industry to create and maintain a positive safety culture on site (Langford *et al*, 2000).

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This paper focuses on micro construction firms working as subcontractors on large projects, thus forming part of the project supply chain. Micro firms are businesses employing less than ten workers (European Union, 2003).

The safety cultures of principal contractors (usually large firms) are different from those of the micro firms (Yapp and Fairman, 2006: 45). The approaches to safety can be broadly categorized as either formal (official procedures and policies) or informal (influenced by culture) (Hinze and Gambatese 1996: 161). Micro firms belong to the latter (Koch 2013: 699). When micro firms operate on large projects, they are forced to change their working practices as they are legally required to follow the rules and regulations set by the principal contractor (Joyce, 2007). In order to prevent disagreements between principal contractors and subcontractors, some principal contractors use safety consultants who help maintain the goals and objectives of the project without compromising safety. Safety Groups UK, a nationwide group dedicated to promoting awareness and safety knowledge, has numerous branches and affiliates helping projects in different areas of the country (Safety Groups UK, 2014). In Nottinghamshire, the group is represented by Nottinghamshire Occupational Safety and Health Association (NOSHA). This project looks at how members of NOSHA help micro firms when they are operating on large projects as subcontractors.

In this paper is a model labelled as the 'Pybus curve' will be used to study safety cultures of construction firms and the evolutionary stages that safety culture is known to go through. A literature review on site safety management is presented, whereby the relationship between main contractors and subcontractors is discussed. This is followed by a section on the research methods adopted for the study. Findings and analysis of fieldwork is then presented and discussed with literature.

THE 'PYBUS' CURVE

The Pybus curve is a model that shows three evolutionary stages of the safety culture of construction firms (Pybus 1996: 18). The Pybus curve has been adopted as a major theory for studying safety cultures and safety management among construction firms by renowned researchers in the field (see Finneran and Gibb, 2013; Lingard and Rowlinson, 2005; Pybus, 1996). Figure 1 shows the stages of change in safety culture.

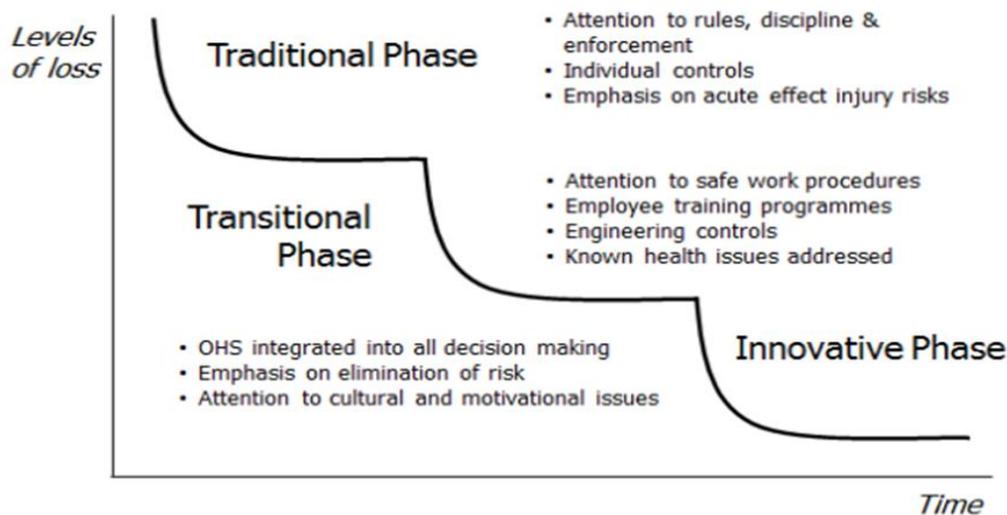


Figure 1: The 'Pybus' curve – Stages in the evolution of a culture of safety (Pybus, 1996: 18)

As illustrated by the Pybus curve, the evolution of a culture of safety occurs in three conceptually distinct stages, namely: the traditional, transitional and innovative

phases. These different phases start from a point in time where losses through injuries and ill-health are at the highest. The traditional approach to health and safety is essentially reactive, as hazards are dealt with as they arise and there is a strong emphasis on discipline and tactics such as enforcing the use of personal protective equipment (ppe) (Finneran and Gibb 2013: 6). At the transitional phase, there is a more proactive approach to managing hazards. Procedures are established in an attempt to prevent injuries and accidents (Lingard and Rowlinson, 2005). The innovative phase on the other hand, fully integrates health and safety into all business making decisions, and every attempt is made to eliminate hazards or minimize workplace risks using technological solutions (Finneran and Gibb 2013: 6). Lingard and Rowlinson (2005) suggest that small construction firms fall into the category of firms in the traditional phase. However, this postulation may not be applicable as relatively small businesses (especially micro construction firms) have been known to use informal approaches (see Marlow *et al*, 2010), thus using less formal rules, and discipline and enforcement of policies as shown in the figure 1. Micro firms and large firms will fall into different sections of the Pybus curve due to their different safety cultures and safety practices (Finneran and Gibb 2003: 11). At best, there may be a combination of the different cultures operating on site, that is, if the large firms' rules and policies do not completely overrule the practices of the other contractors as prescribed in the Construction Design Management (CDM) Regulations.

The next section covers site safety management and how parties interact on site.

SAFETY MANAGEMENT ON CONSTRUCTION SITES

In the UK, safety matters on construction sites fall under the jurisdiction of the Health and Safety at Work etc Act (HASAW) 1974. The Health and Safety at Work Act 1974 states that designers and manufacturers of a given project must demonstrate reasonably practicable effort in identifying and eliminating risks. Reasonably practicable in the context of the act refers to the weighing of a risk against the trouble, time and money needed to control it (HASAW, 1974). Besides this act, there are also the CDM Regulations 2007 which are more specific to the construction industry and lay out specific roles and responsibilities for all parties involved in a construction project. In addition to the legal requirements, large construction companies have their own systematic approaches to safety management within their organisations and on their sites (Sherratt *et al* 2013: 624). The CDM Regulations 2007 states that safety policies and procedures of the principal contractors 'trumps' the working practices of the subcontractors (for example, the micro firms carrying out specialist tasks on site) (Joyce, 2007). In other words; policies of the principal contractors, who often happen to be large companies, supersede those of the subcontractors (which may include micro firms). This rule makes the difference in safety management approaches between the large and micro construction firms even more prominent as one party is forced to adapt their working practices.

Large construction firms tend to have several management layers, along with several departments and perhaps regional offices, and for this reason a firm ordinarily has formalised policies and procedures to cover its large number of workers (Hinze and Gambatese, 1996). On the other hand, smaller companies and micro firms where the owner, superintendent, foreman and lead carpenter can all be one in the same person, can likely do fine by following proper safety arrangements even though the arrangements may be informal (*ibid*). Small firms and projects do not require the types of procedures and practices required by large organisations as long as the firm's

operatives incorporate measures that will ensure safe working conditions (HSE, 2010) and this is reflected in the difference in safety cultures. As such, it is understandable how there can be a conflict of ideas when micro firms have to operate on large projects whereby they have to follow the formalised policies of the larger companies. Managing this difference can become problematic when the different cultures clash.

Integration of parties on site

Large construction projects often involve numerous activities on site. Construction supply chains on larger projects typically involve hundreds of different companies supplying materials, components and wide range of construction services (Dainty *et al.*, 2001). Integrating the supply chains on site can become problematic if not carried out properly (Briscoe and Dainty, 2005). Partnering arrangements have been successfully carried out between clients and main contractors rather than extending down the chain to subcontractors and suppliers (Ochieng and Price, 2010). Briscoe and Dainty (2005) notice an improving trend in integration in partnering practices and this development includes subcontractors. However, there are still some difficulties facing smaller firms including micro firms who attempt to play a fuller role in the integrated supply chain (Manu *et al.*, 2013).

In their study, Briscoe and Dainty (2005) found the following as the key attributes deemed to be the most important for a successful integration of the construction parties:

6. Managing communication
7. Managing information
8. Mechanisms for problem resolution
9. Engineering added value in projects
10. Alignment of supply chain systems
11. Ensuring high quality standards
12. Securing commitment to the client and project objectives
13. Establishing long-term supply chain relations

Whilst the above list is not in order of significance, some of the attributes can be grouped together as they fall within the same area. For example, managing communication, managing information, and mechanisms for problem resolution, can all be placed under a common theme of effective communication. Furthermore engineering added value in projects, alignment of supply chain systems, and ensuring high quality standards, can be labelled as quality assurance. And finally, securing commitment to the client and project objectives and establishing long-term supply chain relations, termed as establishing loyalty and long-term relations.

Briscoe *et al.* (2001) explain that external experts can be used by contractors on site to help improve the management of matters. Some of these matters may include legal issues, safety issues, and other specific project requirements. The use of external individuals or parties is a step in the right direction as it has been found that some workers of micro construction firms at times want to voice out certain concerns on projects but are unable do so out of fear of unwanted repercussions (British Chambers of Commerce, 1995). Smaller businesses including micro construction firms may have concerns about the existing regulations put in place by principal contractors as they may find some of them complex, time consuming and even sometimes ineffective, but feel they are unable to raise these issues in fear of being 'marginalized' and subsequently being blacklisted by major contractors (Taylor, 2013). This 'paranoia'

may be at an all-time high with recent revelations suggesting that blacklists do indeed exist in the UK construction industry and have been used to reject several companies from attaining contracts (BBC News, 2013). Local safety groups have been operating in various regions of the country to promote awareness and knowledge about work-related health and safety risks and how to manage them (Safety Groups UK, 2014). Furthermore, through their consultants who visit sites, they create a harmonious existence between the different parties on site on issues relating to safety. They do so by bringing a wide range of people together to hear essential messages and to share experience, concerns and solutions (ibid). Their approach to helping improve project activities (related to safety) is in line with the Briscoe *et al's* (2005) findings of principal contractors using external expert opinions on projects to ensure effective interactions and cooperation among the different parties involved in the supply chain. The underlying feature for improving most project practices is reliant on effective communication as it ensures that all stakeholders including clients, principal contractors and subcontractors are all satisfied (Dainty *et al*, 2006; Briscoe *et al*, 2005; Love *et al*, 2004).

Managing the principal contractor and subcontractor

Due to the presence of multiple organisations working in an interdisciplinary environment in construction projects, the task of aligning a common objective within a temporary team is fraught with difficulty (Dainty *et al* 2006: 30). These difficulties can be minimized or eliminated through effective communication. NOSHA thus help moderate communications and interactions between principal contractors and their subcontractors. That is, they act as independent parties with no conflict of interests in the relationships.

For the purpose of this research project, emphasis is placed on the construction phase of projects (rather than the design phase) and specifically, the interaction between the principal contractor and the subcontractor (micro firms).

Whilst there is the direct linkage between the principal contractor and the subcontractor, the use of external opinions (see Briscoe *et al*, 2001) has been found to be able to help relationships in projects. This could be a means of improving trust in the relationship as the parties can express their concerns to this mediating party with hope of receiving a fair arbitration. Berry *et al* (1994) recommend trust building and exchanging information on market needs as very important in the developing of meaningful, long-term relationships and adds that they can be attained through effective supply chain management. Safety Groups UK (2014) boasts of making such partnerships prosper for principal contractors and subcontractors in the long term.

Rationale for research

Past research have looked into relationships between principal contractors and subcontractors (see Briscoe and Dainty, 2005; Love *et al*, 2004; Hinze and Gambatese, 1996). In addition, other researchers have studied the informal aspects of the safety practices of small and micro construction firms (see Aboagye-Nimo *et al*, 2013; Abdel Wahab *et al*, 2008; Dainty *et al*, 2005). However, researchers have not studied the role that local safety groups play in moderating the shift in environment and culture that takes place when micro construction firms are subcontracted on large projects. Furthermore, the role that these local safety groups play in the maintaining of long-term relationships between these micro firms and the principal contractors is understudied. Thus this research project offers much needed understanding on what

these 'unsung heroes' (in the form of local safety groups) are doing in the construction industry.

RESEARCH METHODS

Semi-structured interviews were carried out with two members of NOSHA. The interviewees are independent safety consultants for several major construction projects in the Midlands regions. They negotiate and communicate safety concerns between principal contractors and their subcontractors (usually micro firms) on site. In addition, these consultants carry out routine site inspections on sites and highlight safety issues that need to be addressed by all parties. Their roles in NOSHA include discussing site observations to raise awareness amongst the members of the association. They also learn effective solutions for problems from the other group members. Since the interviewer was not a member of NOSHA, interview questions were derived from an external point of view thereby eliminating a potential conflict of interest or researcher bias.

The semi-structured interviews covered the views of the NOSHA members on the safety cultures of micro construction firms and how these firms operate when they have to work with principal contractors on large projects. Other areas of concern were how they create and maintain harmony between the two parties especially when there are misunderstandings due to the different techniques adopted in site safety. Whilst the Pybus model was not used explicitly in the interview questions, the respondents' perceptions of the safety cultures of micro construction firms were sought after. This was to help establish whether these micro firms follow the suggested stages of evolution in the model. Overall, the semi-structured interviews helped acquire rich and in-depth data on the safety culture of workers of micro construction firms. Furthermore, the chosen approach helped the project establish areas required for additional focus as this was the piloting phase.

Thematic analysis was the main method used for data analysis. Themes were identified from literature review and contents of the interview transcripts. Thematic coding of the transcribed data was carried out using QSR NVivo 9. Using the qualitative data analysis software helped the research project with organisation of their data (i.e. interview transcripts, relevant literature and personal reflections). The next section presents findings from the interviews with the NOSHA members.

FINDINGS AND ANALYSIS

Findings and analysis presented here are from the interviews conducted with two members of NOSHA. These members of NOSHA act as independent safety consultants on large projects in the Nottinghamshire were interviewed. The key findings presented in this paper cover their views on the safety cultures of micro construction firms, differences in practices on sites, managing communication, establishing long-term supply chain relations and approaches to problem resolution. NOSHA plays a key role as acting as 'middle men' when the need arises.

Safety culture of micro firms and the Pybus curve model

The interviewees acknowledged that the micro construction firms they work with do not use any formal rules and enforcement strategies. Furthermore, these micro firms rarely have encounters with authorities such as the HSE or local authority, and for this reason they are not concerned being asked to produce formal records. Thus the micro

firms cannot be characterized as being in the traditional phase on the Pybus curve. The traditional phase shows attention to rules, discipline and enforcement.

The micro construction firms according to the NOSHA members, show attention to safe methods of working and train their new workers to also work safely. However these are done in an informal manner, thereby leaving no official records on such practices. The respondents also pointed out that when workers have addressed safety concerns in the past, they did not record them and therefore, the only knowledge of this is committed to memory. Relating these findings to the transitional phase of the model, the micro construction firms exhibit some traits of this but the practices are not officially recorded and as such cannot be placed in this category.

The respondents explain that the safety practices of the micro firms are more dependent on their cultural and motivational issues. Also, the workers of the micro firms include safety in all aspects of their practices rather than treating it as a separate entity e.g. having an official method statement for their safety practices. The final phase of the model may be more receptive to the practices of micro firms. Aboagye-Nimo *et al* (2013) confirm the strong attachment of culture and informality to the safety cultures of small construction firms. From these findings, the notion that micro construction firms do not necessarily go through the three phases of safety culture evolution can be proposed for further exploration. They rather show attributes of firms in the innovative phase.

The respondents believed that the overall safety practices and cultures of small and micro firms had improved, but this did not mean they were working in a similar manner to large firms.

"Even though practices have changed in recent times, small firms still operate differently."

They added that they still carry out their practices such as management and training in informal ways. The different cultures is one of the main sources of misunderstandings between both parties as the principal contractors are more comfortable using official rules and regulations. Using their expertise, the consultants of NOSHA and other safety groups talk to both parties, and try to explain and justify why some of these practices have to be allowed. The practice of using external experts is described Briscoe *et al* (2001) to be effective for integrating project parties.

Also, the consultants sometimes have the responsibility of playing 'Devil's advocate' when they have to ask the subcontractors to go against their usual style of work. The NOSHA members clearly state that there can be safety problems on the part of the principal contractors or subcontractors. In essence, the safety consultants support practices that will be safe and comfortable for both parties. However, some parties may not always be happy with such decisions.

Managing communication

As far as NOSHA's role in managing communication on large projects was concerned, the respondents stated that their presence in the projects enabled both the main contractors and the subcontractors to communicate more openly. Although the most effective means of communication is direct (Dainty *et al*, 2006), the complications of some situations do not make this the best method at all times. There are some concerns that the parties would rather discuss with the consultant representing NOSHA and this is then relayed on to the other party.

One of the main reasons why the micro firms would rather share their concerns with the independent consultant rather than the main contractor is a fear of damaging the long-term relationship they have. One of the respondents stated:

"Complaining could lead to commercial suicide."

He explained that workers of the subcontracted micro firms may have safety concerns about specific practices being carried out on site, but may have a problem with voicing out their opinions. This is because they fear this could create 'bad blood' between them and the principal contractors whom they need for a continuity of supply projects. Getting into disagreements with some of the project managers or site managers, who are representing the large company, can lead to a "*commercial suicide*". This is because the micro firm could be 'blacklisted' if they are deemed problematic to work with and hence will not receive future contracts, hence ending the prospects of the long-term relationship (see Taylor, 2013). Concerns about safety practices are thus conveyed through the safety consultants who try to handle the issues delicately in order to maintain the relationship. As stated by Briscoe and Dainty (2005), parties in the project may seek to build long-term relationships, and in the case of the micro firms, they may need the principal contractor more than the principal contractor would need them. NOSHA may be an important ingredient in keeping this relationship ongoing.

Approaches to problem resolution

In projects disagreements can arise when the different parties involved have different views that they feel strongly about. When such disagreements arise, it is in the best interest of the project and all the involved parties that it is resolved quickly and efficiently without the situation escalating (see Emmitt and Gorse, 2003). The NOSHA members agreed that if problems were not "*handled immediately*", the aftermath would be detrimental to the whole project. The respondent recalled witnessing a situation between some subcontracted workers and the site manager. He stated that:

"...they were absolutely furious about this. In fact one of them had to be held back from punching the site manager."

In this instance, he was able to calm both parties and the project continued. The NOSHA member further explained that it is helpful that the parties in disagreement know that the mediator of a problem is independent and has no conflict of interest in the ongoing situation. The consultants had seen and heard of numerous issues that had occurred on site that escalated into more serious issues as there were no actual problem solving mechanisms in place. The consultants stated that when issues got so intensified, some subcontractors were not even concerned about mending relationships, and this point the relationship is broken beyond repair. This could also be because the subcontractors believe that they cannot conform to the working style of the principal contractor even in future projects. One of the accounts told about site conflicts was the avoidance of a physical attack that almost occurred following a disagreement between one of the subcontracted workers and the site manager (with the principal contractor). Regular consultation with independent bodies on site can help workers share their concerns, as such, matters do not have to get so aggravated.

CONCLUSIONS

This paper has shown the role of local safety groups in improving the relationships between micro firms working as subcontractors for principal contractors on large

projects. NOSHA is a safety group working in the Nottinghamshire region and have been creating and maintaining relationships for small and micro firms with large contractors. NOSHA have the responsibility of working as independent consultants and as such are able to work closely with main contractors and subcontractors, with safety as their main priority.

Using the Pybus curve model, this study has shown that micro construction firms do not follow the proposed evolutionary stages of safety culture. With this in mind, it is proposed that researchers use bespoke research methodology when studying micro construction firms rather than using standardised approaches. This is because the micro construction firms do not use standard methods at work and hence cannot be studied using conventional approaches. This pilot study has highlighted areas that need to be considered critically during the main empirical phase of the overall research project. Further interviews and observations have been scheduled with NOSHA members to explore further how they carry out their role of mediation on construction sites.

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ASSESSING QUALIFICATION SYSTEMS: THE RELEVANCE OF EXPLICATING IMPLICIT REASONING

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In public procurement, most contractors view the qualifying procedures they are obliged to follow as time consuming and wasteful. For one category of public clients, EU rules offer an alternative to qualifying for each project. Public clients operating in the water, energy, transport or telecommunications sectors may establish and operate a so-called 'qualification system'. This offers contractors the opportunity to qualify for a period of time rather than an individual project. The reasons for applying such a qualification system seem traditionally to be rooted in reducing transaction costs, particularly where the administrative demands are significant relative to the typical value of contracts. As such, it may seem self-evident that a client's choice between the two approaches should be based on cost efficiency considerations. However, cost efficiency may not be the only motive behind employing a qualification system. A case study is presented here that examines the evolution of such a system and the corresponding reasoning by its operator. While exploring the usability of a conceptual model for managing procurement knowledge, additional reasons for operating the qualification system are reconstructed by exposing the implicit organizational knowledge. Initial results show that formal reasons are combined with implicit ones. These implicit reasons are found to be key in explaining the current utilization of the qualification system. Over time, implicit reasons get included in the reasoning process and come to dominate the original formal reasons. Without proper explication of these reasons, the real value of the qualification system may remain undetected. The contributions of this paper are twofold. First, it reports a case study in which the usability of a model developed for managing procurement knowledge is explored. Second, this paper offers a first insight into the evolution of a qualification system and the corresponding reasoning by its operator.

Keywords: implicit knowledge, public procurement, qualification system.

INTRODUCTION

Typically, public sector clients apply diverse systems, methods, means and tools to facilitate their procurement activities. Recognizing that procurement is an important means for achieving organizational goals, clients continuously strive to assess and improve the efficacy of such procurement instruments. Assessing and improving the efficacy of a procurement instrument requires adequate procurement knowledge. However, this may not be readily to hand, and may even have got lost to the organization if employees with relevant knowledge have left or simply forgotten important aspects over the course of time.

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The unavailability of adequate procurement knowledge may form an obstacle to assessing and improving processes. Assessing the efficacy of an instrument on the basis of inadequate knowledge will probably misrepresent the purposes of using the instrument, the context it is being used in, or the empirical effects of the instrument. As a consequence, adjustments made to the procurement instrument may be suboptimal. In the worst-case scenario, an assessment based on the wrong criteria may even lead to the decision to discard a reasonably effective instrument.

Our research has addressed two questions related to this matter. First, what kind of procurement knowledge is relevant when making decisions on continuing to use or further developing procurement instruments? Second, how can adequate knowledge be obtained during the daily practices of the client's organization? These questions are addressed using the theory and concepts of Knowledge Management (KM). First, a model is presented that has been developed for the specific purpose of identifying and managing the kind of procurement knowledge that is relevant to the context described above. Next, the model's practical usefulness is explored through a case study. The selected case concerns a form of procurement instrument that is generally known as a qualification system, here one that has been used for several years by a public sector client and which has been adjusted several times.

The contributions of this paper are twofold. It presents a model for managing the procurement knowledge that is developed in practice. Further, given that scientific literature on qualification systems is scarce, this paper offers an initial insight into the evolution of a qualification system and the corresponding reasoning by a public sector client.

MANAGING PROCUREMENT KNOWLEDGE: A KM MODEL

The first research phase has been aimed at developing a conceptual model that focusses on the kind of procurement knowledge that is relevant when making decisions on the further development of procurement instruments. Further, the model is aimed at facilitating use of that knowledge by applying theories and concepts from the literature on KM.

The model's approach to procurement knowledge

What kind of knowledge is relevant when deciding on the continued use or adjustment of procurement instruments? Since this issue is scarcely addressed in the literature, two a priori constructs are introduced to represent two specific categories of procurement knowledge: argumentation and generalization. These two terms are chosen as abstract representations for the two sorts of reasoning that may be encountered in a client organization.

Procurement instruments are used to achieve certain purposes. In recognition of this, the term argumentation is chosen to allude to all the articulated expectations or predictions about the empirical effects of a procurement instrument in a forthcoming application. For example, 'in this Design&Build project, the instrument will stimulate the innovative power of contractors tendering for the contract'. It is assumed that, later, such argumentations will form a relevant source of procurement knowledge since they represent expectations regarding the instrument's effects in a particular procurement process before it is actually used. The term generalization refers to generic statements about empirical effects that employees have actually observed in practice while applying a particular procurement instrument. From a KM perspective, this term links with the notion of organizational knowledge in the sense that

"individuals draw and act upon a corpus of generalizations in the form of generic rules produced by the organization" (Tsoukas and Vladimirou, 2001). Examples of such statements are 'Design&Build improves the constructability of the design' and 'a negotiated procedure enhances the applicant's understanding of the client's vision of the project goals'. While such effects may have occurred in previous projects, these statements are formulated on a more generic level than experienced in those particular projects, and are probably used by more employees than only those who have observed them. The process leading up to such statements is assumed to be similar to the concept of theorization, which concerns *"the self-conscious development and specification of abstract categories and the formulation of patterned relationships such as chains of cause and effect"* (Strang and Meyer, 1993).

The term generalization is also used in the model to reflect the possibility that the statement may not necessarily hold true for all past applications of the procurement instrument. For example, Design&Build may not have improved the constructability in a particular project where the contractor's design team was not able to design well due to particular circumstances such as a temporary lack of design capacity or the lead engineer changing jobs. As such, the attribution of features may risk the fallacy of defective induction. However, the organization may well have experienced many more projects where the statement seems to correspond with the outcomes of the project, and thus they may hold the statement as generally true. Faulty or not, generalizations may subsequently serve as inputs to the set of features that are used by the client to characterize a type of procurement instrument. In turn, these features may serve as sources for argumentation to be used in future procurement decision-making processes, thus creating an iterative process.

In conclusion, argumentations and generalizations represent the kind of knowledge that is relevant when deciding to continue with and/or adjust procurement instruments because they select and express certain characteristics of procurement instruments abstracted from a complex reality.

Knowledge Management concepts in the model

How can theories and concepts from the KM literature facilitate the utilization of argumentations and generalizations? The very idea of KM implies that certain knowledge is present in an organization and, when managed in appropriate ways, the organization will benefit from that knowledge. One of the most widely used classifications of knowledge types is the distinction between tacit and explicit knowledge (Ragab and Arisha, 2013) that is based on Polanyi's concept of tacit knowing (1966). In essence, explicit knowledge is knowledge that can be codified and stored, whereas tacit knowledge cannot. Elaborating on this distinction, Nonaka and Takeuchi developed the SECI conversion model (Nonaka, 1995). In this model, tacit and explicit knowledge are considered the two ends of a continuum (Nonaka and von Krogh, 2009). This stance implies that while tacit knowledge in the strictest sense cannot be articulated, it may be possible to convert less tacit forms of knowledge into explicit knowledge. The SECI model argues that valuable tacit knowledge resides within individuals, and can only add value if it is converted into explicit knowledge. The concepts of tacit and explicit knowledge are applied in the model to account for the possibility that not all argumentations and generalizations occur in an explicit form in the organization.

The model also incorporates the four KM processes that are generally identified as part of the KM concept in order to position the iterative procurement knowledge

process described above in a KM perspective. Although various taxonomies have been proposed, the processes that should be incorporated in any KM system can be grouped within four core KM processes: creation and acquisition, storage and retrieval, transfer and sharing, and application (of knowledge) (Ragab and Arisha, 2013). At this stage of the research, these core processes are sufficient to create a conceptual model and explore its practical usability.

The KM literature can be categorized under several topics. One category concerns Knowledge Management Systems (KMSs), described as configurations of managerial, technical and organizational systems structured to support the implementation of KM within an organization (Massa and Testa, 2009). There have been three main approaches to KMSs: codification, personalization and people finder, plus a hybrid approach (Ragab and Arisha, 2013). Codification concerns documenting and storing knowledge in order to enable access to this knowledge by others and/or for future applications. This is a ‘people-to-documents’ strategy. In contrast, personalization concerns a ‘person-to-person’ strategy and focusses on the transfer of knowledge through face-to-face social interaction. The third strategy focusses on mapping the location of certain knowledge in the organization (the ‘people finder’ strategy). In our current research phase, only the codification strategy perspective is used.

Model for managing procurement knowledge

In the resulting model, the two a priori constructs are positioned against a KM background (Figure 1). This suggests that procurement knowledge should be analysed from the perspective of KM processes and knowledge conversion. The latter refers to the concepts of tacit knowledge (marked in the model as 'T') and explicit knowledge (marked 'E').

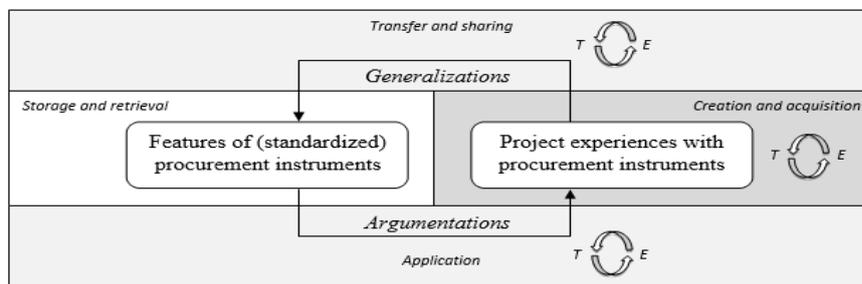


Figure 1: Model for managing procurement knowledge

Although this paper introduces the complete model, the focus is mainly on the a priori constructs and the concept of knowledge conversion. The other aspects of the model are beyond the scope of this paper.

RESEARCH METHOD

To explore the model's usability, the next phase in the research project involves applying the model in the empirical context of a public sector client. For this purpose, we selected a procurement instrument known as a ‘qualification system’. Although the testing phase is not yet complete, the preliminary results are sufficiently interesting to report for two reasons. First, because they illustrate the kind of procurement knowledge that the model is directed at. Second, because the results offer insights into qualification systems, a procurement instrument scarcely addressed in the literature.

The object of the research and its empirical context

The European Union's public procurement directives distinguish a specific group of public clients covering those 'entities operating in the water, energy, transport and

postal services sectors'. The procurement activities of this group are regulated by 'the Utilities Directive' (directive 2014/25/EU). Public clients in this group have the option of selecting possible contractors for a period of time and a certain scope of work, rather than having them re-qualify at every tendering procedure. This is called a 'qualification system' (article 77, directive 2014/25/EU). According to the European Commission, qualification systems are suited to the procurement of technically exacting works, supplies or services that would otherwise involve lengthy qualification procedures (European Commission, 2011). The generally attributed advantages of this system are that it reduces costs and delays in procurement (Arrowsmith, 2003). The case study presented in this paper concerns a qualification system that has been operated for many years by ProRail, the Dutch state railway agency.

Research activities

To date, three research steps have been executed. These are now briefly described to illustrate how the model is used.

Step 1: preparatory activities

The first step was to establish an overview of how the current qualification system (QS) evolved. Documentation on the QS was collected insofar as it could be retrieved from publicly available information and internal archives. Using this information, the changes made to the QS over time were reconstructed. Next, given that the model focusses on the reasoning process, the documentation was closely searched for explicit statements related to motives, reasons or arguments, and descriptions of effects. These were then linked to the modifications to the QS over time.

Step 2: semi-structured interviews

The second step is to carry out semi-structured interviews with employees currently in service at ProRail. This step is ongoing. To date, interviews have been held with four staff members perceived by the organization as the most knowledgeable on the QS because of their current or previous function. Amongst these interviewees were both the current and the previous manager responsible for the daily operation of the QS, and the employee who developed the QS and has remained influential in its later development.

The interviews had several goals. The first being to seek opinions on the reasons uncovered in Step 1: would the interviewees consider these reasons as adequately representing the previous and current purposes of the QS? If deemed inadequate, interviewees are asked to explain their perceptions of the reasoning using a causal map. This approach was chosen for two reasons. First, we assume that the assessment will touch upon the model's reference to tacit and explicit knowledge and, in the KM literature, causal mapping by a group is proposed as a means for extracting tacit knowledge (Ambrosini and Bowman, 2001). Second, we anticipate the reasoning to address various elements and positions in a hierarchical chain of cause-and-effect relationships, and causal mapping facilitates thinking in such a hierarchy. The third purpose of the interviews is to determine whether the interviewees know of additional documents to those retrieved in step 1 that could explain the motivations behind the developments in the reconstructed QS evolution.

Step 3: sorting the collected information

The third step is to sort the collected information based on the model. The model is intended to help categorize the information by prompting questions such as:

- 1) Which motives, reasons or arguments are used to explain why the QS as it stands is

in use and/or why it needs to be adjusted (argumentation)?

2) Which empirically observed effects have been attributed to the QS procurement instrument (generalization)?

3) Which of the answers given to these two questions are available in a documented form that colleagues could use in applying the QS (the concept of tacit/explicit knowledge and the codification strategy)?

PRELIMINARY CASE RESULTS

The preliminary results obtained so far illustrate the type of procurement knowledge that the application of the model directs attention to. This is presented in order to subsequently discuss the usability of the model.

Evolution of the qualification system

At the start of the research project, it was generally acknowledged within the client's procurement department that the QS approach had been in use for a considerable time. Our questions were then, when was it first applied, and how and why had it evolved since? Table 1 outlines the evolution of the QS, providing an initial superficial answer to these questions.

Table 1: Evolution of the QS and the corresponding reasoning as retrieved from documents

Year	Context description and evolution of qualification system (QS)	Corresponding reasoning, as far as it could be retrieved from documents
1995	Context: Splitting up of Dutch railways into an infrastructure manager, a train operating company and commercial firms. Few competitors for railway-specific projects.	-
1995	Establishment of QS 1, for a large programme on platform modifications.	-
1996	Establishment of QS 2 for contractors in the rail branch.	Increase in number of competitors (previous QS led to increase from 2 to 7 competitors); to control market entry; to reduce tendering costs.
1997	Scope of QS 2 expanded to include engineering bureaus	Increase in competitors; to control market entry; to reduce tendering costs.
1998	Scope of QS 2 expanded to include cabling contractors.	Identical to reasoning in 1997.
1998	Scope of QS 2 expanded to include workplace safety companies.	Identical to reasoning in 1997.
2001	Context: Report on procurement practices from 1995 to 2000 by Dutch Audit Court.	Report concluded that the QS had contributed to an increase in competition.
2003	Scope of QS 2 expanded to include maintenance contractors.	Identical to reasoning in 1997.
2005	Context: Management concession granted to ProRail requiring environmental and safety management systems by January 2007 and January 2008 respectively.	-
2006	Scope of QS2 expanded to include companies for securing safe railway passability.	Identical to reasoning in 1997.
2009	Scope of workplace safety companies within QS 2 expanded to include safety personnel agencies.	Identical to reasoning in 1997.
2013	Scope of QS2 reduced by removing companies for securing safe railway passability.	-

The reconstruction shows that the QS currently in use (QS2) has been in place for nearly twenty years. Further, while its structure has remained essentially the same, it has been changed several times, generally to expand its scope. However, the reasons for these changes, insofar as these could be retrieved from documents, did not quite seem to address the particular changes made. This is maybe because the retrieved reasoning was identical for most of the changes: to increase the number of competitors for contracts; to control market entry; to reduce tendering costs. The documents uncovered tended to describe the change itself rather than why an adjustment was being made. When interviewees were asked about this, they agreed that reasons for the adjustments were generally not that explicitly documented. Moreover, they argued that some knowledge of the historical context of the QS is necessary for a good understanding of its evolution. Consequently, descriptions of the historical context are added to Table 1 to illustrate the relevance of the changing context in which the QS has been applied.

An interesting anecdotal detail is that QS1 was only accidentally uncovered when an interviewee produced an old paper document that he thought might be interesting for the research. It dated from 1995 and came from his personal archive. This had preceded QS2 and has apparently disappeared from the collective memory of the interviewees. Interestingly, this document considered the pros and cons of establishing qualification systems. QS1 appears to have been successful in achieving an increase in the number of competitors and this has subsequently been behind some of the reasoning for QS2. None of the retrieved documents related to QS 2 included such considerations of the advantages and disadvantages.

Current argumentations and generalizations

The interviews were also intended to collect additional reasoning through appropriate questioning and causal mapping. Table 2 outlines the reasoning for the current QS in terms of the model: argumentations, generalizations and empirically observed effects. Only those items that are positioned on roughly the same high hierarchical level of the causal maps are presented as these are the most significant. Note that the ordering in the table is indicative of the relative importance attributed by the interviewees as a group. Reasons also identified in the documents are marked by an asterisk (*).

The table shows that the first three argumentations in favour of the QS, the ones most emphasized in the interviews, are not explicitly stated in any of the public and internal documents we uncovered. Nevertheless, they were consistently perceived by the interviewees as the most important reasons for operating the current QS manifestation. The interviews also gave another perspective on the relevance of this kind of knowledge. When asked about the dominant implicit character of the reasoning, one interviewee suggested that the efficacy of the QS would rise if greater attention was given to communicating these argumentations: *"If colleagues better understood the purposes of the QS, they would probably better inform us with early warnings that a firm might be decreasing in capabilities. That would enable us to anticipate, instead of reacting"*.

To summarize, the results show that the QS has been changed several times over the years. Although the original reasons for introducing the QS have remained important, the set of reasons has expanded. In this process, new reasons for operating the QS have become dominant. A factor in the additional reasons appears to be the changing context in which the QS is applied. The organizational knowledge of these additional

reasons is implicit in the sense that this knowledge is not documented. Therefore, the organization has to rely on employees that hold this particular knowledge.

Table 2: Currently used argumentations, generalizations and the observed effects

Argumentation (purpose of QS)	Generalization (what QS does)	Observed empirical effect
1) Compliancy with the safety and environmental requirements of the government's concession.	The QS enables ProRail to comply with the safety and environmental requirements of the government's concession.	The QS has been one of the main reasons for the auditor to conclude that ProRail has been compliant,
2) Contribute to a safe and reliable rail infrastructure.	The QS ensures that only firms that have mastered the required capabilities get to work on the core of the Dutch rail system.	Instances where things went wrong prove that firms require knowledge of the uniqueness of the Dutch rail system.
3) Stimulate contractors to improve or gain additional competences in the future.	The QS enables ProRail to stimulate contractors to further improve or gain additional competences.	The market's adoption of Systems Engineering has been enabled by the qualification system.
4) Market entry to occur in a controlled manner*.	The QS ensures that new contractors enter the ProRail market in a controlled manner.	Newcomers have invested considerably in order to be able to demonstrate their competence.
5) Reduction in tender costs and duration*.	The QS reduces tendering costs and time.	Given the high demands and substantial paperwork, periodic qualifying has reduced costs and times considerably over qualifying for each tender.
6) Increasing number of competitors*.	The QS increases the number of certified competitors.	The number of certified competitors has increased in most branches, though it has remained limited in some.

DISCUSSION

The first question raised in this paper concerned the kind of procurement knowledge that might be considered relevant when making decisions on the continuation and further development of procurement instruments. Although the research is not yet complete, and the usability of the proposed model for managing procurement knowledge has only been investigated in a single case, we are able to offer some preliminary answers to this question.

The reasoning so far retrieved and explicated does arguably represent a relevant form of knowledge since a deliberate decision to continue with the QS approach requires a comparison with alternative instruments that might achieve the same results. One obvious alternative is qualifying on a tender-by-tender basis. Two of the three explicitly noted reasons for using a QS (more competitors, reduced tendering costs) would be a basis for making such a comparison. However, in this specific case, such an approach would risk overlooking the most important purposes in operating this QS since these are held as implicit knowledge. As such, it can be concluded that, alongside the explicit reasons, a proper explication of any additional implicit reasoning is important in coming to a deliberated decision to continue with the existing qualification system.

At this stage of the research, because the early results do not provide reasoning on a level that can explain the individual changes to the QS, we cannot be sure if this is

also true when it comes to the further development of procurement instruments. However, we anticipate the same approach in the next research phases, followed by an in-depth analysis, delivering results that address this aspect.

The second question raised concerned how to obtain adequate knowledge of the daily practices within the client organization. One option would be to simply go round and ask the people who are knowledgeable on the subject. Although this seems sound advice, how will we decide if, and when, the knowledge is adequate? Here, we need to consider the usability of the model. The first concern is that the implicit character of the knowledge introduces the potential for differences in the opinions of employees. It is possible that, over time, opinions will diverge, perhaps because there are effects that are interpreted differently. The model's goal of explicating the implicit reasoning should help in determining the adequacy of the knowledge collected. A second aspect concerns adequateness in the sense of correctness of reasoning. Some of the findings suggest that some of the argumentations for the QS are quite ambitious but it does not follow that they are borne out in practice. For example, the argumentation that there will be 'more competitors' contrasts with the empirical finding that 'the number of competitors has long been limited in some branches'. The model suggests an explanation for this by assuming that an iterative reasoning process takes place over time. In this process, the construction of generalizations helps in understanding where these argumentations may have originated and why expectations have been raised. Explicating and categorizing the reasoning, in terms of argumentations, generalizations and observed effects, enables one to assess its adequateness.

Clearly, there are still some limitations in the current exploration of the model. First, the results presented in this paper do not explicitly illustrate some aspects of the model, such as the four core KM processes or the tacit to explicit knowledge conversion. These aspects will be addressed in more detail in subsequent research phases. Second, the model has been only briefly explored with the qualification system, and not tested at all on other kinds of procurement instruments, nor with other public sector clients.

Finally, it is expected that future applications of the model would benefit from further elaboration of the argumentation and generalization constructs and their coherence with concepts and theories from the field of Knowledge Management that are referred to in the model.

CONCLUSIONS

The preliminary case-study results show how the qualification system, and the corresponding reasoning by the client, has evolved over time. It appears that, over time, the original formal reasons are compounded with implicit reasons. These implicit reasons were found to be the more important in explaining the current use of the qualification system. If these reasons are not properly explicated, the real value of the qualification system may remain undetected. Further, the model presented in this paper offers a framework for reconstructing the reasoning process in an organization, thereby enabling the value of its qualification system to be assessed.

The model's reference to Knowledge Management concepts and theories will be addressed more explicitly in next research activities. It is expected that a further elaboration of the argumentation and generalization constructs and their coherence with concepts and theories from the field of Knowledge Management will help to further advance the model's usability for managing procurement knowledge.

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THE CHANGING ROLE OF THE PUBLIC CLIENT IN CONSTRUCTION PROCUREMENT

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The public sector obligation to improve the performance of construction procurement has resulted in several changes to the organisation, roles and systems adopted for development schemes. For example, a less than expected outturn performance of traditional arrangements and the increase demand for public services led to the adoption of integrated procurement systems. These changes have seen a transition of client's role from merely a funder to an active player working collaboratively alongside the private sector (as service providers) at different periods over the last three decades. These changes were expected to improve construction procurement performance dramatically as they allow the clients to enhance their organisational capabilities by assigning major part of their roles to the private sector. However, the literature does not show that the procurement performance has improved as a result of the changes in the client organisation. While research continues to emphasise the importance of the client role in the construction procurement, so far limited attention has been given to the development of the client's internal organisation for better procurement performance. This paper reports a comprehensive review of the role of the client in construction procurement identified by various researchers to establish the role that the client has been performing over the last three decades. This has been achieved by applying a chronological mapping method of materials published on the subject over the last three decades. The analysis indicates that there are critical elements within the client role which have been consistently addressed over the last three decades. In addition, there are elements which have emerged as a consequence of the shift towards integrated systems. An understanding of critical and emerging elements will allow the clients to identify the gap between the required and the existing capabilities within their organisations, and to assess their procurement arrangement.

Keywords: procurement, public client, tendering.

INTRODUCTION

The public sector effort to improve the performance of construction procurement has driven changes to the organisation, roles and systems adopted for development schemes. The changes in the client roles were expected to improve construction procurement performance dramatically as it requires the clients to overcome the shortage of skills and knowledge by assigning major part of their roles to the private sector. However, the literature does not show that the performance has improved as a result of the changes took place in the client organisation. While research continues to emphasise the importance of the client role in the construction procurement, so far

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limited attention has been given to the development of the client's internal organisation for better procurement performance.

Increasing value and complexity of construction projects over time resulted in the development of different models to aid the construction client in selecting design, construction, management and financial services procurement packages (Kumaraswamy and Dissanayaka, 1998). Masterman (2002) highlighted that client's organisation characteristics and culture is the key factor in developing a sound procurement strategy. Depending on the characteristics of the client team, the procurement strategy may involve third parties (consultants) to support the client objectives of achieving better performances in the project delivery. For public projects, the success and productivity of the relationship for the client and these parties depends on the mutual understanding between the public sector and the consultancy firms (Turner, 2002; Office of Government Commerce, 2003). In addition, Mitchell *et al.* (2011) claimed that the development of the construction project is fragmented between different organisations that have separate objectives and priorities. Inefficient integration between all these parties urges the improvement of procurement in the construction industry (Bankvall *et al.*, 2010). Cohen and Eimicke (2008) argued that the public sector manager should learn to work within multi-organisation network and learn how to identify the most critical influencing factors in managing the relationship.

To overcome these current challenges, client procurement planning approach should be improved with re-allocation of responsibilities, the use of cost based strategies, early contractor involvement, the development of framework agreements, and the adoption of a systematic and strategic approach (Meehan and Bryde, 2011; Watermeyer, 2012). However, Kashiwagi (2008) has argued that, apart from the use of alternative procurement systems, the application of the best-value concept and principles of efficiency, accountability and appropriate transfer of risk and control are several key elements in maximizing value and sustainability of construction activities. This could be achieved with early planning, minimizing contractors direction and management, and minimizing confusion.

Given the above challenges to improve performance, a comprehensive review of the role of the client in construction procurement identified by various scholars has been undertaken to provide a greater understanding of the role that the client has been performing over the last three decades. This has been achieved by applying a chronological mapping method of published literature on the subject over the last three decades.

Changes in procurement systems

Procurement from Ancient Syrian and Greek culture to modern nation has achieved broad social outcomes, and public clients can utilise their purchasing power through the adoption of integrated procurement framework, driven by economic, environmental, and equity values (Nijaki and Worrel, 2012). The construction sector in last five decades has noticed changes in the adoption of different procurement systems. The changes are argued due to several reasons such as client attitude, economic situation, and expectation of procurement outcomes. Particular focus has been given towards integrating design and construction in order to deliver the expected performance of the client. Figure 1 presents changes in the adoption of various procurement systems in the UK during the period from 1987 up to 2010. Up to 1998, the separated procurement was the most dominant system, but at the same

time design and build was becoming more popular. Since 1998 separated and design and build procurement systems have been relatively getting equal share of the construction procurement value. Masterman (2002) argues that the changes in procurement systems since 1945 are mainly a result of transformation in client attitudes and needs more than any other factors.

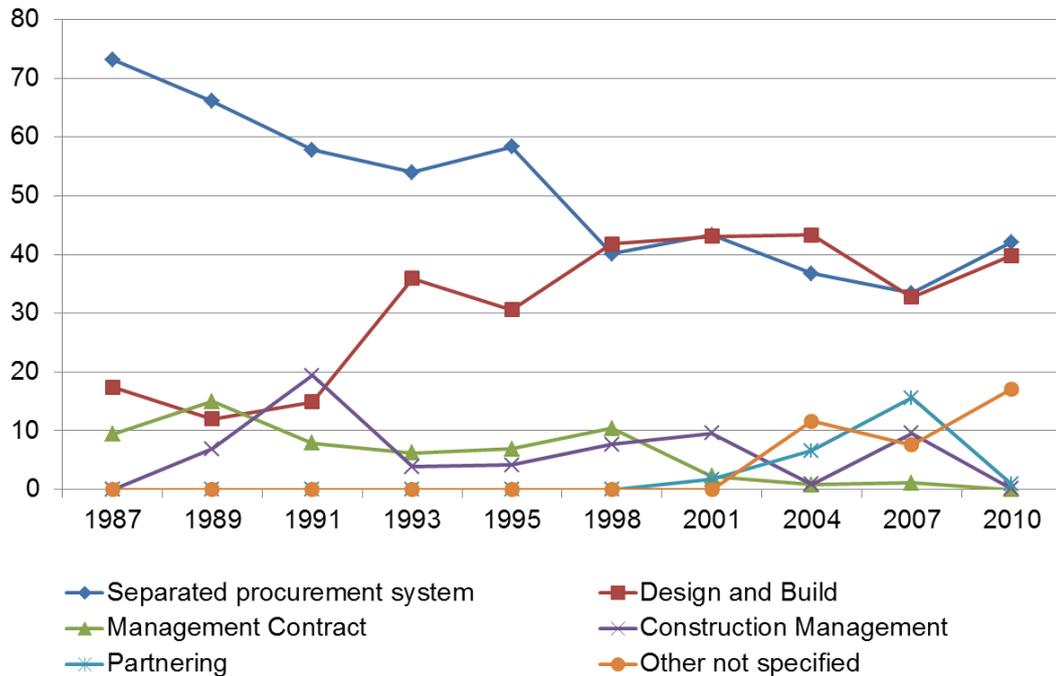


Figure 1 Changes in adoption of various procurement systems in the UK (source: RICS 2010)

On the other hand, Pietroforte and Miller (2002) show that the US government uses a range of systems in procuring construction, operation and maintenance of public facilities depending on economic and social situations. While the adoption of the procurement systems continue to vary, the shortage of work in the 1980s led to a tighter competition and more projects with lower prices being completed within budget and time (Griffiths, 1989). Similarly, Love *et al.* (1998) argued that economic downturn and recession will continue to have a significant effect on the way construction projects are procured.

The review of UK Government reports by Murray and Langford (2003) about public procurement conclude that reports before 1994 provided general and unclear improvement recommendations. In contrast, Latham (1994) and Egan (1998) reports provided the Government with the mechanisms and specified targets, which helped in developing key performance indicators whereby performance could be measured (Masterman, 2002; Murray and Langford, 2003). The period following Egan (1998) report shows a direction toward the adoption of integrated procurement systems with a desire for implementing performance indicators to assess the efficiency of the construction procurement.

The new models of construction procurement in the UK are driven towards team integration and collaboration (Cabinet Office, 2014). The Cabinet Office Guide argues the client should lead the development of processes and systems that are easily adaptable to any procurement system. Similarly, the new changes introduced in PFI2 framework (Treasury, 2012) such as increasing the public client equity and returning

some of the soft services suggest an increasing role of clients in the public sector construction.

RESEARCH METHOD

This study was conducted in several phases comprising: literature review, data collection, data analysis, findings, discussion and conclusion. Initially, the historical development of the procurement system was reviewed. Cooper (2010) suggested that accumulation of past research is necessary condition for systematic knowledge building. Then, a selection of papers relevant to the procurement systems and the client role were obtained from journals and conference proceedings published between 1984 and 2014. Keyword search was used to identify the selected papers. Cooper (2010) further argued that secondary research channels such as Journals, proceedings and government reports grant useful information for the primary research.

The review on the papers emphasised the importance of client role in attaining effective construction procurement. A comprehensive list of the procurement activities was extracted mainly from ISO (2011), RIBA (2013), (Office of Government Commerce, 2003) and ECI client best practice guide (ECI, 2013). A total of 450 papers were found to be relevant to the role of the client in the construction procurement. Further review of the abstracts resulted in shortlisting 200 papers which were classified into three categories based on the date of publication: 1984 to 1993, 1994 to 2003 and 2004 to 2014. After that, a random sample of 25 papers was selected from each category and the review focused on these papers as the source for identifying the changing roles of the client during that period of time. Due to space limitation, a complete list of papers is not included in this paper. The client role in each of the selected sources is presented in Table 1. The initial observation suggests that papers published in the last decade (period between 2004 and 2014) attributed more tasks to the client organisation in order to improve the performance in the construction procurement.

ANALYSIS RESULTS

The published papers have consistently addressed some of the roles, where other roles addressed for some period of time. Table 1 illustrate the frequency each role is considered during the last three decades.

Development of the project brief

The development of the project briefing reflects client capabilities in handling other roles such as risk management, requirement management, and selection method. The development of the project brief is the task that has been extensively researched in relation to the client organisation, especially during the most recent published literature (period of 2003 to 2014). This may be due to the growing realisation of the importance of good briefing to project performance and the need to enhance the client capability to undertake such important role. The client organisation is required to include comprehensive information about the project for example project scope, objectives, milestones, quality expectation, list of stakeholders, operation need and deliverables. Deficiency in the client brief leads to major changes at the design phases. These changes are most likely to cause delays to the project schedule and incur the client organisation additional costs.

Table 1: Project activities in which the client has a role to play

Role descriptions	No. of sources attributed the role to the client		
	1984-1993	1994-2003	2004-2014
Procurement strategy	4	6	6
▪ Selection of procurement Route	-	3	4
▪ Team Building	7	3	3
Project brief	3	2	6
Risk Management	3	3	4
▪ Risk allocation	2	2	4
▪ Monitoring and reporting risk	-	1	1
Performance management	3	1	4
▪ Performance assessment	-	-	1
▪ Regular Feedback	2	-	-
Procurement method	-	-	5
▪ Identify source of funding	4	4	3
▪ Contractor selection method	5	3	4
▪ Consultant selection method	1	1	2
Project Initiation	-	2	5
▪ Identify need of consultancy services	1	-	4
▪ Set out procurement objectives and outcomes	6	7	5
▪ Test Market	1	-	2
▪ Project Planning	2	-	1
▪ Value management	2	-	4
▪ Agreeing project objectives with stakeholders	-	-	2
Project control	-	-	-
▪ Requirement management	7	8	6
▪ Change control	-	1	3
▪ Quality management	4	-	-
▪ Obtaining authorities approvals	1	-	-
▪ Periodic systematic audit	1	-	-
Tendering and award	1	-	3
▪ Award criteria	-	-	3
▪ Set quality/prices criteria	-	-	3
Operation and maintenance/ Facilities management	5	-	2
Project design	-	-	-
▪ Concept design	1	-	-
▪ Design management	-	-	3
Information coordination	-	5	-
Standardisation	2	-	-

Risk management

When selecting an appropriate procurement system for a construction project, the client considers the provision to transfer part of the risks to the contractor. One of the key objectives is to achieve higher cost and time certainty before letting the construction contract. However, the achievement of this objective highly depends on the quality and clarity of scope developed by the clients and their advisers before it is used to development proposals by the contractors. When the scope is not comprehensive or lacks clarity, changes become costly during the construction stage especially when using procurement systems other than separated procurement, when valuing the cost of these changes mainly depends on new prices from the contractor. Consequently, it could be concluded that significant part of the procurement risk remains with the client, and therefore the client should develop appropriate capabilities to manage the risks. Table 1 also shows the importance of risk allocation as it has received a consistent attention when adopting any procurement system, over the last three decades.

Performance management

The review of three-decade literature on construction procurement suggests that time, cost and quality are still the three main performance criteria. It is often argued that the performance of different procurement systems tends to differ against the criteria. That is, a procurement system may exhibit a better performance than others for certain criteria. For example, PPP procurement tends to yield higher time and cost certainty, whereas other procurement systems such as separated system may provide better quality outcomes. Due to lack of actual data which enable an objective comparison between different systems, the performance of a system against the other is often estimated based on previous experience and past performance in different projects. This lack of performance data does not support learning in the construction industry. Since 1984, research has highlighted the importance of using feedback from previous project when developing new schemes. Nevertheless, evidence suggest that the construction sector still has not fully utilised lessons from the past, and therefore, to improve construction procurement, it needs to give greater attention in the development of not only information management but also utilising regular review in developing new knowledge and skills.

Selection of procurement method

The reviewed literature has consistently focussed on investigating three activities under procurement method, namely contractor selection method, consultant selection method and identifying source of funding. Amongst the three, contractor selection methods and criteria have been the focal point when deciding the most appropriate procurement method. The focus on the contractor selection criteria could be attributed to higher adoption of integrated procurement systems where the designers are mostly appointed by the main contractor. So contractor selection criteria take into consideration the consultant selection as well. The procurement funding strategy is an important element in the contractor selection evaluation especially when adopting PPP procurement systems. Additionally, it is also important for the client organisation when planning project cash flow in order to avoid delay that could be attributed to lack of funding from the client side.

Roles which have not been addressed consistently in the last three decades (1984-2014)

In addition to client roles in the activities discussed above, there are roles which have not been addressed consistently in the last three decades. These roles are manifested in seven main activities, discussed below:

Procurement initiation

Procurement initiation was an area of research interest between 1984 and 1993, but it received less attention in the following decade (1994-2003) before gaining greater focus during the period 2004-2014. Despite this, the results presented in Table 1 show that settings out procurement objectives and outcomes continue to be the key issue of the procurement initiation. Public clients are facing this issue more than private ones due to the level of the stakeholder involvement and diversity in publicly funding projects. In contrast, private clients' procurement objectives and outcomes are arguably more stable and clearer.

Project control

Under project control, reviewed literature suggests the client has role to play in requirements management and change control. Requirements management is the most crucial task at any procurement system. Unclear requirements might delay the

procurement process, lengthen the negotiation period (in the case of PPP), and lead to changes at the project execution stages. As a consequence, controlling changes becomes a challenge to the project team and disagreement between the team members is likely to influence team relationship when each of the team members' interest has diverse priorities and objectives. The reviewed literature shows that requirements changes are one of the major causes of cost and time overrun and greater focus by the client organisation is required to control the project requirements over the procurement life cycle.

Tendering and award

Literature in the last decade (2003-2014) provides the client organisation with divers' evaluation and award frameworks which generates a range of quality criteria with different weights depending on complexity of the construction projects and client priorities. This indicates that client is interested in implementing value based award criteria rather than award based on lowest prices. Furthermore, the ratio of quality (performance) and price has been generally considered to determine estimates of 'value for money' when awarding contracts. The role of the client is mainly to determine evaluation criteria that support the procurement objectives and outcomes identified at the initiation stage.

Operation and maintenance/facilities management

The reviewed literature indicates that operation and maintenance/ facilities management received the greatest attention in research during the period from 1984 to 1993. None of the reviewed literature addressed operation and maintenance during the period from 1994 until 2003. However, some literature highlighted operation and maintenance recently during the last decade (Umar and Idrus, 2012). This difference of attention across three decades could be attributed to the adoption of PPP, where the operation and maintenance were pooled in one package with project design, construction and finance which are outsourced to the private sector. The lack of information of operation and maintenance create difficulties when assessing and justifying value for money of PPP system.

During the period from 1984 to 1993 the client was more involved in the operation and maintenances activities and most data were documented within the client organisation. In the case of PPP, client organisation has very limited access to operation and maintenance costs because all information is under the contractor custody.

Project design

The literature suggests a tendency to move away from separated procurement to the adoption of integrated procurement systems. In integrated system, the design should be the main responsibility of the main contractor. However, literature in the decade of 1984 to 1993 highlighted that the client has a role to play in early stages of design process (such as concept design stage), after the development of the brief. In a decade between 2003 and 2014, the emphasis of client role in the design process is even more pronounced with their significant responsibility in the design management. This requires a greater involvement of the client organisation, and the need to evaluate existing capabilities and develop them as appropriate to enable efficient fulfilment of the design management role.

Information coordination

The procurement in the construction industry heavily relies on the quality of information and efficiency in communicating information. At the same time, the

construction procurement is becoming more complex due to increase in projects complexity, increase in the volume of information and technology development. With these changes, papers published during the last decade indicate less attention to investigate the improvement in the quality of information and efficiency in communicating and sharing information between participants.

Standardisation

Consistency in organisations operations influence their performance by minimizing variations and wasting time on repeated work. Examples of areas to standardise in public construction procurement: government arrangements, repeated parts of procurement documents, procedures and methods, procurement policy. Standardisation is well recognized in other sectors like automotive sector. In contrast, it is argued that standardisation is difficult to be adopted in the construction due to complexity and one-off nature of construction projects. However, the review of sources published between 1984 and 1993 show that standardisation is one of the tasks which the client should have the key role, and therefore develop their capabilities. Last two decades show less interest in investigating the client role in standardising process and documentation. The client organisation remains a focal point in the construction sector and assessment of its role standardisation provide the client with indications of possible improvement. However, lack of recent studies requires furthers investigation that highlight: the level standardisation in the sector, the relationship between standardisation and procurement performance, possible standardisation and how the client could utilise standardisation to improve performance.

DISCUSSION

The vast majority of published papers indicate close relationships between the roles of the client and the procurement performance. For example, implementing appropriate team selection methodology and team management increase the likelihood of better performance in the initial procurement process.

It is worth noting that research would seem to have spent greater attention to the roles related to the development of the procurement strategy and risk management, than to those under project brief and performance assessment. Here, the importance of having a clear and intensive project brief has been realised, but the determination of appropriate performance objectives, assessment criteria and methodology remains debatable and lacks consensus.

The outcome of the published papers analysis shows that there are critical elements within the client role which have been consistently addressed over the last three decades. In contrast, the emphasis of seven out of twelve roles varies across activities and time period. The general trend indicates greater direction toward studying specific tasks or activities within some roles such as the procurement initiation role. However, after high focus on studying roles like operation and maintenance and quality control during the period between 1983 and 1994, these roles received less attention during the period between 1994 and 2014. The causes of the changes could be as a result of the client achieved maturity within these roles or other roles become first priority to researchers. How the clients are considering and prioritising various roles highlighted over the period between 1984 and 2014 is questionable. Further investigation of the level of clients' involvement within these roles requires direct interaction with construction procurement main participants, i.e. clients, consultants and contactors.

CONCLUSIONS

Based on a thorough review of literature, this research has catalogued activities in the procurement process, in which the client should exercise appropriate roles to ensure successful projects. The roles of the client have been identified across literature covering three decades, which provide a sound basis for analysing different emphasis that they have received. The findings suggest that the emphasis varies across activities and time periods. Client roles in some activities have been consistently addressed, highlighting their importance. Although client roles in other activities have not been consistently addressed, it does not mean that the clients do not exercise their roles in these activities. Instead, they are just less important than others. This is particularly the case for client roles in, for example, information coordination, quality management and standardisation. Although there has been a tendency to adopt integrated procurement systems over the last three decades, the correlation between client role and integrated procurement systems is not conclusive, due to lack of continuity of literature which addressed client roles in the integrated systems. This review has raised further questions: how the role can be defined? What are the relationships between client roles and procurement systems? What are the capabilities to support the client to undertake their roles, and how can they be assessed? Should the client possess all the capabilities? What are the measures of success? It could be argued that satisfactory fulfilment of these roles provide a sound basis for the development of an integral solution that enable efficient involvement in the development of the construction scheme and simultaneously ensure progressive performance in the construction procurement. These are the subject of further investigation.

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GOVERNANCE STRUCTURES IN COLLABORATIVE WORKING PRACTICES

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Over the past 30 years, there has been growing pressure on construction companies and clients to adopt partnering contracts. This represents an important institutional innovation that potentially acts as a driver for changing rooted managerial approaches towards a sustainable supply chain management and governance. However some of the challenges faced include integrating several relational themes with traditional procurement processes. In addition the factors for creating, managing and fulfilling partnering contracts vary across construction projects. This paper investigates the role of governance structures, processes and actors in the governance of collaboration. Using a case study of a partnering framework agreement between a county council and a road maintenance contractor, some of the factors for creating, managing and fulfilling relational contracts are highlighted. A conceptual framework is adopted to analyse and evaluate the business relationship as it evolves. The results indicate that governance structures, processes and actors involved standardized procedures and use of individual perceptions. In addition, organisational and individual perceptions influenced the choice of appropriate governance mechanisms and strategies used in coordinating, controlling and legitimizing the business relationships. Future studies may look into the moderating and mediating role of relational and formal attributes on performance. Researchers could focus on the interventions that managers undertake to make sure that trust and standardized procedures (control) enhance performance.

Keywords: actors, collaborative working, governance, partnering, structures.

INTRODUCTION

Despite the zeal and practical interest from governments, industry practitioners and clients on the use of partnering initiatives to procure construction works and services (Latham 1994, Bennett *et al.* 1996, Barlow *et al.* 1997, Wood and Ellis 2005), the industry continues to face problems in "*transforming traditionally adversarial contractual relationships between clients and contractors into more collaborative ways of working*" (Bresnen 2010:615). Hence the much flaunted benefits of improving inter-organisational collaboration have yet to be fully achieved.

Much of the research has been on the benefits (Bennett *et al.* 1996, Barlow *et al.* 1997), even though the research evidence was limited and mixed (Nystrom 2008, Bresnen and Marshall 2000b). Most studies have been prescriptive in nature and relying on anecdote, emphasising the use of tools and techniques, such as appropriate formal contracts, incentives, charters and dispute resolution processes and mechanisms, to design ways of working collaboratively. Other researchers have studied the limitations and problems in the project performance, organisation learning

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(Nystrom 2005, 2008, Bresnen 2009, Bresnen and Marshall 2000b). More recently, much of the studies have been on defining and operationalizing the partnering concept (Anvuur and Kumuraswamy 2007, Nystrom 2005) as there is still definition overlap, ambiguity and collective understanding over what it really means to be collaborating on a project and how and in what form it is translated into in practice (Bresnen 2010, Nystrom 2005). Perhaps definition overlaps and an absence of common discourse is hindering collective understanding.

Despite the frequent use and study of working collaboratively, little has been done within the construction literature to explore empirically the governance mechanisms that are potentially useful in inter-organisational settings (Anvuur and Kumuraswamy 2007, Bresnen and Marshall 2000). The paper aims to explore how collaboration is governed and how governance structures evolve over time in practice. Considering that certain types of governance will not be practical or useful in all collaborative settings, a broader focus is needed to comprehend the different processes and elements that characterize each type of governance. Different governance arrangements may require different management skills, hence a more broader and shaded knowledge is required by all stakeholders.

This paper sets out to explore the design and implementation of the governance of collaboration in practice, drawing on the concept of ‘collaborative governance’ (Ansell and Gash 2008, Purdy 2012) and ‘governing collaborations’ (Vangen *et al.* (2014). Emerging from the field of public administration and management, these concepts are concerned with governance through the formation of inter-organizational collaborations and the governance of collaborative entities in essence.

This study would enable stakeholders in collaborative working practices couple appropriate governance mechanisms with desired aims and objectives. By studying the different types of governance mechanisms and variations, construction practitioners and researchers may be able to consider the range of governance mechanism potentially useful and effective in collaborative working practices. The study also contributes to the literature by taking into consideration both people’s capacity for taking action and the constraints on action posed by social contexts and social practices.

In the next section, a brief discussion of collaborative working practices in construction. This is then followed by a brief discussion of the elements of governance in collaborative inter-organisational relations is presented. An account of our research methodology and case study are presented. We conclude with a discussion of the findings from the case study in relations to theory and practice of collaboration in construction projects.

CWP IN CONSTRUCTION

As an important institutional innovation, collaborative working practice (CWP) initiatives potentially acts as a driver for changing rooted managerial approaches towards a sustainable supply chain management and governance. Within the construction industry, CWP have been concerned with seeking to improve inter-organizational collaboration (Bresnen 2009), this collaboration can relate to managing single projects or several projects in longer-term relationships between organisations.

Despite the attention given to CWPs as the solution to the limitations of traditional arm’s length contracting in recent times, problems of coordination, control and legitimacy still continue to badly affect the construction sector (Bresnen 2009, 2010).

Many CWP's falter in the development of governance structures as these CWP models do not live up to expectation (Wood and Ellis 2005). A reason might be that the design and implementation of governance structures for CWP is very much dependent upon intangible and dynamic social attributes, underpinned by the theory and practice of relational contracting (Macneil 1980) while ignoring the importance and complexity of the contexts (socio-cultural, economic, institutional and organizational) within which the CWP evolves (Bresnen 2009, Phua 2006).

The reality of construction procurement is that it involves varying levels cooperation, coordination and collaboration, underpinned by governance mechanisms, processes and structure. Hence, the governance of complex collaborative contexts continues to dominate the work of construction managers. For the practice of collaboration to produce benefits and gains, and the governance mechanisms sustained, there is a need to pay attention to 'collaborative governance' and 'governing collaboration' as collaborations may generate a number of challenges that need to be managed (Vagen 2014). Vagen (2014: 10) emphasize that "*The structure determines not only who (organizations and individuals) are able to influence the collaboration's agenda but also who may take important decisions and have resources, power and legitimate authority to act and be accountable for its undertakings*".

CWP AND GOVERNING COLLABORATION

Within inter-organisational collaborations, as found in the construction projects, governance is an extremely important issue if the efficiency and effectiveness of the goal oriented collaboration is to be safeguarded (Silvia 2011). In the long run, good governance serves to realize organizational and collaborative goals, even though, the process and practices may vary considerably depending on the environment in which they are applied (Huxham 2000). Given that all collaborations are exposed to internal and external forces (Huxham and Vangen 2005, Ansell and Gash 2008), the processes through which governance is designed and enacted can be altered; leading to many collaborative practices evolving over time

Vangen *et al.*'s (2014) seminal work on the governance of cross-sector, inter-organizational collaboration in the context of public administration and management, emphasized that governance decides who has authority and power; who makes decisions, how other players make their voice heard, and how account is rendered. Drawing on the logic of 'governing collaboration' and 'collaborative governance', Vangen *et al.* (2014) defined 'the governance of a collaborative entity entails the design and use of a structure and processes that enable actors to direct, coordinate and allocate resources for the collaboration as a whole and to account for its activities' and consequently conceptualized the governance of collaboration in terms of structures, processes and actors. They propose three key design elements with regards to governing collaborations and which relates to different governance mechanisms.

- Structure - Individuals, organizations and other collaborations engaged in the collaborative practice and the formal interconnections between the partners for the purpose of the collaboration.
- Processes - Ways of communicating, sharing responsibility and taking decisions through instruments such as plans, committees and workshops.
- Actors - Anyone with enough power and know-how to influence and enact the collaboration's agenda.

According to Vengan *et al.* (2014): “*The structure determines not only who (organizations and individuals) are able to influence the collaboration’s agenda but also who may take important decisions and have resources, power and legitimate authority to act and be accountable for its undertakings*” and ‘Tight’ versus ‘open’ structures deal with issues of influence, legitimacy, power and accountability in different ways.”

At the same time, it is very imperative to acknowledge that governing processes do and can take numerous procedures, forms and arrangements, and are mediums via which participating individuals and organisations “*gain legitimacy to exercise power and act*”. While the processes inspire the sharing of vital information and developing a common understanding of issues, other processes can and do deter dynamic communication between partners (Huxham 2000). With regards to actors, as Vengan *et al.* (2014) pointed out, specific actors will and do direct, coordinate and allocate resources for the collaborative practice and are accountable for their actions.

For a better understanding of the governance of collaborative practices in the construction industry context, the governing collaboration conceptual framework is used to explore and examine the design and implementation of a CWP.

RESEARCH APPROACH

Due to the paucity of published studies on governance of CWP in construction projects, first, literature from general management is reviewed to build an understanding of the governance concept. This enabled us to focus on the scope of governance mechanisms that are potentially useful in construction project’s inter-organisational settings, and how governance structures evolve over time in practice. Keywords used were governance structures, project governance, authority, trust, decision making and accountability. A classification system populated with evidence from publications on structures, processes and actors was developed. Hence, the concept of ‘governing collaboration’ is employed to investigate CWP in the construction industry context.

Second, the case study approach is adopted because, as argued by Strauss and Corbin (1997), some organizational procedures and processes being investigated cannot be quantitatively measured. This approach also responds to critique by Marchington and Vincent (2004) that existing research seldom involves studies relating to the operational level of inter-firm relationships. The purpose here is not to produce statistically generalizable results or test specific hypotheses, but rather provide an in-depth description of the structures, processes and actors involved in the governance of collaboration in practice. For example, drawing upon a case study of a partnering Project, Bresnen (2010) present “*a more general case for understanding partnering in construction as an emergent phenomenon*”. Similarly, Delhi *et al.* (2012) and Roehrich and Lewis (2010) use case studies to explore governance structures. While case studies have been described as not being statistically representative to the wider population due to restriction of the sample size (Bryman 2000), the choice of multiple case studies overcomes this. This view is supported by Hakim (1987) and Yin’s (2003) argument that the illustrations of the case study findings can be generally improved by using multiple cases.

Given the need for an in-depth analysis of a CWP, qualitative case study (Yin 2003) was adopted. This was an opportunity to study in detail and collect data about the governance structures that were developed and how they evolved over time. In

addition, the investigation, enables contribute towards understanding and theory developments through analytical generalizations (Yin 2003, Eisenhardt 1989).

Data was collected through semi-structured interviews, obtaining documentation, observation of meetings, informal conversations, and meetings with senior project engineers and project engineers from the county council; meetings with Managing Director, Project Managers and Project supervisors from the road maintenance contractor. These data collection methods were supplement by direct observations where possible. Even though interview durations and focus varied, each interview was based on a piloted master interview plan. The interviewees were asked a series of questions on their role, views on keys issues of implementation, coordination and monitoring decision-making, authority, trust, distribution of resources (resource allocation), accountability, lead organisation and individual leaders, and information sharing. Where necessary, prompting on key issues identified from literature was encouraged.

All interviews were digitally recorded and later transcribed. The transcripts were then uploaded unto the NVivo qualitative analysis software for coding. Thematic codes were developed from literature and from themes that emerged deductively from analysing the data collected. Documentation concerning the design and implementation of the collaboration was collected and reviewed, in order to build a sequential description, comparing and contrasting with data from interviews and observation to outline the collaboration history.

A CASE STUDY OF WORKING COLLABORATIVELY IN PRACTICE IN CONSTRUCTION

The project was a four year partnering framework contract agreement between a County Council (CC) and a highways maintenance contractor to manage and maintain the highway network within the CC's region. The contract had an optional three year extension depending on performance and continuous improvement implemented by the contractors.

Designing the partnering framework agreement

The highways maintenance partnering framework agreement was designed to implement the CC's policies and strategies for inspecting and maintaining its network of highways. It was aimed at developing an informed and transparent decision-making process, and information sharing between the two organizations. To gain a better understanding of the structure, processes and actors, readers are referred to Figure 6.3 in Kwawu (2009: 173) which shows the structures, processes and actors involved at different levels.

Governance through structure

Within the new partnering arrangement, the CC and the MC jointly designed the administrative structure such that the linkages between the various units of both organisations were used to specialized roles and responsibilities among employees. The new structure enabled both organisations to maintain separate entities while the structural linkage encouraged them to contribute specialized skills and resources to specific activities such as the inspection of road defects. The new hierarchical structure encouraged both organisations and individuals to depend on each other to address collective issues and common problems during logging defects and repairs.

As a result an arrangement of shared authority through equal representation on road inspections, participating project managers shared power.

In terms of the agreed roles and responsibilities of the CC and MC, formal and informal agreements were used among project managers and other participants to jointly identify and develop roles and responsibilities with the new administrative structure. This was more evident as the collaboration grew. For instance, due to the nature of some emergency calls, informal agreements were used to support changes such as new project managers joining existing teams or as new problems occurred. The project managers from the CC and MC formalised some social norms and agreements such as a project manager phoning his counterpart to resolve issues without requesting for meetings. Also noticeable was the occurrence of several personal relationships among participants due to frequent joint fieldwork visits.

In terms of organisational and individual autonomy, the collaborative interactions encouraged most participants to give up some independence in order to develop joint policies on road inspection that governed the arrangements. Giving up their independence enabled participants to collectively decide on an activity. The integration and liaison of organisational activities and actions such as raising works orders helped the participants to obtain a wider understanding of the collective advantage of working collaboratively. As clarified by project manager from MC: “... *to make these frameworks work ideally, you’ve got to be able to have a consistent team, people that are engendered into the way that the framework goes.*”

The new structure inherently intertwined the operations of both the CC and the MC such that personnel from each organisation had to make a deliberate decision to work together as they realize that it was supportive of their jobs.

Governance through processes

The collaborative arrangement between the CC and MC used an integrated information technology to improve the structural linkages between individuals, CC and MC. Thus participants had access to all kinds of information.

The decision making process in the new collaborative arrangement was characterized by the transparency process where decision were taken collectively. For example a major road defect is reported, engineers and project managers from the CC and MC jointly inspected the damage before a decision is taken to repair it, based on laid down policy and rules. The decision making process is thus transparent

In respect of conflict resolution over territorial and control issues, the CC and MC encouraged personnel to work with responding counterparts to resolve any differences by rearranging processes and procedures that caused the conflict. As illustrated by a project manager from the CC: “..... *I phone-up This has gone wrong; can we have a chat about it? How do we want it to proceed? And we will do that ... it is just a natural reaction*”. This generates trust among decision makers, and creates the willingness to share sensitive information.

The process also allows for personnel dealing with the conflict to be aware of the pressure of trying to meet organisational objectives and policies while also trying to support the objectives of the partnership.

Another way that collaborative arrangement was governed by the CC and MC involved pooling resources together to control funding of collective targets, leverage personnel and expertise. In addition individuals personnel on the project were

encouraged to draw on their organisational ties where they have access to expertise, personnel and funds that corresponding counterparts did not have.

Through participative processes, trust between individuals within the collaborative arrangement was encouraged to be committed to the collective objectives and should always act within the laid down policies and rules. Mutual trust was built right from the start with the two tier arrangement consisting of partnering charter or memorandum of agreement.

Governance through key personnel

Due to the collaborative actions and activities, project managers and other participants played key roles in the partnering arrangement. Often they relied on discretions to negotiate rules and make organisational decisions at the project level in order to achieve a collective goal. In the new collaborative arrangement, by the linkage of activities and collective identities, the participating managers and other workers collectively identified and influenced mutually beneficial relationships to improve road maintenance.

With the new administrative structure, leadership roles were given to personnel from the CC and MC giving them legitimacy to coordinate and control collaborative activities and actions. As exemplified by the MC's project manager: *".....it's a give and take, you know; we don't really want to fall back to the contract. we might be giving them a bit more on something, but they're giving us something back on something else. I'm happy to run things like that, because it enhances relationships."*

The participating personnel from the CC and MC communicated openly and frequently communicated during field visits and discussing problems thus developing a common knowledge and understanding of the project requirements, responsibilities and rules. The participating project managers and engineers through information sharing processes such as meetings, joint field work and road inspection, were able to inform corresponding counterparts what resources they could make or not make available to the team.

Through consensus and compromise, project managers and engineers from the CC and MC jointly made decisions regarding new operations, bridge difference between the CC and MC managers and engineers. The CC and MC assumed lead roles at various levels. Engineers and project managers of the 'lead organization' thus secured greater legitimacy to direct, coordinate and allocate resources for collaborative activities.

DISCUSSION

The case analyses reveal that in establishing the CWP, the CC and MC had several potential governance mechanisms at their disposal to coordinate and control activities and outcomes. The administrative structure and standardized procedures and processes for inspecting repairing defect on the highways served as governance mechanisms to adjust and adapt the participants' activities, and expected outcomes. Furthermore, these formalities legitimize the activities of the participants (Ansell and Gash 2008), creating shared understandings and affording the organizations and individuals a collective structure from which to construct their actions. Participants are then able to make-sense of the collaborative contexts in which they were engaged and to an extent legitimize the relationship.

Drawing on the logic of 'collaborative governance', the collaborative inspection and repair of defective highways requires a governance mechanism that upheld

governance principles such as legitimacy and trust. This is a further example of the link between structures, processes and actors. However, it was also acknowledged that trust resides with individuals and therefore depended on the interaction and conduct of partners and the interaction between them.

Instituting standardized procedures such as joint road inspection and decision making on repair process could be seen as a way of governing the practices and legitimizing the process. The standardized procedures and processes facilitated the work between the participants involved in the collaborative practice. The result was an increased personal interaction between the teams, thus building trust among the teams' and mobilizing the CC and MC's resources toward the achievement of joint goals. It also illustrated the impact that processes have on individuals. In terms of the ways governance structures are implicated in collaboration, there was a lot of improvisation and sense making through informal interactions.

The case study demonstrated that a successful collaborative arrangement depends on institutionalized processes that encourage and monitor the relations (Silvia, 2011) Even though participants were accountable to the collaboration as well as their respective organizations, the designed administrative structures reassured them of the responsibilities to both organisations. For example, governance structures, key personnel and processes such as the road inspection and repair process were continuously being adapted to improve the working relationship. By formalizing the practices through these formal structures and processes, the CC and MC were ensuring that all the parties understood each other well enough to resolve issues when they arise. These governance procedures and processes determined who made certain decisions and how responsibilities were divided. In other words, these provided a process for decision-making, issue resolutions and communication between the participants.

The processes and structures put in place to govern the collaboration also provided a range of decision making mechanisms among participants seeking to attain collective advantages. These structures and processes were a mixture of both formal and informal governance mechanisms such standardized procedures for raising orders and accounting for completed repairs. The key to attaining desired outcomes laid in ensuring a good working collaborative relationship through efficient and effective governance structures and processes. This then challenge the dominant ways in which we have often thought about governance structures in the field of construction management.

The project documentation such as log of project issues, change management forms, or notes of project meetings served as governance mechanisms that protected organisations and individuals from risks and controlled and coordinated their behaviours. It gave power and authority, accountability to participants. Although organizational processes and procedures empowered managers and other individuals, individual perceptions, attitudes and behaviours were very important in building the relationship in collaborative arrangement.

Without establishing the governance structures and processes, both the CC and MC would have had difficulty in sustaining a strong working relationship. Consequently, the structures, processes and personnel provide a good illustration of how governance and management of the working relationship evolves through information sharing, making decisions jointly, was an integral part of controlling and coordinating the partners to achieve a collective advantage.

CONCLUSION

With the growing pressure on construction clients to adopt partnering and collaborative ways of working, there are several governance mechanisms associated with the design and implementation of CWP. In particular, the partnering approach requires that managers and organisations rely on a myriad of processes, structures and key participants to deliver construction works and services. While much of the construction partnering literature focuses on the benefits and how to better manage the challenges with its implementation in practice, it is important for the construction clients and professionals to understand the elements of governance that can be used to govern and empower participants. It is through this understanding of the elements of governance that integrate processes, administrative structures and partners in a way that enables clients and practitioners to learn new collaborative ways of working at a more localised level.

The research highlights the importance of governance structures and processes in designing and implementing partnering agreements and shows how processes and joint decision making helped transform the relationship and outcomes of a road maintenance project. The findings highlighted in this report, indicate that there are important inter-organisational interactions that need to be governed so that integration processes and structures can be aligned with the local context and collective advantage or targets. The case study showed that in the practice of working collaboratively, participants had access to particular resources as a result of collaborative interactions, which in turn were enhanced by the designed structures and processes.

The study also contributes to the literature by taking a dynamic perspective on the interface between individual and organisational behaviours and the wider institutional practices in terms of selecting a governance mechanism. Thus taking into consideration both people's capacity for taking action and the constraints on action posed by local contexts and practices.

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STAKEHOLDER MANAGEMENT IN PUBLIC PRIVATE PARTNERSHIP PROJECTS IN NIGERIA: TOWARDS A RESEARCH AGENDA

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Over the last couple of decades, Public Private Partnerships (PPPs) have been identified as a viable alternative for procuring public infrastructure. PPPs bring together the best of both worlds; private sector managerial expertise and public sector regulatory and supervisory capacity to procure public infrastructure. While several PPP projects have been delivered successfully, others have experienced challenges such as stakeholders' opposition. PPP projects are by their nature complex involving multiple stakeholders and thus far, there is a lack of adequate and well-structured means of managing these stakeholders and their varied interests which has resulted in neglect of stakeholders. Neglect of interest of stakeholders has been identified as a major factor that undermines the success of PPP projects in Nigeria.

To this end, managing stakeholders in PPP projects in Nigeria has become necessary owing to the fact that support for PPP projects by the general public and transparency in the PPP process are enhanced when end users, local communities and other stakeholders are involved in all phases of the PPP scheme. This paper reviews literature on stakeholder management and concludes that existing frameworks do not provide adequate guidance on how stakeholders in PPP projects should be managed from project conception to operation and maintenance. Some of the main flaws identified with existing frameworks are their lack of attention to multiple parties involved in PPP projects and the inadequacy of stakeholder identification process. This paper thus identifies the gaps in existing stakeholder management frameworks and makes a case for developing a framework for managing stakeholders in PPP projects which would be all inclusive, transparent and that gives end users, local communities and other stakeholders their rightful place as co-owners of the project. This will enhance public support for PPPs and attract private sector investment in infrastructure in Nigeria.

Keywords: frameworks, public private partnership, stakeholder management.

INTRODUCTION

The procurement of public infrastructure such as roads, rails, hospitals and schools through the PPP scheme has gained global acceptance (Ng *et al.* 2013). Several PPP projects have been delivered successfully to the required quality, on schedule and within budget. However, many PPP projects have experienced some challenges that led to undesirable outcomes and outright cancellation in some instances.

Stakeholders' opposition has been identified as the main cause of PPP project failures (El – Gohary *et al.* 2006). End users and other stakeholders resistance to PPP projects

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occur more in projects where individuals are expected to be charged directly for services (World Economic Forum 2010) such as highways and water facilities (El – Gohary *et al.* 2006).

Stakeholders can generally be described as individuals, groups or organisations that can affect or be affected by the performance or completion of a project (Freeman 1984; PMBOK 2008). Stakeholders may include clients, project managers, designers, subcontractors, suppliers, funding bodies, users and the community at large (Newcombe 2003). It is therefore important to manage and involve stakeholders early in the life of a project (El – Gohary *et al.* 2006) and keep them involved throughout the project life cycle. Stakeholder management as a field of study offers the platform for engaging different project stakeholders. Stakeholder management has the capacity of providing critical strategic information, resources and problem- solving techniques and offers different stakeholders the opportunity to make meaningful input to a project (Foo *et al.* 2011). Scholars and authors have recognised the importance of managing the interests and needs of projects' stakeholders and have proposed strategies for managing these stakeholders. While several frameworks and models have been developed to aid in the management of project stakeholders in conventional procurement, the frameworks specifically developed for PPPs are inadequate to address the challenges of stakeholders in PPP projects due to some apparent flaws of their processes.

These PPP stakeholder management frameworks provide project practitioners with some tools to identify project stakeholders and engage with them. However, a review of these frameworks shows significant limitations and the inapplicability of some of the proposed processes. This paper proposes the development of an all-inclusive and participatory framework for stakeholder management in PPP project in Nigeria. Firstly, the PPP concept and stakeholder opposition as a major challenge that inhibits its success is discussed. Secondly, stakeholder management as a field which recognises the importance of managing stakeholders is discussed. Frameworks for managing stakeholders in traditional procurement and PPP projects in particular are then examined and their limitations highlighted. Finally, a research agenda aimed at developing a framework for managing stakeholders in PPP projects in Nigeria is proposed.

PUBLIC PRIVATE PARTNERSHIPS: CHARACTERISTICS AND EXPERIENCES

Public Private Partnerships are models that have been adopted for procuring hitherto traditionally owned public infrastructure. The concept of PPPs has been identified as a veritable tool in the procurement of public infrastructure. PPP is a generic term for the different forms of relationships or partnerships that could possibly exist between the public sector (government) and the private sector to form a synergy with the sole aim of financing, developing, building/constructing and for the effective management of public infrastructures (Robinson *et al.* 2010; UNECE 2008). The relationship between the public sector (government) and the private sector for the provision of public infrastructure comes in different forms: Build –Own- Operate- Transfer (BOOT); Build Operate Transfer (BOT); Design Build Operate Transfer (DBOT); etc. These relationships are usually long term and in a concession arrangement, could last up to 40 years (Smyth and Edkins 2007). The essence of the long term contract is to enable the private sector to repay loans sourced from banks and other financial institutions (NAO 2011) and make some profit in the process. The relationships are designed to be

of mutual benefit as well as risk sharing to the parties (Grimsey and Lewis 2005). Under the relationship, the strength and expertise of both the public and private sectors are combined to improve the efficiency of resource allocation and the quality of public service (Robinson *et al.* 2010). PPP programmes have developed rapidly and replicated in different forms across the world.

Several countries in both developed economies such as Australia, Canada, USA, and the UK and developing economies and middle- income countries from Africa, Asia, Eastern Europe have procured many infrastructures through the PPP scheme (Robinson *et al.* 2010). According to Public Works Financing (PWF); International Major Project database (2013), a total of \$876 billion (or £524 billion as at current rate) has been invested in PPPs across the world. With an estimated £54.7 billion invested in 717 projects (HM Treasury 2012), the United Kingdom is one of the leading countries with huge private sector investment in infrastructure. Canada is another example of a country that has made progress in PPPs. About £38.3 billion have been invested in 198 infrastructure projects in Canada through the PPP scheme (Media Planet 2013). In Sub- Sahara Africa, through private sector investment, an estimated £39.1 billion has been invested in 249 infrastructure projects (World Bank PPI Database 2012). Nigeria is a Sub – Saharan Africa Country that has embraced the PPP concept and has initiated policies and frameworks geared towards improving private sector participation in the financing and development of infrastructure.

The history of private sector participation in financing, developing and managing public infrastructure in Nigeria is recent but has grown considerably with some PPP projects completed and operational and several transactions reaching financial close. Notably, in 2003 the Federal Airports Authority of Nigeria (FAAN) and Bi- Courtney Limited (BCL) entered into a concession agreement for the financing, development and operation of the Murtala Mohammed International Airport (MMA2). The project has since been delivered and is operational. Following the successful delivery of the MMA2 project, the Federal Government took a decisive step in revamping major seaports in the country. The government in 2004 engaged competent private ports operators to rehabilitate, operate and manage 26 seaports through a concession arrangement (Ekanem 2010). Also, the first phase of the 49.5km Epe – Lekki toll road in Lagos state which was started in 2006 has been completed and operational. The project with an estimated cost of £222 million is a Design – Build- Operate – Transfer (DBOT) road concession arrangement between the Lagos state government and the Lekki Concession Company (LCC) (World Economic Forum 2010). However, the tolled road since its opening has come under public scrutiny with stiff opposition from human right activists, local residents and road users which have led to protests and litigation (Falayi and Ajaja 2014). Such opposition by the public and other stakeholders is now a source of worry for PPP projects around the world (El- Gohary *et al.* 2006).

Several cases of public opposition against PPP projects have been reported across different countries of the world. For example, the 2.1km Cross City Tunnel (CCT) in Sydney, Australia went into receivership less than two years after its opening in August 2005 (Phibbs 2008) which was as a result of low traffic volume caused by public resistance and boycott of the tunnel. As noted by Chung *et al.* (2010), had the public sector authority taken on board the views of the community at the early stage of the project, public resistance would have been minimised. The Jin long toll road (JLTR) project, a 17Km road in the Zhejiang province of China is another example of a failed PPP tolled road project due to public opposition. Drivers used all available

alternative routes to register their frustration and protest at the exorbitant fees charged. Chen *et al.* (2012) note that the fundamental factor that led to the collapse of the concessioned JLTR project was the non-engagement of stakeholders and neglect of public interest in the concession project, particularly at the planning phase. Public opposition is mainly caused by lack of effective public participation in project planning (Ng *et al.* 2013). To this end, adequate consultation and involvement of end users, local communities and other relevant stakeholders from project initialisation to completion has been recommended as one of the core good governance principles for PPP projects (UNECE 2008). Generally, consultation and involvement of stakeholders is considered in the field of the stakeholder management concept.

STAKEHOLDER MANAGEMENT

Modern stakeholder management can be attributed to the scholarly work of Freeman (1984) with his now classic book, *“Strategic Management: a Stakeholder Approach”* (Andriof and Waddock 2002; Chinyio and Olomolaiye 2010). Managing stakeholders is *“trust-based collaborations between individuals and/or social institutions with different objectives that can only be achieved together”* (Andriof and Waddock 2002: 42).

Stakeholder management is a concept that describes an organisation’s resolve to manage relationships with its stakeholder groups (Chinyio and Olomolaiye 2010) in a proactive manner (Freeman 1984: 53). The aim of managing relationships is to motivate stakeholders to act in manners that will promote the objectives of a firm (Harris 2010). Although, the origin of stakeholder management can be traced to strategic management, its ideas and principles have been researched and applied in various fields of study including construction project management (Atkin and Skitmore 2008).

The importance of effective management of stakeholders in construction projects cannot be over stated due to the impact stakeholders can have on projects. The complexity of modern construction projects has created a web of stakeholders which often make several demands on a project depending on their interest in the project. These multiple stakeholders more often than not have different interests and concerns which could be conflicting (Harris 2010) and mismanaging these interests and concerns can have devastating consequences on projects (Chinyio and Olomolaiye 2010; Manowong and Ogunlana 2010). Therefore, there is the need to develop a broad project management process that would aid in active interaction with stakeholders from the start of project to completion (Oyegoke 2010). Jawahar and McLaughlin (2001) suggest the deployment of different strategies to effectively manage the interests of different stakeholders’ groups and individuals. Strategies should be formalised so as to help project practitioners manage stakeholders more intelligently and to avoid the unreliable informal or hit- or-miss methods (Cleland and Ireland 2007).

Different stakeholder management process models for construction projects have been proposed by several researchers and scholars (Yang *et al.* 2011). Stakeholder management frameworks developed by Karlsen 2002; Bourne and Walker 2006; Olander 2006; Cleland and Ireland 2007; PMBOK 2008 are the most cited. These frameworks identify various processes for engaging and managing project stakeholders. The following are some of the key processes in these frameworks: identification of stakeholders and their interest; prioritisation of stakeholders; communicating with stakeholders; engagement of stakeholders; predication of

stakeholders. Stakeholder identification is a common process for all the frameworks. This agrees with Manowong and Ogunlana (2010) observation that a stakeholder management strategy begins with the identification of stakeholders. However, as yet, there is no agreement on the best model or framework (Yang *et al.* 2011).

The frameworks listed above were developed based on the conventional procurement methods and did not consider other forms of procurement such as PPP and are therefore inadequate to manage stakeholders in PPP projects. The multiple parties involved, lengthy contract duration and the various project phases such as operation and maintenance are some of the unique features of PPP that have to be considered in developing a framework for managing its stakeholders. The frameworks proposed by El-Gohary *et al.* 2006, Henjeweale *et al.* 2013; and Ng *et al.* 2013 are the prominent frameworks that have been developed specifically to manage stakeholders in PPP projects.

El- Gohary *et al.* (2006) with their sematic and taxonomy model were amongst the first to propose a model for managing stakeholders in PPP projects (Henjeweale *et al.* 2013). The semantic model considered the multiple stakeholders involved and aimed at capturing and integrating stakeholders input early in the project especially in the design phase of a PPP project. The model consists of five main entities: processes; products; actors; constraints; and concerns and resources and several sub sections. However, the sematic model considered the input of stakeholders at the design phase only and not across other phases of a PPP project. Also, the model appears too complex to apply in real life situation. For example, the process and product entities have nineteen different main processes and sub – processes which is way too much considering the fact that the model is developed to capture stakeholders concerns at only one phase of a PPP project (design phase).

Henjeweale *et al.* (2013) proposed a multi- stakeholders management model for PPP projects. The model considered all aspects of a typical PPP project from the conception phase to operation and maintenance. It consists of five different processes: identification of stakeholders; prioritisation of stakeholders; building relationships; identification and management of concerns and conflicts; and management of communication. These processes are repeated for each phase of a PPP project. However, the prioritisation of stakeholder phase concentrates on the ‘powerful’ or ‘major’ stakeholders and neglects the ‘less powerful’ stakeholders could be detrimental to a PPP project like a tolled road in which everyone pays the same fee regardless of political or social stature. Also, the proposed public sector stakeholding structure did not consider any form of communication (formal or informal) between the Special Purpose Vehicle (SPV) and the end users and other stakeholders. Further, the model did not consider the involvement and engagement of stakeholders at the operation and maintenance of any importance other than for informing stakeholders on performance and tariffs.

Ng *et al.* (2013) developed the Public Private People Partnership (P4) process framework. The P4 framework advocates for the engagement of the general public in PPPs. The framework is a step by step flow chart process for engaging and managing stakeholders at all phases of a typical PPP project from project initialisation to operation and maintenance. However, the stakeholder identification process is not clearly spelt out. The framework failed to provide the method for identifying stakeholder. Also, the process for engaging with stakeholders at the operation and maintenance phase was not specified.

Additionally, the processes for identifying stakeholders in the frameworks are inadequate to capture all stakeholders of a project. The stakeholder identification processes of the frameworks reviewed will be unsuitable for a project involving multiple government agencies which is typical of government projects in Nigeria. For example, the Ministry of Environment in Nigeria conducts the EIA and are by law required to consult with local communities and relevant stakeholders with regard to the environment. Another government agency is responsible for engaging land and property owners whose properties fall within the right-of-way (ROW) to facilitate compensation. Also, processes for engaging stakeholders at the operation and maintenance phase are not sufficient to keep stakeholders involved throughout contract or service duration. Further, the process for accommodating and engaging new stakeholders were not stated. For example, the integration of the SPV after selection into the existing stakeholder network and how this interface is managed were not considered in the frameworks reviewed. To this end, a research agenda which seeks to develop a more comprehensive PPP stakeholder management framework that addresses these limitations is set. The essence is to address challenges of PPP stakeholder management in general and PPP stakeholders' management in Nigeria in particular.

CHARTING A NEW COURSE FOR STAKEHOLDER MANAGEMENT IN PPP PROJECTS IN NIGERIA

Paucity of funds for public infrastructure projects has led the Nigerian government to source for other means of procuring public infrastructure. Of particular interest is the Nigerian government's quest to involve the private sector in the financing and development of public infrastructure. This is a fairly new concept in Nigeria which requires the understanding and support of the public and other stakeholders. Public support is of paramount importance considering the fact that early PPP projects such as the Lekki – Epe road did not enjoy public support. Public opposition to PPP projects, if not mitigated, has the capacity to discourage potential investors and undermine the government's initiative to fund and build the huge infrastructure deficit in the country. There is a need to forge true partnership between the public sector, the private entity and the general public which has to be fundamentally different from the usual government's 'decide- announce- defend' approach. Therefore, a new stakeholder management framework that would recognise and integrate stakeholders' concerns and needs into the final project design and keeps the stakeholders involved throughout the project lifecycle is required. The core of the framework is inclusivity and transparency which have been identified by Bickerstaff *et al* (2002) as key principles in public participation process. Real partnership among all the different stakeholders is anchored on these principles.

Inclusivity

Inclusivity involves the identification and engagement of all project stakeholders in the stakeholder participation process. It is fundamental to the entire process and has two broad dimensions (Bickerstaff *et al*. 2002). Firstly, it implies the capacity to capture and involve all concerned citizens. The end users of facilities and other stakeholders can no longer be neglected during project planning and implementation. The importance of end users and other stakeholders to the success of PPP projects are two-fold especially in direct user charge projects such as tolled road. End users and other stakeholders are the main revenue stream of the project and in a way part of the project financiers. Their continued support and patronage to the facility are vital for

the survival of the project. Also, end users, local communities and other stakeholders have some fundamental rights to be informed and participate in projects that affect them in one way or another. This is because the cornerstone of democracy is citizen participation in their government (Arnstein 1969). The framework should promote the publicising of proposed projects by the public sector authority in the media including use of social media facilities such as facebook and twitter. Also publicity of proposed projects can be done in religious places of worship, market square, village squares (equivalent to town halls in UK), use of town criers (means of information dissemination in villages in Nigeria), public hearings, call for memoranda, public hearings etc. Project stakeholders can be identified through these medium. Secondly, the timing of public involvement in the project is important to the stakeholder participation process. It is important to address the question of how early in the planning phase of a project does participation take place and who gets involved (Bickerstaff *et al.* 2002). The identified project stakeholders should be involved early from the very beginning at the conception phase before any key decision is made. As noted by Alexander (2008), public participation at the early stage of planning ensures that all parties can influence decisions and outcomes and offers a direct contact and interaction between the public, non – governmental organisations and other stakeholders and the government rather than the elected representatives. Inclusivity of all stakeholders in PPP projects ensures that no stakeholder is left out of the decision - making process which could undermine transparency.

Transparency

Transparency of the PPP scheme has been identified as a key factor that inhibits public support (Ortiz and Buxaum 2008). In Nigeria, there is public mistrust of government policies due to lack of transparency in the way these policies are formulated. Transparency implies adequate opportunities for the public and other stakeholders to make an input during the decision -making process (Zhao *et al.* 2011). To promote transparency, the framework should propose the formation of a project team that includes the public sector, representatives of would be end users, local communities and other stakeholders. After the tendering and selection phase is concluded, representatives of the chosen SPV will be integrated into the project team. This can be advanced when vital information relating to the PPP scheme is open to the public and subjected to questioning. Transparency ensures that the public are fully aware of what the PPP scheme is about, the cost and financial implications, user charges, toll fees, who the owners of the SPV are, potential benefits and possible risks. Public participation should not be limited to surveys alone but one that should involve stakeholders from the early stages of planning and procurement (Chen *et al.* 2012) through to operation and maintenance. Transparency in the PPP process enhances public support and acceptance of the PPP scheme which is vital for forging an enduring partnership between the public sector authority, private entity and the public.

Real Partnership

Real partnership requires collaboration between the public sector, private entities and the general public at every stage of the PPP scheme from conception to operation and maintenance in a participatory manner. An all-inclusive stakeholders management framework that ensures the concerns of all interested parties are considered in a transparent and consensus atmosphere is needed. This framework will provide for interaction and participation of all the stakeholders. This is because actual participation is one that forms partnership and anything else such as mere consultation

and informing are nothing more than tokenism or nonparticipation (Arnstein 1969). The essence is to promote power and responsibility sharing amongst stakeholders and in particular ensures that the end users and other stakeholders feel a sense of belonging and become more co-owners of the project and not just those been affected by the project. Bringing end users, local communities and other stakeholders on board will not only guarantee public support for the scheme and enhance legitimacy for PPP projects but will also attract private sector investment in public infrastructure.

CONCLUSION

Despite the many advantages of the PPP scheme and its successful application in several instances, failures of the scheme caused by stakeholder opposition have been reported around the world. Poor management of the relationship of stakeholders, their neglect and non-involvement were identified as a major factor for this resentment or opposition. Existing frameworks and models are inadequate to manage the multiple stakeholders throughout the different phases of the PPP scheme. This is because these frameworks and model were developed based on the conventional procurement and did not consider some features of the PPP scheme such as operation and maintenance and the long term contract arrangement. The stakeholder identification process suggested in the frameworks for managing stakeholders in a PPP arrangement is inadequate to capture the myriad of stakeholders. Also, stakeholder engagement process at the operation and maintenance phase is insufficient for the continuous engagement of stakeholders throughout the contract term and the process of integrating the SPV after selection into the existing stakeholder network were not considered. Based on the apparent limitations and gaps of the reviewed frameworks, this paper advocates for an inclusive, participatory stakeholder management framework that promotes transparency in the PPP scheme and that gives the end users and general public a co-ownership statue in a PPP project or facility. This would ensure public acceptance and support for PPP projects. Public support for PPP projects is required in Nigeria because it promotes transparency and gives legitimacy to the PPP scheme and also boosts the confidence of the private sector to develop and finance public infrastructure.

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A COMPARATIVE ANALYSIS OF THE DESIRED AND ACTUAL BIDDING BEHAVIOUR OF CONSTRUCTION COMPANIES

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In the present paper, we quantify the desired and actual bidding behaviour of Japanese companies by analysing public procurement data from three regional development bureaus. Our study extends the findings of Iwamatsu *et al.* (2013), who use a survey questionnaire to determine the desired (but not the actual) bidding behaviour of major Japanese construction companies. To compare actual bidding behaviour with desired bidding, we model the probability of participation and the bidding ratio, both of which are regressed on the quantified values of the bidding data and other information. The results are then ranked, compared with those of Iwamatsu *et al.* (2013), and analysed. We focus on the factors on which firms concentrate when determining (i) whether they will participate in the bidding process and (ii) their pricing during bidding. Although both Iwamatsu *et al.* (2013) and our study include widely used high-ranking items, in our analysis, 'company circumstances' are highly ranked at the participation stage, while 'competition circumstances' are highly ranked at the pricing stage. This offers a practical justification for including competition circumstances when modelling real-world bidding behaviour.

Keywords: bidding, procurement, statistical analysis, price.

INTRODUCTION

In Japan, bidding systems for government procurement have been undergoing significant changes. For example, designated competitive bidding has been replaced by general competitive bidding, and the method used to select the winning bid has changed from automatic selection of the lowest bidder to a comprehensive assessment system. Under these circumstances, the bidding activities of firms have declined; indeed, firms no longer participate in bidding activities that do not benefit them.

The Japanese construction market saw somewhat of a downward trend during 2002 to 2011. Before the early 1990s, Japan's economic bubble created extensive domestic demand; thus, many construction companies did not need to develop overseas market strategies. After 1994, some prominent cases of bid rigging came to light and public investment dropped dramatically as procurement authorities changed their policies to improve input objectivity. However, this policy change may have resulted in decreasing product quality and a suspension of technical progress. The Japanese construction industry struggled with this situation from 2002–11. This is similar to what occurred in the United States and the United Kingdom during the 1980s. The

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Latham Report (1994) and the Egan Report (1998), for example, pointed out similar problems.

The most recent examination of bidding behaviour in Japan was conducted by Iwamatsu *et al.* (2013), who used a questionnaire survey to study the desired bidding behaviour of major Japanese construction companies. They obtained 283 responses on 36 factor keywords in two situations and compared these characteristics with perspectives from Japan, the United States, and the United Kingdom. Similarly, Laryea and Hughes (2008) conducted a review of questionnaire surveys, while a number of empirical studies—such as Ahmad and Minkarah (1988), Shash (1993), and Mochtar and Arditi (2001)—have addressed interview surveys, paying particular attention to two decisions: the decision to participate in bidding and the pricing decision at the bidding stage.

The present study aims to quantify the desired and actual bidding behaviour of Japanese companies by analysing public procurement bidding data. We use bidding data and other sources to represent each item keyword by an appropriate proxy value, and then compare this with the questionnaire responses. The questionnaire responses are thus compared effectively with the real intentions of the bidding companies based on regression estimation using actual bidding data. We aim to use this comparative analysis to understand the gap between the desired and actual bidding behaviours displayed by Japanese companies.

This study makes three contributions to construction management. First, a new method of analysis is used. In this research, it is very important for the method of analysis to reveal preferences about bid decisions. The analysis therefore includes (i) a discrete logit analysis of the participation decision, and (ii) an ordinary least squares regression of the bid or the winning price on factors such as the predetermined price and the number of participants. Such analysis of participation and/or bidding factors is important in the construction management field. Our method can accommodate bidding in the presence of environmental concerns, and is useful for the comparative analysis of factors that influence bidding.

Second, this research contributes to a new way of thinking. We study the similarities and differences between stated preferences and revealed preferences. Doing so is important for the implementation of institutional reforms, which requires understanding how actual bidding behaviour compares with intended behaviour. Our results indicate the importance of capturing the actual competitive situation in an industry. This study provides insight into the actual impact on the construction industry worldwide, allowing the design of a welfare-improving social system.

Third, this study yields unique results. Although we find very little difference between desired and actual bidding, an entity tailors its behaviour to its expectations of its competitors' actual (rather than desired) behaviour. This finding is similar to that found in the research on U.S. and U.K. markets. In this regard, competition is a more significant factor than entities are aware of. Conversely, preventing the restraint of competition by using a bidding system is more important than entities in the worldwide construction industry recognize. This is a common caveat for construction management practitioners and authorities.

Public procurement is a highly important issue for the global economy. While developed economies use private innovation and procurement to stimulate the economy, emerging economies use public accountability and procurement to obtain more investment. Our research aims to find ways to use public procurement to

improve the construction industry by shedding light on the tools that construction firms use and on their actual preferences. This will aid effective procurement design.

RESEARCH DESIGN

In their comparative study based on surveys of major construction journals and interviews with influential construction managers, Iwamatsu *et al.* (2013) found that Japan, the United States, and the United Kingdom share certain common bidding characteristics, indicated by relatively high scores for 'type of job' and 'competitiveness in your industry', as well as other features such as 'labour environment (union, non-union, cooperative)' and 'time of bidding (season)'. To describe desired bidding, we describe the conceptual outline of their study in Table I.

Table I: Keywords and Questionnaires in Iwamatsu *et al.* (2013)

		Participation stage						Pricing stage					
		Iwamatsu <i>et al.</i> (2013)		Ahmad and Minkarah (1988)		Shash (1993)		Iwamatsu <i>et al.</i> (2013)		Ahmad and Minkarah (1988)		Shash (1993)	
		Simple average	Weighted average	Simple average	Simple average	Weighted average	Simple average	Weighted average	Simple average	Simple average	Weighted average	Simple average	Weighted average
Technical characterization of the project	Type of job	0.957	0.904	0.956	0.774	0.786	0.830	0.791	0.901	0.525	0.666		
	Location of project	0.663	0.682	0.856	0.718	0.741	0.663	0.681	0.765	0.427	0.634		
	Degree of difficulty	0.829	0.752	0.778	0.691		0.863	0.784	0.951	0.556	0.681		
	Project duration	0.694	0.714	NA	0.318	0.514	0.824	0.781	NA	0.338	0.565		
	Size of job	0.968	0.859	0.822	0.729	0.755	0.862	0.792	0.744	0.554	0.683		
	Type and no. of equipment required/available	0.612	0.672	0.289	0.481	0.577	0.813	0.769	0.407	0.476	0.641		
	Designer (A/E)/Design quality	0.668	0.701	0.678	0.614	0.687	0.852	0.809	0.752	0.550	0.688		
	Project cash flow	0.496	0.642	0.556	0.602	0.692	0.564	0.648	0.683	0.549	0.661		
	Rate of return	0.661	0.663	0.742	0.695	0.714	0.700	0.673	0.793	0.525	0.764		
	Need for work	0.785	0.736	0.933	0.917	0.864	0.714	0.684	0.753	0.649	0.736		
Procurement authority and method	Owner	0.662	0.701	0.910	0.824	0.788	0.595	0.654	0.775	0.626	0.706		
	Type of contract	0.512	0.646	NA	0.647	0.716	0.529	0.636	NA	0.556	0.678		
	Bidding method	0.786	0.775	NA	0.686	0.752	0.769	0.751	NA	0.367	0.563		
	Duration	0.808	0.761	0.449	0.686	0.692	0.589	0.651	0.650	0.304	0.501		
	Time of bidding	0.709	0.720	0.200	NA	NA	0.535	0.633	0.341	NA	NA		
	Degree of hazard	0.751	0.739	0.878	0.452	0.617	0.807	0.760	0.963	0.474	0.619		
	Future perspective of the similar project	0.832	0.761	NA	NA	NA	0.781	0.708	NA	NA	NA		
Circumstances of competition	Number of competitors	0.675	0.703	NA	0.821	0.835	0.780	0.739	NA	0.420	0.603		
	Competition	0.804	0.760	0.800	0.512	0.644	0.863	0.794	0.732	0.432	0.596		
	Strength in the industry	0.901	0.807	0.833	0.857	0.832	0.775	0.731	0.707	0.531	0.665		
	Previous owner	0.500	0.629	NA	NA	NA	0.543	0.603	NA	NA	NA		
	Overall economy	0.658	0.696	0.822	NA	NA	0.665	0.662	0.744	NA	NA		
	Labour environment	0.361	0.559	0.844	0.564	0.687	0.420	0.566	0.716	0.479	0.646		
	Portion of work to be subcontracted	0.482	0.592	0.438	0.297	0.518	0.488	0.587	0.667	0.355	0.546		
	Reliability of subcontractors	0.649	0.684	0.633	NA	NA	0.671	0.668	0.753	NA	NA		
	Situation of the company	0.809	0.792	NA	NA	NA	0.800	0.768	NA	NA	NA		
Circumstances of the company	Current workload	0.823	0.781	0.789	0.834	0.832	0.777	0.745	0.841	0.704	0.764		
	Uncertainty in the estimate	0.815	0.769	0.724	0.513	0.598	0.796	0.778	0.890	0.462	0.634		
	Availability of qualified staff	0.911	0.827	NA	0.608	0.716	0.665	0.699	NA	0.387	0.582		
	Number of supervisory persons required/available	0.979	0.908	0.700	0.529	0.652	0.750	0.738	0.654	0.346	0.677		
	Cost of making the bid	0.605	0.667	NA	NA	NA	0.561	0.617	NA	NA	NA		
	General overhead	0.818	0.772	0.352	0.299	0.540	0.834	0.792	0.525	0.269	0.531		
	Capital requirement/availability	0.416	0.594	0.411	NA	NA	0.494	0.590	0.561	NA	NA		
	Intuition	0.505	0.597	NA	NA	NA	0.551	0.601	NA	NA	NA		
	Differences between predetermined total price and internal total price	0.890	0.840	NA	NA	NA	0.899	0.855	NA	NA	NA		
	Mathematical model	0.424	0.544	NA	NA	NA	0.489	0.568	NA	NA	NA		

Table II: Keyword Quantification in our Study

	Iwamatsu et al. (2013)	Quantification Method	Remarks
Technical characterization of the project	Type of job	Selecting general civil engineering projects of three regional development bureaus of the Ministry of Land, Infrastructure, Transport and Tourism	
	Location of project	No quantification	
	Degree of difficulty	No quantification	
	Project duration	No quantification	
	Size of job	Dummy of project level (Level A=1)	Considering the size of job as the size of the project-level dummy
	Type and amount of equipment required/available	Index of cement price	Representing the cement price index as the equipment required/available
	Designer (A/E)/Design quality	Ratio of the maximum and minimum bid to the value of the predetermined price	Considering the difference of recognition of the project value in the project bidding stage
	Project cash flow	No quantification	
	Rate of return	Gross income on sales	Excluding negative values
	Need for work	No quantification	
Procurement authority and method	Owner	No quantification	
	Type of contract	No quantification	
	Bidding method	Dummy of bidding method (WTO, selecting)	
	Duration	No quantification	
	Time of bidding	No quantification	
	Degree of hazard	No quantification	
	Future perspective of a similar project	Days to next winning bid	Considering days to next winning bid as the future perspective
Circumstances of competition	Number of competitors	Number of participants	Including a declining or invalid number of participants
	Competition	Basic and additional point in comprehensive bidding	Considering the evaluating points
	Strength in the industry	Days since last winning bid	Considering days since last winning bid as the past strength in the industry
	Previous owner	No quantification	
	Overall economy	Nikkei stock average	
	Labour environment	Wage index of construction workers	Considering the wage index of construction workers as the Labour environment
	Proportion of work to be subcontracted	No quantification	
	Reliability of subcontractors	No quantification	
	Situation of the company	Average value of completed general civil engineering works	
Circumstances of the company	Current workload	Days after last bid	
	Uncertainty in the estimate	Gross profit on sales	Considering the total amount of the winning bid benefit as risk-taking in lieu of uncertainty
	Availability of qualified staff	No quantification	
	Number of supervisors required/available	Number of first and second supervisors for civil engineering	Number of engineers
	Cost of bidding	No quantification	
	General overheads	General administration cost	
	Capital requirement/availability	No quantification	
	Intuition	No quantification	
	Difference between predetermined total price and internal total price	Difference between predetermined total price and internal total price relative to the value of predetermined price	
	Mathematical model	No quantification	

* Quantification Method: Selecting general civil engineering projects from three regional development bureaus of the Ministry of Land, Infrastructure, Transport, and Tourism

We quantify Iwamatsu *et al.*'s (2013) keywords and present them in Table II. Note that this study uses Japanese terms instead of U.S. terms, but the basic concept is common across the three study regions. Comparing the questionnaire results of Iwamatsu *et al.* (2013) with our quantified values based on bidding data and other information reveals similar characterization of stated and revealed preferences (for competing views, see Diamond and Hausman, 1994; Hanemann, 1994; and Portney, 1994). Critics of stated preference methods point to numerous potential sources of bias associated with these methods. According to Azevedo *et al.* (2003), for example, survey respondents may ignore or downplay their budget constraints when answering hypothetical questions (see also Arrow *et al.*, 1993; Loomis *et al.*, 1994; and Kemp and Maxwell, 1993). Moreover, stated preference-based willingness-to-pay estimates fail to vary sufficiently with the scope of the resource being valued, the so-called 'embedding effect' (Desvousges *et al.*, 1993; Kahneman and Knetsch, 1992), while they are inordinately sensitive to the elicitation format used (McFadden, 1994; Diamond and Hausman, 1994).

In this analysis, we examine the firm's desired strategy based on the results of the questionnaire survey presented by Iwamatsu *et al.* (2013). This approach is similar to a stated preference-type method, in which the decision-making and conduct of the organization are likely to be more reasonable than those of individuals are because outlier preferences are balanced. However, in addition we consider three alternative viewpoints. According to the first viewpoint, no differences exist between the questionnaire survey and the quantified bidding data and other information. The second viewpoint is that stated preferences are upwardly biased because of an embedding effect reflecting altruism. According to the third viewpoint, the stated preferences display an additional embedding effect that arises from over-individualism. In consideration of these viewpoints, our analysis of quantified bidding data and other information is more akin to a revealed preference-type method.

DATA ANALYSIS

This study used bid data for Level A and B general public engineering works (>300 million yen) from the Shikoku, Kanto, and Kinki regional development bureaus of the Ministry of Land, Infrastructure, Transport, and Tourism (2002–2011). The study periods were as follows: FY2002–2011 for Shikoku, FY2004–2011 for Kanto, and FY2005–2011 for Kinki. The dependent variables were the probability of participation and the bidding ratio. The probability of participation was measured as the probability of an entity participating in a bid offered by the regional development bureau in a certain period. The bidding ratio was calculated by dividing the bidding price by a predetermined price. Taking the log of both bid numbers allowed us to overcome problems posed by price elasticity. The estimation equations for the probability of participation and the bidding ratio are, respectively,

$$\log(\text{Profparticipation}_i) = a_1 + \sum b_{1,i,t} \log(\text{quantified_data}_{i,t}) + e_{1,i} \quad (1),$$

and

$$\log(\text{bidratio}_j) = a_2 + \sum b_{2,j,t} \log(\text{quantified_data}_{j,t}) + e_{2,j} \quad (2),$$

where indicators i and j are the individual bidding indices, t is the factor of consideration index, $\text{Profparticipation}_i$ is the probability of participation, and quantified_data_i is the factor of consideration. e is an error term. Ordinary least

squares regression analysis was then used to estimate the coefficients a_1 , a_2 , $b_{1,i,t}$, and $b_{2,j,t}$. Table III presents the results.

Based on these coefficients, we compared the ranking and statistical significance of our results with the ranking presented in Table III of Iwamatsu *et al.* (2013), as shown in Table IV. According to the comparison analysis presented in Table IV, we decided to examine (i) items determining a firm's participation in the bidding process, and (ii) items driving firms' pricing during the bidding stage.

Table III: Regression Results

Dependent variable method: ordinary least square	Pr of participation n=4586	Bidding ratio n=4586
	Coefficient (standard err.)	Coefficient (standard err.)
Size of job	0.587 * (0.3438)	-0.279 (0.2861)
Type and no. of equipment	0.182 *** (0.0395)	0.897 *** (0.0328)
Designer (A/E)/ Design quality	-0.016 (0.0131)	-0.216 *** (0.0109)
Rate of return	0.003 (0.0023)	-0.002 (0.0019)
Bidding method (designated dummy)	0.011 (0.0517)	0.135 *** (0.0430)
Bidding method (WTO dummy)	0.074 (0.0531)	-0.011 (0.0442)
Future perspective	0.002 (0.0024)	0.000 (0.0020)
Number of competitors	-0.063 *** (0.0157)	0.022 * (0.0130)
Competition	0.029 (0.0535)	-0.143 *** (0.0446)
Overall economy	-0.082 (0.1403)	-0.158 (0.1167)
Labour environment	-0.190 *** (0.0364)	0.219 *** (0.0303)
Situation of the company	0.024 (0.0155)	-0.072 *** (0.0129)
Current workload	-0.008 *** (0.0012)	-0.004 *** (0.0010)
Uncertainty of the estimate	-0.453 *** (0.0576)	0.071 (0.0479)
Number of supervisory persons	0.346 *** (0.0170)	-0.003 (0.0142)
General overhead	0.365 *** (0.0549)	0.003 (0.0457)
Differences between predetermined and bid	-0.084 (0.1157)	0.795 *** (0.0963)
C	-5.781 *** (1.9563)	19.177 *** (1.6277)
R-square	0.226	0.689
adjusted R-square	0.223	0.687
standard err. Of regressions	0.527	0.438
Akaike Information Criteria	1.559	1.191

Note: The upper values in the cell are the estimated coefficients and the lower values in parentheses are the standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels respectively.

Table IV: Comparing our Results with those of Iwamatsu *et al.* (2013)

Iwamatsu <i>et al.</i> (2013)		The present study	
Participation stage	Pricing stage	Participation stage	Pricing stage
1 Size of job	Difference between predetermined total price and internal total price	Size of job	Type and amount of equipment required/available
2 Number of supervisors required/available	Rate of return	Uncertainty in the estimate	Difference between predetermined total price and internal total price
3 Bidding method	General overheads	General overheads	Labour environment
4 Rate of return	Competition	Type and number of supervisors required/available	Designer (A/E)/Design quality
5 Current workload	Bidding method	Labour environment	Competition
6 Situation of the company	Size of job	Type and amount of equipment required/available	Bidding method
7 Competition	Uncertainty in the estimate	Current workload	Situation of the company
8 General overheads	Situation of the company	Number of competitors	Current workload

RESULTS

Items used to determine participation

Iwamatsu *et al.* (2013) and our study have some high-ranking items, such as 'size of job' and 'Number of supervisors required/available', in common. Therefore, both analyses are considered to have captured the actual industry situation. In other words, the stated and revealed preferences are similar for these items. Further, both analyses rank personnel issues such as 'type and number of supervisors required/available' and 'labour environment' highly. Personnel management issues may reduce the probability of participating in the bidding process.

However, there are some differences between the two studies. In our study, the 'uncertainty in the estimate' and 'general overhead' items, which fall into the 'company circumstances' category, are high-ranking, whereas they have a relatively low ranking in Iwamatsu *et al.* (2013). The reason for this difference is that the stated preference approach taken by Iwamatsu *et al.* (2013) relies on an analytical recognition of a person's own ex post behaviour, whereas our study, which uses revealed preferences, tends to capture people's real instincts during bidding.

Pricing items considered at the bidding stage

In their examination of pricing at the bidding stage, both analyses have a high-ranking item in common. This item is the difference between the predetermined total price and the internal total price. This suggests the absence of significant differences between stated and revealed preferences with respect to this factor. With regard to the 'type and amount of equipment required/available', once a large project has been started, it may affect the demand for and the supply of equipment. Thus, the high ranking of this item should be somewhat discounted.

Factors such as 'rate of return' and 'general overhead', which fall in the 'company circumstances' category, are highly ranked in Iwamatsu *et al.* (2013), unlike in our study. This finding may reflect the fact that a company cannot win bids due to 'company circumstances' alone, which companies recognize at the point of actual bidding. Therefore, firms may take a realistic approach by emphasizing other items such as 'competition' (in the 'competition circumstances' category).

Overall trends and comparison with the United States and the United Kingdom

No self-serving disclosure or non-disclosure tendencies were recognized either in our study or in Iwamatsu *et al.* (2013). In this regard, the findings of Iwamatsu *et al.*

(2013) are likely to reflect actual business practices. Nevertheless, we can still determine how competition plays a role during the pricing stage, which goes beyond the company's own circumstances. Companies may not fully recognize this themselves. Finally, the ranking presented in our study is closer to that of Iwamatsu *et al.* (2013) than it is to the results of the U.S. or the U.K. surveys. Neither our study nor Iwamatsu *et al.* (2013) found any evidence for an embedded effect or for any other inordinately sensitive effects (e.g., cultural competition avoidance).

REVISITING THE ANALYSIS OF A TYPICAL PRICING PATTERN

Iwamatsu *et al.* (2013) examined four typical bid-pricing patterns, adopting the process flowchart for bid pricing referred to by Mochtar and Arditi (2001). We describe them below.

In Model 1, pricing is based on cost accumulation. The bid price is determined using the accumulated benefit and the cost of the necessary factors based on a project's books.

Model 2, also called hybrid type 1, involves first accumulating costs and then considering competition. The preliminary price is set as in Model 1 above. Then, the bid price is determined based on the competition situation. If the winning price is higher than the preliminary price, it is reduced as much as possible.

Model 3, also called hybrid type 2, involves first considering competition and then accumulating costs. First, the preliminary price is set by considering the competition, and then the bid price is determined as in Model 1 above.

In Model 4, pricing is determined by competition. The bid price is determined by considering the competitive situation and the company's risk policy.

Iwamatsu *et al.* (2013) believe that Japanese firms behave according to Model 2. This is justified by the result that the difference between the predetermined total price and the internal total price was the highest ranked item in their study. Our results also support Model 2 for the same reason. However, during the bidding stage, companies recognize the fact that they cannot win bids solely based on 'company circumstances'. Therefore, a company may actually emphasize the competitiveness of the market, offering a strong justification for the belief that actual behaviour is approximated by models that include competition circumstances, such as Model 3 or Model 4.

CONCLUDING REMARKS

In this study, we quantified the desired and actual bidding behaviour of Japanese companies by analysing public procurement data from three regional development bureaus. Our results extend those of Iwamatsu *et al.* (2013), who used a survey questionnaire to determine the desired (but not the actual) bidding behaviour of major Japanese construction companies. Specifically, we contrasted the survey findings put forward by Iwamatsu *et al.* (2013) with companies' actual bidding behaviour, based on bid data and other information.

One contribution of this study is that we shed light on firm-level differences between stated and revealed preferences. While we show that no significant differences exist between these two, some factors related to competition are only exhibited during the analysis of revealed preferences.

We modelled the probability of participation and the bidding ratio, both of which were regressed on the quantified bidding data and other information, and then compared the ranking we obtained with the results of Iwamatsu *et al.* (2013).

Both our study and Iwamatsu *et al.* (2013) rank the factors ‘size of job’ and ‘type and number of supervisors required/available’ as important determinants of firms’ participation decisions. Therefore, both analyses are considered to have captured the actual situation in the industry. However, in our study, the items ‘uncertainty in the estimate’ and ‘general overhead’, which are in the ‘company circumstances’ category, are high-ranking, whereas they rank relatively low in Iwamatsu *et al.* (2013).

Both analyses find that the difference between the predetermined total price and the internal total price is an important determinant of pricing during the bidding stage. However, Iwamatsu *et al.* (2013) finds that items in the ‘company circumstances’ category, such as the ‘rate of return’ and ‘general overhead’, are highly ranked, unlike us. Our results suggest that companies may take a realistic approach to the market and emphasize competition circumstances. In other words, a company cannot win a bid based on ‘company circumstances’ alone. This offers a strong justification for the real-world implementation of Model 3 or Model 4, as described by Iwamatsu *et al.* (2013).

Our findings add to the literature by accurately describing actual bidding behaviour in Japanese organizations. This is both important and novel in the construction management literature and beneficial for designing bidding institutions. To create a better bidding system, it is necessary to consider actual firm-level behaviour as well as the desires of the companies involved. Nevertheless, future research should aim to verify the findings of this study by using further questionnaire surveys as well as through interviews with both procurers and bidders. Doing so will help shed light on entities’ behaviour and will be useful for optimal policymaking.

The contributions of this study lie in its method of analysis, in the new way of thinking it introduces, and in its findings. While we apply our method to Japanese public procurement, this method can also be applied to bidding in the presence of environmental concerns, or to a comparative analysis of bidding determinants. Such analysis of participation and/or bidding factors is significant for the construction management field. In addition, this study provides insight into the actual impact on the worldwide construction industry, enabling the design of a welfare-enhancing social system.

ACKNOWLEDGEMENTS

We are grateful to Professor Hideo Yamanaka for his advice on data preparation. We gratefully acknowledge support from the Shikoku regional development bureaus of the Ministry of Land, Infrastructure, Transport, and Tourism announcement of Bidding and Contract Data (2002–2005).

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ASSESSING THE PRACTICE OF PROJECT-BASED JV BETWEEN LOCAL AND INTERNATIONAL CONTRACTORS IN THE UAE

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This paper is about assessing the practice of Project-Based Joint Ventures formed between local and international contractors in the UAE construction industry. This common practice nowadays, provides the means for contractors to quickly add resources to enhance project acquisition. Studies indicate that JVs are among the tools that contractors will need to get together in the face of increasing market demands. Specifically, Project-Based JVs are often used in the UAE Construction industry with an exceptional growth in an attempt to diversify from Oil and Gas. The UAE is very business friendly which makes it attractive for such kind of alliance or partnership for local contractors to get the necessary experience and for international contractors to minimize the risks associated with entering new markets. In this context, studies that evaluate this alliance phenomenon in the UAE construction industry are limited. The few industry-related studies have primarily focused on large, international JVs; yet, many JVs are formed on small and medium-sized projects within the UAE. The paper aims to assess the current practices and understand the many factors involved with forming, managing, and controlling JV partnerships. The research methodology adopted a mix of quantitative and qualitative approaches. First, a closed question survey was disseminated to construction professionals in the UAE in light of the literature findings. Second, two case studies were demonstrated and analysed, then triangulated with the literature and survey findings to remove possible bias and improve the confidence in the collected data. The paper concluded that the JV in the UAE construction industry is mostly formed on project-basis rather than continuous collaboration. The management control mostly used in the UAE construction industry is shared management of activities in a venture with the operations shared between parents. The paper addressed major factors that lead to successful JV in the construction projects of the UAE which are namely trust, correct structure, communication, and partner's commitment. Partners' common objectives do not affect the JV success or failure. Willingness to adapt eliminates conflicts and enhances the JV success prospect.

Keywords: joint venture, partnering, procurement, success factors.

INTRODUCTION

Construction industry studies indicate that JVs are among the tools that firms will need to successfully get together with future market demands. Owners are well aware that the choice of procurement route has a significant effect on the design and construction of construction projects. Over the past few years, some procurement routes have fallen out of favour due to the rise and fall of the economy. This includes framework agreements, specifically JV which is somehow a new form of procurement

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which has taken extensive times to come into general use, despite being addressed in the Latham report (1994). This paper will mainly focus on local and international contractors forming the JV to execute projects in the UAE.

The construction industry in the UAE is witnessing exceptional growth in the past few years. In 2006, the construction industry recorded a real growth rate of 19.7% on-year, while the sector is expected to expand at a slower pace of 10.4% until 2012, as given by the UAE-based investment bank, Al Mal Capital, in its annual report (Cited in *Emirates Business* 24/7, 2010). The study will concentrate on assessing the practice of Project-Based JV in the UAE Construction Industry from the contractors' perspective, aiming to identify the main project-based JV structures in the UAE construction industry, examine the significant factors in JV partners formation and selection and investigate issues related to construction JVs ownership, control, and management. The paper also investigates the factors affecting JV relationships in construction projects between local and international contractors in the UAE and evaluates the primary factors that support the successful application of JV arrangements.

JV STRUCTURES AND FORMATION

JV Structure and types

There is no model for a JV structure as each JV contract has multiple issues and jurisdictions involved and the contract documents should be specially modified to suit the JV under consideration. Normally in the Gulf Region, the structure is likely to take the form of a contractual alliance or limited liability company into which the JV partners will invest. The joint scope can be local or international. According to Chen (2005), three of the entry modes for international markets are related to JVs: strategic alliances, JV project, and JV Company. JV in this paper is defined as a combination of two contractors who agree to share the responsibilities, profits and losses of a construction contract on a project basis and will be terminated when the project is completed.

Kale (2013) addressed three types of JV: Integrated, Non-Integrated and Combination types. An Integrated JV is shaped when the JV partners work together and share resources to deliver the project. No distinction can be drawn between the acts of any of JV partners. In the case of a Non-Integrated JV, the overall responsibility for the contract usually has to be negotiated by a JV board. Separate sections of the work are then subcontracted out, with each of the partners taking over the responsibility for running their own technical and administrative elements of work. The Combination JV is used for large projects which is a mix of the two types where each member takes on specified scope of work and responsible for the profit or losses associated with that scope of work. However, the member also agree to act as partners with respect to a portion of the necessary work, which may include sharing the preliminaries and general condition necessary for each member's separate scope of work, as well as the actual performance of portion of the work of the project.

Partner Selection

Some studies indicate that one of the major decisions when seeking a JV arrangement is the careful selection of the JV partner. This is further increased in the international perspective as partners themselves are from different jurisdictions and the foreign culture of each JV member becomes an added aspect of unfamiliarity. Adnan and Morledge (2004) stated the partner selection criterion is a critical success factor for JV projects. Beamish and Lupton (2009) highlighted that the JV partnering process

continues through the whole JV partnering process, from assessing the strategic logic for creating the venture, through the partner selection, negotiating the terms, and finally, the implementation and continuous management of the JV.

Beamish and Lupton (2009) stated that the concerns on selection of partners focus on shared objectives, common trust, willingness to collaborate and having necessary skills and resources. Rowan (2005) mentioned that prior to the selection of a JV partner; firms should adopt criteria that will guide their undertakings. The main criteria considered by Rowan when an organization is looking for possible partners to go into JV partnership are Skills, Experience, Financial Stability, Partner's Willingness to form JVs, and finally Same Spoken Language to avoid communication problems. Adnan *et al.* (2011) identified critical factors in JV partner selection criteria related to the Reputation, Experience, Personal Knowledge of the Partner Organizations, Commitment, Inter-partner Trust and Human Resources Management.

JV Formation

A good understanding of the laws that will apply to the JV is a key to identify the most appropriate structure of the JV (Minja *et al.*, 2012). The GCC countries are civil law jurisdictions, with codified statutes, that are still evolving to meet the demands of global trade. In the UAE, JV formation and contract signing is even more significant given the fact that there are many international contractors, not licensed to engage in business in the UAE, but working on local projects by forming JVs with local companies. In general, the JV form option should be selected according to the resources contributing to the JV to serve its purpose of formation. It should be noted, however, that the amount of control over the JV agreement might be one of the major concerns of a partner when forming a JV.

JV Management and Control

Control in JVs has been traditionally modelled by relative degree of ownership. However, new work on JV forms, networking and other organizational models suggests that ownership may not be the best means of control in every situation and may be a minor issue in domination (Mjoen and Tallman, 1997). As stated by Killing (2012), the primary problems in managing JVs arise from the fact that there is more than one head. That's probably what makes control issues in JVs at the centre of management conflict between the JV partners. So the control here is not only the influence on the partners own JV management, but also the ability of an owner to implement control over the other partner JV management.

The level of Partners involvement in the decision making process of daily operations of the JV is the primary question in JVs management. JVs are difficult to manage as partners usually have different managerial skills, beliefs, values, and traditions, which make them competitors as well as collaborators (Ozorhon *et al.* 2010). It was found that 31% of JVs end up with disputes between partners and more than, half was caused by JV site team. That is why; the management control type should be carefully selected to avoid disputes and management pitfalls. Ozorhon *et al.* (2008) identified the factors which significantly contribute towards achieving good relations between partners involved in JVs such as commitment, communication, and trust.

JV Success Factors

It is important for companies that consider entering into a JV to examine strategies applied in order to find out what makes them successful or unsuccessful and why they work differently in different situations. Key factors include the necessity of honesty,

trust, and commitment for the success of the JV. Factors also include settling disputes by focusing on what is best for the JV rather than individual partner objectives (Beamish and Lupton, 2009). Sillars (2004) stated that once a project is procured, the culture match between partners is a major factor to ensure JV success. Beamish and Lupton (2009) added that JVs with similar organizational cultures had a higher probability of success. Other researchers claimed that organizational and innovative capabilities, the existing market strength, and competitive advantage, may be potential determinants of success and satisfaction with a JV.

Given the time limits of project-based JVs, the initial level of trust between partners may determine the overall success of the partnership. Also, partner selection and analysis may have an ultimate impact on the potential success of the project-based JV. According to Ozorhon (2008), organizational fit between partners, compatible technical and managerial resources affect the success of JVs. Results from the study of Minja *et al.* (2012) showed that highly ranked key factors for success in JVs are willingness, financial stability and competitiveness of required task. Such success factors are yet to be examined in the UAE if applicable to the success of JVs through the empirical study of this paper.

METHODOLOGY

The research design is inductive adopting a mix of quantitative and qualitative methods to enjoy the advantages of both approaches. Multiple sources of evidence were used to collect information, mainly literature review, questionnaires and case studies. A closed-question survey was disseminated to construction professionals in the UAE to compensate for the poor literature on the project-based JV in the UAE construction industry. Two case studies were fully demonstrated and analyzed then triangulated with the literature and survey findings to remove possible bias and improve the confidence in the collected data.

QUESTIONNAIRE SURVEY

The questionnaire was disseminated via email to 118 experienced practitioners in the industry and the response rate was 44% which is satisfactory. Table (1) shows the sample response rate among respondents. 60% of respondents have more than 10 years of experience while 75% of the respondents' companies have been operating in the UAE for more than 15 years. This might indicate some bias in the results towards local contractors' perspective; therefore, careful interpretation was carried out.

Table 1: Sample Response Rate

Respondent	Sent	Received	Response Rate %
Law Firms	10	4	40%
Consultants	17	8	47%
Contractors	54	16	30%
JV Contractors	37	24	65%
Total	118	52	44%

JV Formation in the UAE

Respondents were asked to select the type of JV they are familiar with. 67% of respondents believe that JVs in the UAE are formed on a project-basis. This indicates a relationship that lasts for the duration of the project and might turn into continuous

collaboration basis depending on the success of the JV in executing the project. On the contrary, only 9% believe that JV is based on a continuous collaboration. 20% of the respondents consider the use of both formations in the UAE. Results indicate that some companies may collaborate with the same partner in quite few projects depending on the level of success; however, the results validate literature findings that JVs in the construction industry are well thought-out to be project-based rather than continuous collaboration. It should be noted, however, that there are some other formation arrangements mentioned by respondents about more specific contractual arrangement.

JV Types

Respondents were asked to rank the mostly used JV types in the UAE. The Authors used the Relative Importance Index (RII) to rank the results which is calculated as follows: $RII = \frac{\sum W}{A \times N}$ Where; W = weight given to each factor by respondents, A = highest weight, N = total number of respondents.

The responses from table (2) show that Integrated type is mostly used followed by the combination of both types and the least used is the non-integrated type. The RII for all three types did not reach a high ranking. In addition, the results from the previous question on JV formation contradict with the findings here that integrated JVs are mostly used given the suggestion by Kale *et al.* (2013) that integrated JV types are usually used when JV partners have strong and lengthy relationship.

Table 2: JV Types in the UAE

JV types mostly used in the UAE	RII	Rank
Integrated (Jointly Managed JVs)	0.71	1
Combination of an Integrated and Non-Integrated JVs	0.66	2
Non-Integrated (Separately Managed JVs)	0.60	3

Factors affecting the selection process of JV partners

Results on ranking the factors affecting the selection of JV partners show high RII for Partner's Financial Stability, Partner's Experience, while Similar Business Philosophy and Spoken Language were the lowest in the ranking as shown in table (3). The results are mostly consistent with the criteria considered by Rowan (2005). The financial stability is the most significant factor to ensure low potential for default and avoid partner's risk. Also, Partner's experience is highly important to reduce transaction costs and enhance the effectiveness of the JV operation, specifically in large and complex projects where partners prefer to avoid any disputes and unsuccessful relations.

Table 3: Factors affecting JV partner selection

JV Partner Selection Factor	RII	Rank	JV Partner Selection Factor	RII	Rank
Partner's Financial Stability	0.87	1	Partner's Track Record in JVs	0.76	6
Partner's Experience	0.86	2	Partner's Commitment	0.76	7
Reputation	0.85	3	Similar business philosophy	0.72	8
Inter-partner trust	0.81	4	Spoken Language	0.63	9
Competitiveness of required task	0.80	5			

JV Partners' Ownership

52% of respondents agree that the best approach of JV ownership that both partners have equal share of ownership. This would mean greater stability because the partners

are equally committed to the JV as argued by Beamish (1985). However, 31% prefer that the partner from the host country to have dominant ownership but it can be argued that, this approach might be advantageous for the local contractor as it helps increase stability avoiding the managerial costs inherent in a JV as well as potential conflicts between partners (Killing, 2012). The rest of respondents prefer to retain the ownership with the foreign contractor who have high level of international experience and key resources, but this might result in a conflict between partners

JV Partner's Trust and Commitment

Around 68% of the respondents agree that higher trust amongst JV partners leads to partners achieving their objectives, whilst 4% disagree with this statement only. More than 90% of the respondents agree that JVs with higher levels of relationship commitment lead to partners achieving the goals of the JV project. Only 2% disagree with this which implies that commitment is a significant factor through the whole JV relationship which is in line with the findings of Beamish and Lupton (2009).

JV Management Control

The outcome from results shown in table (4) indicates that shared management of activities in a venture is the highest ranked management control used in the UAE with the operations shared between parents, followed by split management of activities where the scope of work is split between partners such as civil and MEP works. However, the parents' involvement is minor which keeps the control with an independent group employed under the JV.

Table 4: Type of management control mostly used in the UAE

Type of JV Management Control	RII	Rank
Shared management for all activities	0.72	1
Split management of activities	0.67	2
Dominant management for all activities by one of the partners	0.58	3

JV Success Factors

Results from table (5) show that respondents give high rankings to all factors mentioned except the common objectives factor which doesn't seem to support JV success. Again, trust is an important factor, followed by the correct structure which will be suitable for both partners to manage the JV successfully and avoid disputes. Common objectives is not a factor of success given that partners do not necessarily share the same objectives, specifically, the local/international JV where both partners have different reasons to JV apart from the typical project objectives to complete the project respecting time, cost and quality constraints.

Table 5: JV Success factors in the UAE

JV Success Factors	RII	Rank	JV Success Factors	RII	Rank
Trust between partners	0.90	1	Partners' commitment	0.85	4
Correct structure	0.88	2	Interaction between colleagues	0.80	5
Communication	0.88	3	Common objectives	0.78	6

CASE STUDY

Two case studies were demonstrated with factual data along with views from individuals after the following projects were completed and handed over to their respective clients. Case-1 was a UAE-Japanese JV for a value of \$ 40,000,000 leisure

project and Case-2 was a UAE-Korean JV for the \$76,000,000 project and both projects were located in Abu Dhabi, UAE.

Case Study 1:

This case study represents a successful JV and shows how a Japanese firm and its local partner successfully managed their JV project in the UAE. This four-storey cast-in-situ circular building, flanked on either side by a water cascade which is one of the world's largest and most spectacular, customized water features is located in Abu Dhabi City. One of the main challenges was to finalize the project on time to make sure that other phases of the overall project are not hindered or delayed. The case is for the Mechanical and Electrical Works project whereas the local company was responsible for the Electrical part only while the Japanese partner was responsible for the Mechanical Works.

Data collected from the project documents as well as interviews with the project team and the following key information was gathered:

- The legal form was project-based JV contract.
- Integrated JV structure was deployed with both companies jointly managing it and jointly taking decisions.
- Partners have equal share of ownership.
- Split management of activities was the management control agreed by both parties.
- Both companies were committed to the project from the start to finish.
- Problems, if any, were immediately highlighted in senior management meetings to reach agreements on how to overcome the problems.

One of the senior managers of the local company stated that the reason behind entering a JV is that the client (semi Government Company) required a high experienced organization with a global reputation to do the job. In addition, the Japanese company have financial stability and strong 'know-how' experience. While the assistant project manager of the Japanese partner stated that the well-established local partner in the UAE with strong local experience and industry connections was the reason for JV agreement. It can be seen that government policies sometimes have a role in forcing local contractors to enter into JV agreements. However, the partner's financial stability, complex projects, and combined experiences and resources seem to be the most demanding reasons.

When the interviewees were asked about management control decisions, both companies were responsible for their own decisions because of split management JV control. The Japanese contractor had to get approval from overseas on some decisions which did take time. The local company was able to make decisions very quickly. The local company had their General Manager in the JV Management Committee while the foreign company had assigned managerial staff with less prominent positions. They did, however, have more management on site which increased their costs dramatically. Therefore, some of the urgent decisions were taken by the local contractor. This shows that the involvement of partners in decision making process on major day-to-day operations of the JVs could be difficult to make them competitors as well as collaborators in such situations (Ozorhon *et al.* 2010).

For the local company, the project was successful and when the interviewees were asked about the essence of success, one manager mentioned it's finishing the project

on time with good profit. Another manager said that it was profitable and they have learnt a lot from the Japanese contractor while the third manager said the client was happy with the finished product and with this project in their profile, they have been able to secure works in projects with both Mechanical and Electrical scopes. As for the Japanese contractor, feedback was not that good as they spent so much on their increased staffing levels, hence, they lost money on the original project contract. They did however, say it was a learning curve for them and they learnt a lot from the local contractor and gained local experience. Also, they have successfully gained some compensation with their approved extension of time claim. The above clearly shows how successful JV achieves win-win scenario where the expertise of the international contractor benefited the local contractor, while the international contractor managed to gain significant local experience and access to local work opportunities.

Case Study 2:

This case study represents an unsuccessful JV. The project was delayed and both JV partners suffered financial losses. The case provides useful lessons for construction companies of the risks that they could face in undertaking a JV. The project was designed to include a five-storey technical and support building integrated with a 110-meter-high visual control tower. The finished building will be equipped with state-of-the-art navigational and meteorological equipment. The project had some principal objectives and challenges which were to create an architectural landmark for Abu Dhabi International Airport.

Data collected from the project documents as well as interviews with the project team and the following key information was gathered:

- The legal form was project-based JV contract.
- Integrated JV structure type was deployed.
- Ownership was decided at award of contract and agreed mutually. Korean contractor had 80% ownership while Local contractor had 20%.
- Dominant management control by the Korean contractor was used in the project due to the level of ownership with the agreement to counter signature (authorization) from the local contractor on all decisions.
- There were many cultural conflicts between the partners in the project.

When asked about the major reasons for seeking a JV in this project, the local partner's manager mentioned they wanted to maintain the relationship with the client they were used to work for, although the project is beyond the expertise. Therefore, they decided to minimize their exposure and share the risk in this complex project. Also, branding was another reason as the structure was an iconic building. As for the Korean partner, they looked for a JV with a local contractor for the reason that, they did not have the necessary experience in the UAE construction industry.

This indicates that the foreign contractor is using the JV as mode of entry to new markets as described by Chen (2005). For the local contractor, it is used to acquire talents and resources, share risks, and undertake large and complex projects which is consistent with Ping *et al.* (2009) suggestion that JV is critical to local contractors in complex projects in developing markets who do not have enough capability or the required technology. As stated by the Korean contractor, there was a huge cultural conflict with their partner, project subcontractors and clients.

Communication was not proper and interaction between partners was not good enough which indicate the main reasons behind the failed JV. The local contractor stated that they have not considered cultural factors in the JV negotiation process as other important factors in their opinion were fulfilled, including partner's financial stability, experience, and reputation. Specifically, financial stability seems to be the significant factor for JV local contractors.

There was clear JV management issues noted from the interviewees when asked about decision making. Local partner was used to seek decisions from the management in head office whilst the Korean partner was used to refer to their Head office in Korea to make decisions which took long times, hence delays occurred as they possess the majority of control and ownership. On the other hand, although, the Korean contractor had dominant ownership as stated above, all decisions, even minor ones should have been mutually agreed with the local contractor. This represents some "hidden" control as expressed by the construction manager of the Korean contractor which has also caused some delays on the project. Therefore, the ownership in this project proved not to be the best means of control and was a minor issue in domination as suggested by Mjoen and Tallman (1997).

CONCLUSIONS

JV in the UAE construction industry is mostly formed on a project-basis rather than continuous collaboration as the contractors in the UAE prefer temporary relations in construction contracts. Integrated JV type was found mostly used in the UAE and the least used is the non-integrated type. One of the most important decisions when entering into a JV arrangement in the UAE is the careful selection of the JV partner. Key factors for JV partner's selection are Financial Stability, Experience, Reputation, and Inter-partner trust. Also, when the partners have equal share of ownership, greater stability is attained because the partners are equally committed to the JV. The level of international experience will affect the company ownership as the more critical the strategic resources transferred to the venture are to the parent, the more likely the parent is to desire the highest possible level of ownership which might result in disputes. The management control mostly used in the UAE is the shared management of activities in a venture with the operations shared between parents. Split management of activities for which partner has competence is mainly used when the scope of works is split between partners. Decision making management of the foreign contractor represents a source of delay whenever a critical decision needs to be taken as the foreign contractors usually take long time to seek head office advice. Management control difficulties can be increased because of cultural differences which contribute to conflicts. Major factors that lead to successful JVs in the UAE are namely trust, correct structure, communication, and partner's commitment. Partners' common objectives do not affect the JV success or failure. Willingness to adapt eliminates conflicts and enhances the JV success prospect. It should be noted however, that due to the lack of experience of some survey respondents about JV arrangement as well as the insufficient feedback from case study interviewees about significant relevant matters, there was some vague arguments on JV success factors.

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INTERNATIONAL COLLABORATION AND PARTNERING IN THE SUPPLY CHAIN AS BUSINESS OPPORTUNITIES FOR ARCHITECTURAL FIRMS

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Due to a shift towards market driven concepts, a risk allocation from the demand side to the supply side and the increasing competition with other skilled actors in the value chain, architectural firms have to adapt quickly to stay competitive. They need to innovate not only their products and services, but also make more fundamental changes in the way they create and appropriate value, thereby replacing or innovating their business models. This research addresses business model design of architectural firms from an activity system perspective. It aims to identify activity systems that are used within the architectural service sector to create and capture value. By analysing the possibilities and restrictions of the activity systems in relation to both firm and supply chain, business opportunities for architectural firms are explored. Archival data and 20 explorative interviews with different architects, clients and contractors, contribute in the identification of two emergent activity systems: international collaboration and partnering in the supply chain. Since the activity systems include new activities, linkages and actors, they require managerial attention in order to 1) enhance value creation and capture by the firm and 2) guarantee optimal collaboration within the supply chain. By applying the concept of activity systems on the field of architecture, the importance of business model design for the value chain of architectural services is showed.

Keywords: architectural services, business model design, collaboration, supply chain integration.

INTRODUCTION

Fuelled by our fast changing society and increasingly unpredictable economy, organizations ability to adapt has become more important to survive. Firms need to develop new business models or alter their existing ones to create and capture value when markets, technologies and legal structures are changing (Teece 2010). Thus, constant innovation of the business model is essential to maintain a healthy business. Together with the financial crisis, global societal changes forced the architecture, engineering and construction (AEC) industry to undergo significant changes during the last decennium. In the Netherlands, a shift towards more integrated project delivery and a risk allocation from the demand to the supply side have resulted in new forms of collaboration, new roles and new responsibilities for all actors in the value

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chain (Volker and Klein 2010). Driven by their decreasing performance, architectural firms pursue new activities and even take over roles of other actors. Competition has become widespread and extremely high. Since the end of 2008 the turnover of architectural firms decreased tremendously. While the total turnover of the Dutch architectural service sector was estimated at approximately € 1.7 billion in 2008, in 2012 it was only € 0.7 billion. Employment within architectural firms decreased with 58% in that same period (BNA 2013). Although recent studies show stabilizing trends, firms expect further shrinkage of their turnover and workforce (Holtackers 2013).

As a result of the difficult market situation, the demand for new business models in the architectural service sector is high. But, especially when working in the public sector, firms tend to focus on the architectural quality of the service they provide and largely neglect the entrepreneurial side of their business (Cohen *et al.* 2005). Insights into business model design of architectural firms might improve managerial thinking by architects and could subsequently increase business opportunities within the sector. Zott and Amit (2010) present an activity system perspective on business model design. The activity system enables the firm, together with its partners, to create value and to appropriate a portion of that value. In this empirical research we use the activity system perspective on business model design to analyse value creation and appropriation of architectural firms. So far, research on value creation by architectural firms has been mainly explorative (BNA 2011, RIBA 2012). These studies provide insight in activities that might be of importance for architects to secure their current and future workloads. However, interdependencies with the firm's business model - other activities, actors and revenue models - remain underexposed.

Hence, our study addresses value creation in the field of architecture by using a systematic approach from business model literature. The research aims to identify and analyse current trends in value creation of architectural firms in order to recognize business opportunities. This shows the importance of business model design for the AEC industry and demonstrates that business model theory is able to contribute to an analysis of value creation by architectural firms. In addition, this research provides practitioners with an understanding of business model design and a detailed description of activity systems. The activity system perspective helps firms to rethink and redesign their business model based on current and new activities.

This paper is organized as follows. First, the theoretical background is presented, starting with a discussion of value creation in the AEC industry and by architectural firms in particular. Then business model design is introduced from an activity system perspective. Next, the paper focusses on our research methods, including research strategy, selection of respondents, data collection and data analysis. Then the findings of the explorative study are presented and analysed. Finally, concluding remarks and directions for future research will be offered.

VALUE CREATION IN THE AEC INDUSTRY

The AEC industry involves complex activities and many actors. Although different models can be used to understand the value creation and appropriation in the AEC process, none of them seems able to capture the totality (Bygballe *et al.* 2013). Architectural firms, as part of the supply chain, create and appropriate value together with their business model partners. Following Winch and Schneider (1993), several factors distinguish architectural practices from other types of firms. Architectural organizations deliver services, are professional, creative and purely knowledge-based. Value creation within architectural firms highly depends on the people involved, since

the expertise of the staff is indispensable for the service that is delivered. Within the scope of Dutch AEC activities, the traditional selection of architectural activities is very broad. This comprehensive amount of architectural activities originates from the time that only client, architect and builder were involved in the building process (Duffy and Rabeneck 2013). As complexity and fragmentation of AEC projects grew over time, the number of actors in the value chain of architectural services increased. Architectural firms, however, were still used to deliver a range of ‘full services’ in architecture, engineering and construction stages. The ‘Standard Job Description’ (BNA and ONRI 2009), which is used by Dutch clients and architects to define their working arrangements, mentions ten stages in which architectural services can be delivered. The activities include programming activities prior to the design in the first two stages, architectural design activities in stage three until five, engineering activities in stage six to seven and engineering, supervision and aftercare activities in the last three stages. Due to scarcity of financial resources, integrated contracts and an increasing competition among actors in the value chain, the scope of architectural activities has declined and become less defined in the last couple of years. However, the business model and revenue structure of most architectural firms is still based on the delivery of ‘full services’ in architecture, engineering and construction stages.

BUSINESS MODEL DESIGN

Although the concept of the business model is very popular among scholars and business strategists, there is no general agreement on what the business model is and how it can be used (e.g. Shafer *et al.* 2005). Starting from different conceptualizations of the business model, certain common themes emerge in literature (e.g. Morris *et al.* 2005, Zott *et al.* 2011). The business model can be viewed as a template of analysis on how firms conduct their businesses on a system level. Business models try to explain how value is created and delivered to all stakeholders (e.g., the firm, clients, partners, etc.), and how value is appropriated by the firm (Zott *et al.* 2011). The emerging consensus is that a business model may be defined as the rationale of how an organization creates, delivers, and captures value in relationship with a network of exchange partners (Afuah and Tucci 2001, Osterwalder and Pigneur 2010). The business model is a conceptual, rather than a financial model of a business. It outlines the logic to create and capture value, by making implicit the expectations of (changing) customer needs, associated revenues and costs, and competitor responses (Teece 2010). The overall objective of a firm’s business model is to exploit a business opportunity by creating value for parties involved, while generating a profit for the firm and its partners. The objective is reflected in the customer value proposition and explains why clients choose for a certain firm (Zott and Amit 2010). A good business model presents value propositions that are attractive to customers, is specifically designed to deliver that value, and has a profitable revenue model that enables the firm to capture a share of the value that is created (Teece 2010).

Teece (2010) notes that without a well-developed business model, firms will either fail to deliver or to capture value. To stay competitive, firms should re-evaluate their business model design frequently. They need to consider not only how to address changing market demands, but also how to capture value from providing new products and services. Hence, an understanding of business model design may help firms to establish competitive advantage (Teece 2010). The business model design captures how the firm is embedded in its networks and defines who are the firm’s potential partners, customers, suppliers and competitors. Zott and Amit (2010: 216) present an activity system perspective on the design of the business model. They conceptualize a

business model “*as a system of interdependent activities that transcends the focal firm and spans its boundaries*”. An activity can be viewed as the engagement of resources of any party to the business model to create and deliver specific value. Focusing on activities allows concentration on the firm, while considering the social aspects and transactional dimensions of relationships with business model participants. It provides a natural perspective for entrepreneurs and encourages the firm to think about the fundamental and integral aspects of the business model (Zott and Amit 2010). The activity system helps to create value and to appropriate a share of that value in an understandable and well thought out way (Zott and Amit 2010).

Zott and Amit (2010) suggest two sets of parameters that should be considered in the design of an activity system: design elements and design themes. The design elements describe the architecture of an activity system. These are content, structure and governance. The content of an activity system refers to the selection of activities. For example, a secondary market influences the selection of activities and is therefore a content issue. The activity system structure describes the linkage between activities and their importance for the business model. By building on existing knowledge and experience, for instance, new services delivery can be developed. The linkage between established methods and new services is a structure issue. Finally, governance refers to who performs the activities within an activity system. Whether an architectural firm, client or contractor is performing a set of activities is a governance issue. The design themes describe the sources of the activity’s system value creation. They detail the main value creation drivers and are configurations of the design elements. Zott and Amit (2010) distinguish four common design themes that are used by firms to create value. In novelty-centered business model design the economic exchange between partners is focussed on the involvement of new activities, new connections between activities or new governance mechanisms for activities. Efficiency-centered business models aim to maximize the efficiency of firm’s transactions and to reduce the costs of all the partners. When activity systems are designed for lock-in, they are able to retain third parties as evident participants of the business model. Complementarities are present when more value is generated by bundling activities (Zott and Amit 2010).

RESEARCH METHOD

In this research we use Zott and Amit’s (2010) activity system perspective on business model design to identify and analyse emerging activity systems in the architectural service sector. Since service delivery by architectural firms is highly complex and depending on the collaboration with other actors, a qualitative research strategy with exploratory interviews was used to gather a wide range of empirical data from the perspectives of different actors. In the presentation of our findings, we identify emergent activity systems firms use to maintain or improve their performance in the field. After a short introduction, the activity systems are analysed using the three design elements – content, structure, governance – as defined by Zott and Amit (2010). Due to the short time-span of this study we chose to limit this research to the identification and analysis of design elements, the core ingredients and architecture of the activity system. But, as design elements and design themes of activity systems could be highly interdependent (Zott and Amit 2010), some tentative links with design themes will be made as well in the discussion of our findings.

Research sample

In order to gather in-depth information on current and future business model design of architectural firms, we used the purposeful sampling technique of maximum variation

to capture a wide range of perspectives. We selected architects, clients and contractors from different areas in the Netherlands to allow various perspectives to arise on architectural value creation and delivery and to address collaboration within the supply chain. Respondents were selected from different types of established project collaborations (e.g. traditional-, team-, integrated collaboration), to explore typical ways of working, and from different types of innovative project collaborations (e.g. bottom-up initiatives, strategic alliances, network collaboration), to include more extreme ways of working. To ensure a good representation of the architectural field in the Netherlands, the sample consists of firms with different characteristics and different firm size. We included design firms, that are characterized by their emphasis on the delivery of design services, and firms that focus on the delivery of integral services, which for instance may comprise design, engineering and management services. With regard to firm size, three sizes are distinguished: micro-sized firms that employ fewer than 10 persons, small-sized firms with fewer than 50 persons and medium-sized firms with fewer than 250 persons (European Commission 2005). We refer to the respondents as architect A to O, client A to B and contractor A to C. Table 1 presents an overview of the selected respondents.

Table 1: Overview of respondents

Respondent	Firm characteristics	Firm size
Architect A - B	design	micro
Architect C - D	design	small
Architect E	design	medium
Architect F - G	integral	micro
Architect H - L	integral	small
Architect M - O	integral	medium
Client A - B	not relevant	not relevant
Contractor A - C	not relevant	not relevant

Data collection

We used 20 exploratory face-to-face interviews to collect data on value creation, delivery and capture by architectural firms. Archival materials and informal discussions were used to prepare for the interviews, to expand the understanding of each firm's context, and to strengthen or question the findings of the interviews. All interviews were approximately 1,5 hour in length. For the interviews a semi-structured protocol with open-ended questions was used. To ensure reliability of the data, the interviews were audiotaped, fully transcribed and checked by the respondent. The following topics were addressed in the interviews: roles and activities of the architect, collaboration with partners, client and suppliers and future business directions. The respondents were asked what activities they perform to enhance their value creation, what processes are used to organize the output and what actors are relevant in the delivery and capture of value. In order to identify activity systems that are important for the entire field of architecture, we looked for activities that were mentioned by multiple respondents or had a strong relationship with aspects mentioned by another respondent.

Data analysis

The data from the interviews were analysed by the authors and two other researchers using the technique of context mapping (Sleeswijk Visser *et al.* 2005). Statement

cards with paraphrases and relevant quotes have been derived from each interview transcript by one of the researchers. Then, the statement cards were discussed in a group meeting and categorized by themes. Disagreements that occurred were discussed until consensus was achieved. The relations between the themes were visualized and a codebook was created. Different key themes were identified as activity systems for value creation. The research findings were consolidated and validated in a workshop with practitioners to ensure reliability of the data. After this validation, data were reexamined and the key themes were further analysed and extended by looking for similarities and differences in the data. The codebook went through several iterations.

FINDINGS

Two activity systems that were identified in the content analysis are international collaboration and partnering in the supply chain. Each activity system is introduced shortly. Then the activity systems are analysed from a firm perspective using Zott and Amit's (2010) design elements – content, structure and governance. As Zott and Amit stress, the activity systems remain firm-centric. However, since our data suggest that other actors are of major importance to the architectural firm's business model, we choose to discuss the activity systems from a more structural point of view.

International collaboration

While some respondents believe that international markets provide opportunities to create and appropriate value, others deliberately don't work outside the Netherlands. Eight of the fifteen architectural firms are currently working abroad. They include design and integral firms of small or medium firm size. Reasons to work abroad include a higher building activity, available resources and lack of international competition. Some of the firms, like the firm of architect M, are asked by international parties because of their specific knowledge in a field that is less evolved in the country in question. Also Dutch architects are chosen because of other design approaches or working methods. The architectural firms that do not work outside of the Netherlands only include small or micro-sized firms. The firms of architect B and G still have a big workload in the Netherlands. Other firms, like the firm of architect D, simply do not have enough resources available to focus on international markets.

Content

Regarding the content of the activity system, working in international markets focusses on design or consultancy services in the first stages of the AEC process. Engineering and construction related tasks are executed by a local partner because these activities require knowledge of the local legal context and construction methods. Hence, all respondents believe that the collaboration with local partners is vital for the delivery of value to international clients. This means that 'full service delivery' is not applicable for architectural firms when working in international markets. However, activities in the first stages of the AEC process might become more comprehensive.

Structure

The internationally active respondents expect their international workloads to grow in the future. However, for some firms the revenues are currently still lagging behind expectations. The firm of architect O, for instance, is only able to participate in smaller one-on-one activities in Poland, because of the local price-based procurement tradition. But a good relationship with the embassy leads to multiple lecturing activities at the University and might eventually improve the firm's position. Although the linkage of different activities is highly project specific and varies per country, the

example of architect O illustrates that regarding the structure of the activity system, contacts with local authorities or institutes might be beneficial to the acquiring or performance of activities. As new connections play a vital role in the process of value creation, the activity system's structure relates strongly to the design theme novelty.

Governance

In order to gain more international projects and to maximize mutual benefits, Dutch architectural firms engage in partnerships with other firms. Regarding the governance of the activity system, three types of actors are mentioned to contribute in international value creation and appropriation. First, as explained earlier, international partners are crucial to understand the market situation, culture and customer needs. Secondly, partnerships with other Dutch architectural firms are initiated to compete with (bigger) international companies and to expand the scope of service delivery. These firms include architectural firms of same size and characteristics (architect M) and firms with different expertise (architect L). Finally, other Dutch firms from the supply chain, such as engineering firms, contractors or product suppliers, can contribute in a broader and more integrated service delivery. *"We note that the Netherlands is the world top right now in new, innovative work environments. (...) we really have a Dutch export product. Therefore, we have (a collaboration with) a furniture supplier and a concept developer. With those three, we want to create a kind of total project delivery"* (architect K). In this way, value creation can be enhanced on both firm level and supply chain level. Since new actors are involved, the activity system's governance closely relates to the design theme novelty.

Partnering in the supply chain

As architect H articulates, the design process and involved actors, activities and responsibilities are becoming more and more fragmented. *"The design is no longer an entity that requires one party to be involved, it has become a cluster where various parties each have their own input. It has become much more complex"* (architect H). Collaboration with other actors is not only important to deliver adequate services to the client, it also enables the firm to capture more value (architect K). The empirical data showed that partnering in the supply chain is done by six of the firms in order to stimulate value creation and appropriation. In addition, five of the firms work together with other architects to improve their value creation and appropriation in the field. Partnering with organizations outside the AEC industry is done by some architectural practices (architect C), but was only scarcely mentioned by the respondents.

Content

Partnering in the supply chain involves new activities that are not directly linked to the traditional AEC work of the architect. Networking activities and the investment in relationships have become very important. Partner selection, although this is often executed last-minute (architect E), or in contradiction with the established ways of working (contractor C) is also a new activity that requires attention. The selection of partners can be of major importance to acquire a project and also highly influences the total value that can be created and captured. Finally, with the identification and development of common strategies firms are able to improve value creation among all partners. The new activities involved in the content of the activity system point once again towards the importance of the novelty-centered business model design.

Structure

When analysing the structure of the activity system, it stands out that activities of partnering are mainly linked on the basis of trust and common ground. Trust can be

established by developing and working towards a shared goal or by discussing each partners priorities from the start (e.g. architect N and contractor B). Incentives, like a success fee, are used to create high involvement of all partners and to make sure that all partners maximize their input (contractor C). Since every project is highly unique, most of the respondents are currently working with different partners on each project. Several firms, however, are looking for possibilities to engage in long-term partnerships, as a way to stimulate efficiency and increase revenues. At this moment long-term partnerships are still scarce and in development. Although the structure of the activity system is currently characterized by a high degree of novelty, the aim of many firms is to move on towards an efficiency-centered activity system.

Governance

Regarding governance of the activity system, the interviews show that the actors involved in partnering include all kinds of firms from the supply chain. The firm of architect N pushed off some of their divisions to keep focus on their own core business: to conceptualize and visualize an idea based on the requirements of the client. Since these requirements are becoming more complex and comprehensive, partnerships with other actors are used by architectural firms to keep a focus on the core business (architect L). The partnerships generate a more integrated service delivery and increase the scope of the service. Suppliers have become important partners to deliver an integrated process and product to the client. These actors are involved in early stages of the AEC process to improve integration, efficiency and reduce costs (architect O). Partnering with other actors from the field can also stimulate innovation, which is illustrated by architect I, who develops strategic alliances with contractors, construction engineers and research institutes to further innovate their shared BIM expertise. The activity system's governance contains elements of the design themes novelty and efficiency.

CONCLUSION

This research aims to identify and analyse current trends in value creation of architectural firms. It also discusses their implications on firm level and supply chain level. Empirical results of 20 explorative interviews with different architectural firms, clients and contractors show two emergent activity systems that are used by architectural firms to create and capture value: international collaboration and partnering in the supply chain. Since these activity systems involve new activities, linkages and governance mechanisms, they point out that business model design of architectural firms should change concurrently. A re-design of current or design of new business models is necessary to 1) successfully create and capture value on firm level and 2) optimise collaboration on supply chain level. The design elements of Zott and Amit's (2010) activity system perspective on business model design – content, structure and governance – are used to systematically analyse the two activity systems and discuss their implications. The activity system international collaboration contains elements of the design theme novelty, while the activity system of partnering in the supply chain includes both novelty- and efficiency-centered aspects.

Regarding the content of the activity systems our study confirms that the traditional selection of architectural activities is currently changing. International collaboration results in a narrowing down of activities to the first stages of the AEC process.

Partnering in the supply chain helps firms to provide a joint 'full service delivery' to the client. Partnerships can help to secure activities and revenues for the firm, but

require attention to new activities like partner selection and a shared goal definition to optimise collaboration among all actors.

Although the linkage of activities is highly project related, certain common topics can be identified regarding the structure of the activity system. For international collaboration the involvement of high level parties can help to generate a stable basis for settlement. Partnering in the supply chain requires arrangements for collaboration. These arrangements can be based on trust or formalized in contracts. In both cases the development of a common ground and use of incentives can be fruitful.

Regarding the governance of the activity system, other actors are of importance to the business model of the architectural firm. In international collaboration, actors include local partners, other Dutch architectural offices or Dutch firms from the supply chain. For partnering in the supply chain, firms with different kinds of expertise are important to provide a 'full service delivery'. When collaborating with contractors or product suppliers for instance, value creation and appropriation can be enlarged for the architectural firm as well as for the partners involved.

LIMITATIONS AND FUTURE RESEARCH

The theoretical framework of the activity system offers opportunities to gain insight in the aspects that contribute to the design of business models. This research emphasizes the importance of business model design for architectural service firms, but has certain limitations that deserve to be mentioned. First, as mentioned in literature (Cohen *et al.* 2005) and confirmed by our respondents, the majority of architectural firms is not particularly concerned with their business model. To understand why this is and how this can be improved requires further research. Secondly, as pointed out in the section on our research method, this paper focusses on the identification and analysis of design elements in architectural activity systems. Further research and analysis will be necessary to study design themes in architectural service delivery more thoroughly and to provide a broader discussion on the interrelation of design elements and design themes.

As noted by Zott and Amit (2010), the activity system perspective could help to improve empirical understanding of past and current business models, to develop predictive theory on business model design, and to design new business models for the future. Future research could explore the relationship between the firm, the business model stakeholders and the value creation processes further. For this purpose, a larger sample of firms and combination of empirical research techniques is desirable.

Other AEC firms, for instance engineering firms or consultants, could also benefit from the activity system perspective on business model design. When applying the concept on several sectors of the industry, new sustainable models for collaboration within the supply chain could emerge. Hence, when customized to the characteristics of the industry, the activity system perspective on business model design could present a framework to address strategic issues on different industry levels.

ACKNOWLEDGEMENTS

This work is part of futurA, an ongoing research project in the Netherlands on new governance and business models for architectural services (www.future-architect.nl).

The authors would like to express their gratitude towards The Netherlands Organisation for Scientific Research (NWO) and the consortium partners for funding

and supporting the project. Also they would like to thank all interviewees for their time and enthusiasm in participating.

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EXPERIENCES OF TRUST IN CONSTRUCTION PROJECT MANAGEMENT: THE INFLUENCE OF PROCUREMENT MECHANISMS

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Trust is a key element in the project manager's toolkit, and fostering trust in a project team is often critical to the project's outcome. Literature suggests that relational procurement mechanisms underpinned by "pain-share/gain-share" principles ought to increase levels of trust between project participants as compared to traditionally procured projects, yet little related research exists. Using "trust as a phenomenon" as the philosophical point of departure the intricacies of trust formation and maintenance are explored in these contexts. A framework of trust-related personal attributes, attitudes and behaviours is used to analyse a series of 15 detailed interviews with multiple representatives from construction and client organisations. Preliminary findings identify: participants' desire for trust in projects; widespread absence of strategies for trust building, maintenance and repair; adversarial dispute resolution as the default; poor project team member selection. Widely valued traits in trading partners include open and honest communication; technical competence; fairness; integrity; honesty, and; benevolence. Where disputation has occurred trust repair skills appear to be rare. Positive pre-existing relationships are reported as the antidote for many project ills. Differences in the perception of trust variables associated with procurement context are identified: superficially surprising and counter-intuitive, they reveal pan-procurement principles for trust-based project success.

Keywords: relational procurement, transactional procurement, trust, trust repair.

INTRODUCTION

Trust is considered to be a fundamental requirement for human interaction (Romahn and Hartman 1999), and there is widespread agreement on the value of trust in human behaviour (Bigley and Pearce 1998). When contextualised in a construction project setting issues of risk, vulnerability, and trustors' expectations (or not) of fair treatment by trustees are central to the application of the concept.

In this context trust is primarily a psychological state rather than a behaviour. Moreover it is different to a cooperative relationship, which can exist without the presence of trust: it follows that compliance as a behaviour does not imply the existence of trust (Brewer and Strahorn 2012).

This research illuminates the formation and maintenance of trust through the lived experiences of multiple practitioners across various projects procured using both transactional and relational methods.

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LITERATURE REVIEW

Transactional based procurement

Transactional based procurement has traditionally been utilised within the construction industry. Under this procurement method, traditional construction contracts aim to definitively allocate risk to stakeholders despite it being fundamentally impossible to foresee or quantify all potential risks and uncertainties (Macneil 1978). It is apparent that the construction industry operates within a challenging environment; consequently the capacity to contend with change appropriately manage and allocate risk is considered critical (Sakal 2005). In this regard transactional based frameworks are somewhat limited, particularly when dealing with high risk and complex construction projects (Campbell 2004). Effective risk management under transactional based procurement is therefore compromised.

The shortcomings of a transactional-based contract have been widely acknowledged. The respective parties are contractually encouraged to protect their own individual priorities, which often result in disputes, as well as outcomes inconsistent with the overall interests of a project (Chan *et al.* 2006). Adversarial relationships frequently develop (Chen and Chen 2007), and can be ascribed to the competitive fixed price context (Pesamaa, Eriksson, and Hair 2009). Responsible tendering can also be discouraged as a result of onerous contract conditions. To this end, there exists the potential for opportunistic parties to enter agreements with conniving intentions, particularly in relation to tender price, expected variations (Rahman and Kumaraswamy 2004), and exploitation of errors or omissions in the contract documentation (Mosey 2003).

In light of these shortcomings project outcomes under transactional-based procurement have been found to be negatively impacted, including: conflict and distrust (Sakal 2005), disputes (Pesamaa, Eriksson, and Hair 2009), reduced productivity (Ng *et al.* 2002), and cost overruns and project delays (Chan, Chan, and Ho 2003). A preference for litigation (Yiu and Cheung 2007) and disagreement rather than cooperation (Wood and McDermott 1999) are frequently the result.

The need for alternative procurement mechanisms has therefore been widely acknowledged by literature (Rahman and Kumaraswamy 2004). While the transactional-based approach aims to definitively identify uncertainties in a project, in doing so it fails to contractually acknowledge or facilitate the cooperative relationships which are vital to the success of a contractual arrangement in terms of responding to issues when they eventuate (McInnis 2003). The human element influencing the outcomes of a project procured under a traditional framework is therefore significant.

Relational contracting procurement

Relational contracting (RC) was developed in response to the identified shortcomings of the conventional transactional based procurement approach, and the adversarial culture that was often common place within the construction industry (Goddard 1997). Rahman and Kumaraswamy (2004: 148) described RC as follows:

“Relational contracting is based on recognition of mutual benefits and win-win scenarios through more cooperative relationships between the parties”.

Essentially, and as applied within the construction industry, the principals of RC aim to encourage collaboration (Rahman and Kumaraswamy 2004), appropriately allocate

and manage risk (Jones 2000), and foster benevolent contractual relationships which negate the transactional barriers to team building (Macneil 1980). Through a recognition of mutual benefits, stakeholders within a relational contract move past a reliance on purely legal terms, and function instead dynamically within a contractual, economic and behavioural framework (Macaulay 1963). As complex construction projects inherently result in an ever evolving contractual landscape, the relationships between parties are critical, and RC provides the context within which said relationships can be developed and maintained in a manner typically difficult in traditional transaction based procurement (Rahman and Kumaraswamy 2004).

The concept of collaboration is particularly pertinent in terms of the fundamental principles of RC and the overarching desire to reduce conflicts (Rowlinson and Cheung 2005). In this regard the benefits of collaboration within the construction industry are widely recognised (Gajendran and Brewer 2012). Given the significance of collaboration within the RC context, the question of how to foster a collaborative environment is logically pertinent. To this end, precursor dimensions for collaboration identified by literature include mutual objectives and actions, individual competence, and distribution of authority. Communication and trust are also identified (Gajendran and Brewer 2012), and these dimensions are especially relevant to the scope of this research.

The ultimate benefits of RC have been extensively acknowledged (Jones 2000; Macneil 1980; Rahman and Kumaraswamy 2004) and with consideration to the fundamental principal of reducing conflict, the re-occurring themes pertaining to relationships, team work, collaboration, communication, culture, and risk management are considered particularly significant within the context of this research. Furthermore, the importance of trust between parties (Rahman, Kumaraswamy, and Ling 2007), trust and trust based relationships (Rahman and Kumaraswamy 2008), and mutual trust (Chan *et al.* 2006) are also significant.

It should be noted that there remains some criticism that literature professing the benefits of RC fails to adequately consider its limitations, nor the poor examples that have at times eventuated (Bresnen 2007). However, these criticisms have not attempted to contest the potential advantages. Similarly, when considering the definitive advantages of RC, the qualification is often given that they are conditional depending on application and context, and that there is never a universally applicable solution (Bresnen 2007).

Within the Australian construction industry, Alliancing is a form of RC that is becoming increasingly popular. An alliance arrangement is described as a long term strategy between client, contractor and supply chain (Rowlinson and Cheung 2004) whereby risks and rewards are shared, and common goals are established in the pursuit of a particular outcome or project (Peters, Walker, and Hampson 2001).

Factors considered pertinent for successful Alliancing align closely with RC fundamentals; trust, collaboration, open and honest communication, cooperation, relationships and relationship management, joint problem and conflict resolution, team selection, goal alignment, team work, a win-win philosophy, and total organisational buy in (Peters, Walker, and Hampson 2001; Rowlinson and Cheung 2004). The influence of trust and other dimensions of trust are widely acknowledged in this regard, and are categorised within the “*soft*” elements that are said to form one part of an alliance arrangement (Yeung, Chan, and Chan 2007). These “*soft*” elements are of particular significance within the context of this research.

The second part of an alliance arrangement concerns the “hard” contractual elements relating directly to legal positions (Yeung, Chan, and Chan 2007). So despite the collaborative approach that is fundamentally at the heart of any alliance and the identified “soft” elements, the rights and obligations of the contracting parties are nonetheless still spelt out in strictly legal terms. The hard contractual elements define the collective sharing of risk, through the pain-share, gain share agreement which adopts a best for project approach (Sakal 2005). A “no dispute” clause is also often included in which the contracting parties wave their rights to litigation (except in instances of wilful default), with this arrangement further fostering the fundamental themes of trust and goal alignment (Rowlinson *et al.* 2006). However, it should be noted that a no blame culture or contract cannot exist without a clear relational vision and a positive approach to relationship management (Rowlinson *et al.* 2006). This further highlights the importance of the softer elements in an Alliance arrangement. In this regard, the terms that define an alliance contract appear to exclude or certainly ignore the softer interpersonal aspects of relationships, of which trust – a response to risk exposure – is key.

Trust

Trust is an essential requirement which makes initial human interaction possible (Romahn and Hartman 1999: 233), and there is a wide spread acknowledgement on the value of trust in human behaviour (Bigley and Pearce 1998). Within the context of the management discipline, literature has provided various characteristics of trust and its constructs which have general applicability to a project environment. In this regard, an applicable framework of trust themes can be considered along contextual, human and attribution variables, with factors of trust failure also significant (Brewer and Strahorn 2012; Strahorn, Thayaparan, and Brewer 2013).

With consideration to the risk management function of any procurement mechanism, the contextual variables of risk, vulnerability and uncertainty are significant in terms of trust and its influence. Risk is inexorably present in every project setting (Schwalbe 2004), and any attempt to prevail against issues in this regard are critically dependant on trust its dimensions. Trust facilitates an individual’s positive motivation towards universal project objectives (Wong *et al.* 2007), and the benefits of trust cannot come to fruition without one party’s willingness to accept some degree of risk (Romahn and Hartman 1999). Ultimately, trust helps to overcome risk and uncertainty.

As project outcomes are essentially reliant on people to get things done (Lechler 1998), it stands to reason that the human variables influencing any project are significant. In this regard, the ongoing interactions within stakeholder relationships are considered to be a key determinant of trust (Tomlinson and Mayer 2009).

Consequently, attribution variables in which character traits are assigned amongst stakeholders are also a key determinant of stakeholder relationships and trust. To this end, dimensions of trustworthiness are notable (Good 1988), along with mutually related trust building mechanisms (Lander *et al.* 2004); reliable behaviour, communication (Karlsen, Graee, and Massaoud 2008), competence, benevolence, integrity, and honesty (McKnight and Chervany 1995).

METHODOLOGY

With consideration to the identified relevance of trust in both transactional and relational procurement, and also the variables at play in the differing contexts each mechanism presents, the design of this research aims to consider theoretical trust

themes against the 'lived experience' of practitioners in both procurement environments.

In investigating the lived experiences of construction practitioners, the human, technical and socio-technical dimensions need to be considered.

The human dimension is logically significant in terms of trust and the dimensions of trust which are central to this research, while the technical dimension includes the respective legal frameworks which underpin the alternate procurement methods. The socio-technical dimension is essentially concerned with the interaction between the human and technical dimensions, and is influenced by the project context.

This research has therefore adopted a phenomenological investigation of both trustors and trustees within a construction industry context. The exploratory nature of the topic and phenomenological stance adopted dictates the suitability of a qualitative and descriptive investigation. This aims to accurately conceptualise and explain meaningful trust-related themes exposed through lived experiences of practitioners (Wertz 2006). This research has investigated the consciousness of project stakeholders and the observable phenomena regarding the influence of trust; specifically in terms of what and how it is experienced (Moustakas 1994). Ultimately, this research is intended to illuminate the ontology of trust and its influence within a construction management framework.

When considering implementing a phenomenological research approach, a number of methodological considerations must be taken into account: firstly, prior knowledge must be bracketed and judgement suspended, until confirmed by findings and founded on an objective basis respectively; secondly, consciousness is always directed towards an object, but reality is inevitably linked to an individual's consciousness of that object, therefore; lastly, reality of any object is only perceived within the context of the individual's experience (Stewart and Mickunas 1990).

Informed by the foregoing, the procedural approach proposed by Moustakas (1994) for phenomenological research has been adopted. An investigation by way of in-depth interviews with multiple stakeholders within transactional and relational procurement contexts has been undertaken. Fifteen individual stakeholders from different sectors were interviewed, including five each of clients, project managers and contractors. Participant selection and recruitment was dictated by pragmatism: they were working on major projects within the Hunter region of NSW; each was experienced (5+ years of responsibility in their role); all had experience of both traditional and relational contracting.

Interviewees were asked about their background and the current context within which they were involved. Their familiarity with, and experiences of projects let under traditional and relational procurement mechanisms were then probed. Specifically the influence of trust (e.g. Bigley and Pearce 1998), trust failure, and its subsequent repair were explored in relation to: pre-existing relationships (Tomlinson and Mayer 2009); project initiation; supply chain relationships (Lander *et al.* 2004), project success/outcomes (Karlsen, Graee, and Massaoud 2008), and; strategic relationships (Tomlinson and Mayer 2009).

Analysis of the interview transcripts was then undertaken using an inductive thematic process. This allowed identification, abstraction and synthesis of context-specific trust-related concepts.

RESULTS AND IMPLICATIONS

Trust

In both procurement contexts, the interviewees demonstrated an understanding of trust related issues within their lived experiences. There was wide spread acknowledgement of many dimensions of trust and the subsequent influence on project outcomes, relationships and relationship interactions. *"You have to be able to develop trust"* (Int. # 2- Client), in order to build stakeholder relationships, and relationships are dependent on *"the individuals involved and the trust that you have between them"* (Int. # 5- Contractor). *"Trust is obviously something that you need to develop and that's where interpersonal relationships become very important"* (Int. # 7- Client). Both good and bad relationships were evident, and themes of trust were central in this regard. *"When people cooperate, it generates a whole series of unrecorded benefits"* (Int. # 10- Project Manager). *"It is all about trust"* (Int. # 13- Project Manager). Relationships founded on past experiences were also considered to be significant in terms of stakeholder interactions and project outcomes. *"There is a relationship there. It plays a big part"* (Int. # 8- Contractor).

Despite an understanding that strong relationships provided a significant disincentive for exploitive behaviour and help *"overcome the pressures to be adversarial"* (Int. # 13- Project Manager), there existed minimal evidence of any proactive strategies for developing and maintaining trust as part of standard project management practice. Furthermore, irrespective of the procurement mechanism, the default position in some instances remained founded on an adversarial approach to dispute resolution, despite an appreciation that alternative trust based approaches would likely result in improved project outcomes. Consequently, improved outcomes could be realised through dedicated strategies for trust building, and embracing a trust based response to dealing with negative events.

Trust repair

In terms of trust repair, strong relationships were widely considered valuable when responding to negative events however there was little evidence of trust repair techniques, nor of the intricacies of trust repair itself. An understanding of how the trust repair process differs from initial trust development (Kim *et al.* 2004) would therefore be useful. The interviewees were also silent regarding the variable influences on trustworthiness of the apparent grounds for the negative outcome, in terms of the extent to which the cause is deemed internal, controllable or stable to the trustee (Tomlinson and Mayer 2009). A greater level of understanding in this regard would also be beneficial in both procurement environments.

Risk and trust

The link between risk allocation and trust in stakeholder relationships was also significant in both procurement contexts, with divergent outcomes evident in this regard. To this end, the outcomes were not definitively driven by the underlying principles relating to the chosen procurement mechanism, but rather by the extent to which risk was identified and allocated amongst the project stakeholders at the commencement of the project. In both procurement contexts, poor risk apportionment was shown to lead to *"a level of resentment"* (Int. # 9- Project Manager), and an environment which was *"adversarial"* (Int. # 4- Client). Similarly, irrespective of the procurement mechanism, where a balanced approach to risk apportionment was adopted, positive outcomes were achieved. *"As long as we have identified the risk and*

we have made allowances for it” we can avoid “*adversarial*”, and “*contractual head bashing*” (Int. # 4- Client). It is therefore apparent that a greater understanding of the risk/trust nexus and the apportionment of risk in any procurement mechanism would be beneficial. To this end, the overall interests of the project need to be the driver for risk apportionment, as when risk is allocated to an individual with a limited ability to adequately manage it, adversarial interactions and reduced levels of trust can be the result.

The underlying principles of RC are also significant in terms of the risk/trust nexus. Through encouraging themes of collaboration, benevolence, communication, competence, and ultimately trust, these principals aim to facilitate the development and maintenance of strong relationships. However, while these principals do in deed nurture trusting relationships, the allocation of risk within relational procurement actually diminishes the need for trust. Trust cannot transpire without one party accepting a degree of risk, and given that the parties in RC are sharing risk collectively rather than accepting it individually, the requirement to embrace trust and its dimensions is to some degree negated. The full benefits of trust and trusting relationships may therefore be inadvertently hindered within a RC environment, despite fundamental principles to the contrary. The design and implementation of future RC mechanisms would subsequently benefit from a deeper level of understanding in this regard.

Individual personalities

Regardless of the procurement context, the individual stakeholders themselves were widely considered to be the most significant influence on project outcomes, with issues of trust fundamental in this regard. “*The attitude of people is key*” (Int. # 7- Client), and “*in any contract, it comes down to having the right people for the task more than anything*” (Int. # 12- Project Manager). “*It's all about people, individual people, and the relationships they build*” (Int. # 10- Project Manager), and “*things succeed or fail on the personalities involved*” (Int. # 6- Contractor). Hence a greater focus on stakeholder selection during the formation stages of any project would be valuable.

While the respective procurement mechanism was shown to drive behaviour to some degree, the personal traits of the individuals involved, and how they choose to behave and interact within the constructs of the contract were considered most critical.

“*People are always key, but the different styles of contract procurement can place certain pressures on the team that can put a lot more tension in relationships*” (Int. # 7- Client). The human element influencing any project environment was also acknowledged. “*If there is not a human connection, it will not work anyway*” (Int. # 10- Project Manager). Ultimately, the respective procurement mechanism was considered to be secondary to the influence of individual personalities. “*The formal contract does not build trust. The building of trust and relationships, etc. etc. It is all the informal process*” (Int. # 13- Project Manager). To this end, personal characteristics of competence, honesty, benevolence and trustworthiness, were highlighted, along with willingness for open communication and a cooperative approach to resolving issues when they arise. While dimensions of trust within the context of this human element were recognised, a greater understanding regarding the activation of trust (Wong *et al.* 2007), excessive control and distrust (Pinto, Slevin, and English 2008), and the reduced need for control through trust (Aubert and Kelsey

2000), would likely prove beneficial irrespective of the chosen procurement mechanism.

CONCLUSIONS

Stakeholder relationships operating within any construction environment are governed to a large degree by the chosen procurement mechanism. To this end, the transactional based approach of traditional procurement can be seemingly at odds with the facilitation of trust-based interactions. Similarly, the fundamental principles of relational contracting could be considered more conducive to, and reliant upon developing and maintaining high levels of trust. Hence varying and divergent influences of trust and its constructs would reasonably be expected within the management of projects operating under different contractual arrangements. However, this research has revealed that the chosen procurement mechanism is secondary to other more significant and influential factors.

The allocation of risk is instrumental in terms of driving stakeholder relationships and project outcomes, irrespective of the procurement mechanism. The respective risks on any project should therefore be a primary consideration in terms of the type of procurement mechanism, as well as contractual design. The fundamental principles of the selected procurement mechanism should also acknowledge the intricacies of the risk/trust nexus, and aim to find common ground between appropriate risk allocation and the development of trusting stakeholder relationships.

Given the reported importance of personal attitudes and subsequent trust-related behaviours to the subsequent conduct of project activities, it is perhaps an anomaly that attention is focussed on procurement as the primary determinant of project outcomes. Whilst the formalisation and mandating of trusting beliefs and behaviours is clearly impossible, more attention could be given to understanding the nature of a formalised environment conducive to allowing such behaviours to flourish.

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REASONS FOR CONTRACTORS' DELAY CLAIMS FAILURES IN SRI LANKA

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Project delays often occur due to the dynamic and complex nature of the construction industry and would lead to claims and disputes between contracting parties. Once a project exceeds the period contractually required to complete a project, there is bound to be an effect on expenditure or income of the contractor as well as the project owner. This study therefore determines the reasons for unsuccessful contractors' delay claims in Sri Lanka. The study administered a questionnaire survey to construction practitioners, contractors and consultants. A total of 55 respondents from both contracting companies (n = 40, with C1-C3 grading) and consultants (n = 15) were selected using stratified random and snowballing sampling methods respectively. The data obtained were analysed using descriptive statistics and Relative Importance Index (RII). The study found that time overrun occurs in 90% of projects in Sri Lanka and was indicative of the delays to settlement of contractors' claims. On average 60% of contractors submitted delay claims with only 40% success rate. The top most frequent reasons for unsuccessful claims include: inadequate documentation to substantiate claims, delayed submission of claim details, failure to establish link between cause and effect of claims and failure to use appropriate delay analysis method. Sri Lankan contractors explained that failure to use appropriate delay analysis method and contractors failing to mitigate the effects of the delays are also contributory factors to failures. In order to mitigate these issues, the study recommends that contractors adopt innovative strategies such as providing a contingency for the amount of claim failures under preliminaries or mark up at bidding stage and includes a measure of over valuation as a negotiating margin when preparing the claim first time. Also contractors would need to maintain up to date records of site transactions, while training of their staff to increase their knowledge of contract procedures are a necessity in Sri Lanka.

Keywords: delay claims, reasons for failures, Sri Lanka.

INTRODUCTION

Construction claims refer to any application by the contractor for payment and extension of time (EOT) for changes which arise outside the ordinary contract provisions (Chappell 2011). Claims are one of the significant concerns in the construction industry especially with increasing magnitude of complexity of modern day projects. With modern complex construction contracts claims have become inevitable when things go wrong.

Contractor's claims are contractual in nature and often experienced due to delays and disruptions to project objectives. For example, on average final cost at completion of

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mega projects in Korea have increased by 122 over original budget due to extended duration of 3.6 years on average (Han *et al.* 2009).

Iyer *et al.* (2008) explained that a claim could neither be completely accepted nor rejected, there is partial acceptance of the claim. On the similar note, Thomas (2001) indicates that often contractor's claims are under-settled, below a sum which reflects the contractor's full entitlement. For example, 86% of the respondents to a survey were of the view that clients always either reduce or completely reject contractors' claim entitlements in Zambia (Sibanyama, Muya and Kaliba 2012).

O'Connor (2003) stressed that many contractors damage their credibility by submitting complex and emotionally charged claims without addressing the primary requirements for a claim to succeed. However, Zaneldin (2006) is of the opinion that contractors accept partially approved claims as they are normally reluctant to refer to arbitration or litigation because of time and costs associated with these two methods of resolution.

The foregoing indicates that failure of delay claim occurs for several reasons that may be attributable to clients as well as contractors. Anecdotal evidence suggests that the rejection of contractors' claims seem to exist to a greater extent in the Sri Lankan construction industry. This research therefore primarily investigates the reasons why contractors' delay claims are unsuccessful in Sri Lanka and what strategies contractors use to mitigate the effects of such failure.

LITERATURE REVIEW

Construction delays refer to the time overrun either beyond completion date specified in a contract or the date that the parties agreed upon for delivery of a project (Assaf and Al-Hejji 2006). These are classified in to two major categories: excusable and non excusable (Bramble and Callahan 2011). Excusable delays are further classified as compensable or non compensable. Non excusable delays are compensable to the owner as to actual damages. These delays occur due to the fault of the contractor and therefore prevent contractors from obtaining a time extension and additional compensation (Bramble and Callahan 2011; Yates and Epstein 2006). Compensable excusable delays on the other hand are caused by owners or their representatives without any contributory fault of the contractor or its subcontractors. The contractor is entitled to a time extension for contract performance and additional financial compensation for the costs of delay, if the delay is deemed to be compensable (Bramble and Callahan 2011; Yates and Epstein 2006). Non compensable excusable delays occur due to the 'acts of god' or unforeseeable causes such as unusual severe weather conditions which are beyond the control of owners and contractors. These delays are not the fault of both parties and therefore often entitle the contractor to an EOT, but not to additional costs (Yates and Epstein 2006).

Difficulty of establishing fair and expeditious settlement of claims depended on untimely notification, poor record keeping, inadequate legal and factual justification and poor presentation (Sibanyama *et al.* 2012). On a similar note, O'Connor (2003) suggests that primary requirements for successful claims are timely notice of the claim in accordance with the terms of the contract, effective record keeping, establish entitlement and causation, calculate damages in accordance with the contract and negotiate the claim. The review suggests that reasons for the contractor's delay claims failures include: inadequate documentation to substantiate a claim, failure to notify the intention to claim in due time, delayed submission of the claim details, failure to

establish causal link, failure to establish entitlement to the claim, insufficient breakdown of claim amount, not calculate damages in accordance with the contract, not negotiate the claim and poor presentation of the claim. Kululanga *et al.* (2001) therefore suggest that to enhance the chances of success of claims, contractors need to closely follow the steps stipulated in the contract conditions, provide a breakdown of alleged additional costs and time and present sufficient documentation.

The foregoing review suggests that the following are responsible for contractor's delay claims failures.

- 1) Inadequate documentation to support a claim
- 2) Failure to notify the intention to claim in due time
- 3) Delayed submission of the claim details
- 4) Failure to establish causal link
- 5) Failure to establish entitlement to the claim
- 6) Insufficient breakdown of claim amount
- 7) Not calculate damages in accordance with the contract
- 8) Not negotiate the claim
- 9) Poor presentation of the claim.

RESEARCH METHODOLOGY

The research adopted a quantitative approach in order to answer the research question, why contractor's delay claims are unsuccessful. As Punch (2005) suggests, research approaches depend on the research questions posed in any study. Rea and Parker (2012) explained that there is no better approach to a research than a survey for collecting information about large population. Literature suggests delay claims are prevalent in different forms and cut across many different types of organizations in Sri Lanka. Therefore the research employed a survey approach using questionnaire as the data collection technique.

A total of fifty five (55) respondents were selected for the study from both contracting (40) and consulting (15) organizations. Samples of consulting and contracting companies were drawn from the registry of Chamber of Construction Industry (CCI) and the Institute for Construction Training And Development (ICTAD) based in Sri Lanka respectively.

Stratified random sampling was used in selection of each grade of contractors (C1 to C3). The sample size for each category of contractors was determined using the formula suggested by Bless, Higson-Smith and Kagee (2006).

$$n_s = \frac{n}{N} \times N_c$$

Where, n_s = Sample for the sector; n = Size of the sample, N = Population size; N_c = Category population (Bless, Higson-Smith and Kagee 2006).

Table 1: Sample size and the response rate

Category	Category population	Category sample	Response	Response Rate %
C1 contractors	22	10		
C2 contractors	22	10		
C3 contractors	52	20		
Total of contractors	96	40	30	75
Consultants		15	12	80
Total sample		55	42	76

A snowballing technique was used to select samples from consultants. Table 1 presents the sample size of each category and their respective response rates. A total of 42 responses were received out of 55 questionnaires which were sent out. This yields a response rate of 76% for the research.

Non parametric statistics involving descriptive statistics and Relative Importance Index (RII) were used to analyse the survey data. RII analysis is used for aggregating the scores of the factors rated on an ordinal scale to find the relative importance of each factor relevant to other. In addition, the Spearman’s rank correlation coefficient was used to find the degree of agreement between contractors and consultants in relation to rankings of reasons for failure of delay claims.

RESEARCH FINDINGS

Prevalence of delay claims in the Sri Lankan construction industry

In order to identify the extent the contracting firms submit delay claims, the respondents were asked to indicate their views in terms of: number of projects undertaken by their companies, number of projects that had time overruns, number of projects that had delay claims submission and number of projects that settled the claims without problems during last three years (2010 - 2012). Figure 1 gives an indication of number of projects that had time overruns.

As observed from Figure 1 majority, 76% of respondents indicated that time overruns occurred in more than 75% of the projects where they were involved. Only a 2% of respondents opined that less than 24% of their projects had experienced time overruns. This confirms that with 95% confidence time overruns occur in 78-90% of projects in Sri Lanka.

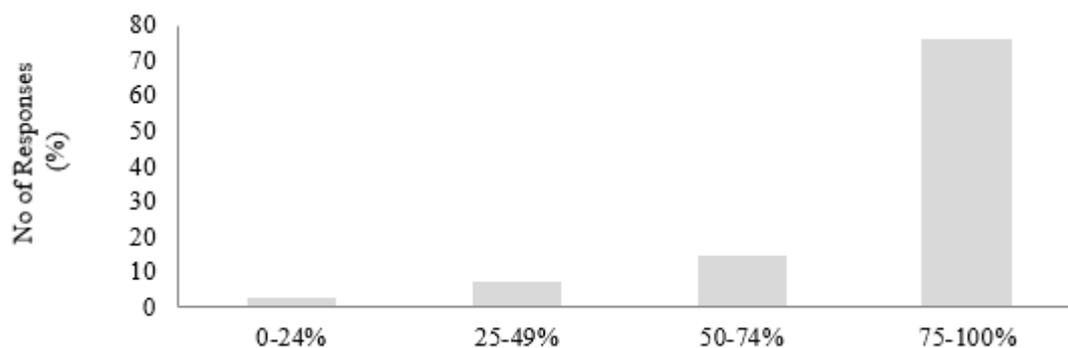


Figure 9: Projects that had time overruns in last 3 years (2010 - 2012)

Time overruns of projects could be an indicator of the potential delay claims by contractors. Thus an analysis was made of time overruns against the submission of

delay claims by contractors. Figure 2 presents the distribution of projects that had delay claims' submissions.

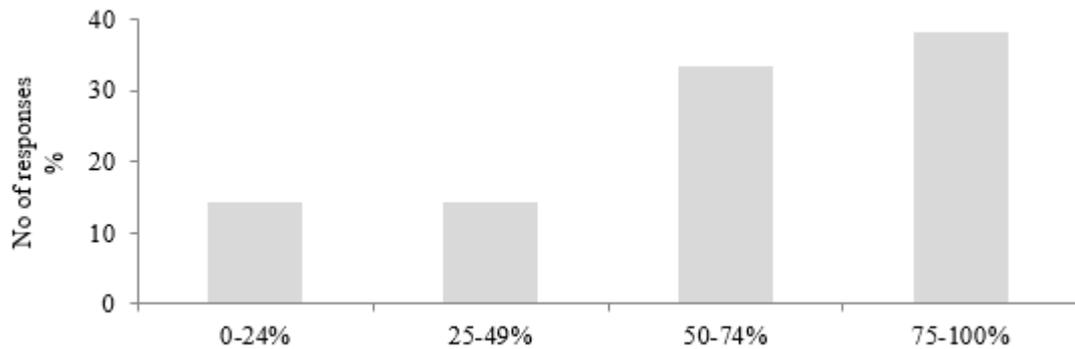


Figure 10: Projects that had delay claims submission in last 3 years

From Figure 2, 38% of the respondents reported that delay claims submission occurred in more than 75% of the projects that had time overrun. Nearly 14% of respondents indicated that delay claims submission occurred in less than 24% of the projects that had time overrun. This suggests with 95% confidence level that delay claims submission occurs in 50-70% of the projects delayed in Sri Lanka.

A comparison was made between claim submission and the extent of their settlement. As observed from Figure 3, 40% of respondents indicated that claims settlement was not problematic for only 24% or less number of projects that had delay claims submission. Nearly 12% of respondents indicated that among the projects that had delay claims' submission, more than 75% of the projects were successful in settlement. The analysis confirms that with 95% confidence only a 25-40% of the projects where delay claims were submitted, were successful with their claims in Sri Lanka.

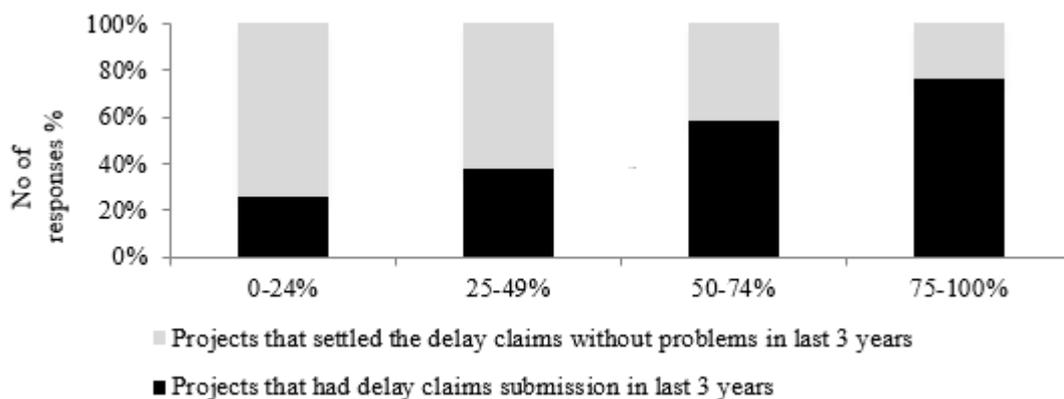


Figure 11: Comparison of claim submission and its settlement

Reasons for the failures of contractors' delay claims

This part of the questionnaire sought views of consultants and contractors on the most frequent reasons for failures of contractors' delay claims. A five point Likert scale where 1 represents 'never' and 5 represents 'very frequently' was used to identify the most frequent reasons for delay claims failures. A total of 9 reasons identified through literature review were tested in the Sri Lankan context. In addition, participants were asked to indicate any other reasons they have experienced. Table 2 provides the reasons for failures of claims and their respective relative importance values (RII).

Table 2: Reasons for the failures of contractors' delay claims and their frequencies

Reasons for the failures of claims	Contractors		Consultants		Overall	
	RII	Rank	RII	Rank	RII	Rank
Inadequate documentation to substantiate the claims	76.00	1	88.33	1	82.17	1
Delayed submission of the claim details	66.67	2	71.67	2	69.17	2
Failure to establish link between cause and effect of the claim	61.33	3	65.00	4	63.17	3
Failure to use appropriate delay analysis method	56.00	5	66.67	3	61.33	4
Failure to notify the intention to claim in due time	58.00	4	63.33	5	60.67	5
Failure to establish the entitlement to the claim	54.00	6	58.33	7	56.17	6
Contractor failed to mitigate the effects of the delays	50.00	8	61.67	6	55.83	7
Poor presentation of the claim	48.67	9	56.67	8	52.67	8
Not negotiate the claim	53.33	7	50.00	9	51.67	9
Damages are not calculated in accordance with the contract	42.67	11	46.67	10	44.67	10
Insufficient breakdown of claim amount	43.33	10	41.67	11	42.50	11

The spearman's rank correlation coefficient value of 0.92 indicates that there is a strong consensus between contractors and consultants in their rankings. As observed from Table 2, inadequate documentation to substantiate the claims is the most frequent reason for the failures of contractors' delay claims with an importance index of 82%. This finding confirms the criticism the construction industry has long received that the contractors' failure to maintain adequate records of project activities and their costs is most responsible for unsuccessful claims (Society of Construction Law 2002). As Yates and Epstein (2006) suggest extensive documentation is essential for the proper management of construction delay claims. Thus the FIDIC (1999) conditions of contract require the contractor to keep necessary contemporary records to substantiate any claim.

As seen from Table, delayed submission of claim details is the second most frequent (RII = 69.17%) reason for contractors' delay claim failure. It is not practical for project engineers to assess a claim for EOT, if the contractor does not submit the details of the claim at the date specified by the engineer. FIDIC conditions of contract (1999) require contractors to submit an account giving detailed particulars of the amount claimed and the grounds upon which the claim is based. This research found that failure to establish the link between cause and effect of the claim, use appropriate delay analysis method, notify the intention to claim in due time, and establish the entitlement to the claim are also responsible for unsuccessful claims.

A clear demonstration of the link between cause and effect is an essential ingredient for delay and disruption claims to be successful. In line with this view, Thomas (2001) suggests that claims which are based on logical analysis, where cause and effects are established, are at the high end of the probability scale of success. Delay situations therefore need a careful analysis to assess the resulting damages by satisfying the causation requirement. Although there are several techniques available to assess, determination of the appropriate technique to be used under given circumstances is a subjective decision and it is guided by experience, the available information and the other relevant factors.

Timely notice of a claim is not only critical to the success of the claim ultimately, but also provides the employer an opportunity to assess project circumstances to determine whether or not there is an alternative method of dealing with problem situations. As Yates & Epstein (2006) explain, most construction contracts require notice of the occurrence of a delay to be provided within a fairly short period of time. FIDIC conditions of contract (1999) require the contractor to give the notice relative to delays and constructive changes as soon as practicable as and not later than twenty eight days after the contractor became aware of the event or circumstance. If this requirement is not followed, claims may become invalid.

Table 3 compares the findings of this research with previous findings in terms of reasons for failures. As shown on the table, current study indicates that failure to use appropriate delay analysis method and contractors failing to mitigate the effects due to delays are also responsible for contractors' delay claims failures. However in terms of top most frequent reasons for failures, the findings of the current study seem to be in line with previous researchers.

Table 3: Comparison of reasons for the failures of contractors' delay claims

Reasons for the failures of claims	Rank	
	Authors	Previous studies
Inadequate documentation to substantiate the claims	1	1
Delayed submission of the claim details	2	3
Failure to establish link between cause and effect of the claim	3	4
Failure to use appropriate delay analysis method	4	-
Failure to notify the intention to claim in due time	5	2
Failure to establish the entitlement to the claim	6	5
Contractor failed to mitigate the effects of the delays	7	-
Poor presentation of the claim	8	9
Not negotiate the claim	9	8
Damages are not calculated in accordance with the contract	10	7
Insufficient breakdown of claim amount	11	6

Strategies to mitigate the losses due to failures of delay claims

Participants were asked to indicate the degree of agreement with the strategies that the contractors used to mitigate losses due to failures of delay claims. A five point Likert scale where 1= strongly disagree to 5 = strongly agree was used to assess the agreement with the strategies. Figure 4 presents the extent of agreement with three different strategies identified through literature review. The strategies identified include:

- A - Include contingency for the amount of claim failures under preliminaries at bidding stage
- B - When preparing construction programme allocate longer duration for the items that could appear variations
- C - Include a measure of overvaluation as a negotiating margin when preparing the claim at first time

As shown in Figure 4, nearly 60% of contractors agreed that contractors operate strategy A, include a contingency for the amount of claim failures under

preliminaries or mark up at bidding stage. Another 53% of contractors indicated that strategy B, assign longer duration for the items which are likely to have variations while executing the project, and preparing the construction programme is adopted by contractor. Nearly 73% of the contractors responded that they include a measure of overvaluation as a negotiating margin when preparing the claims at first time.

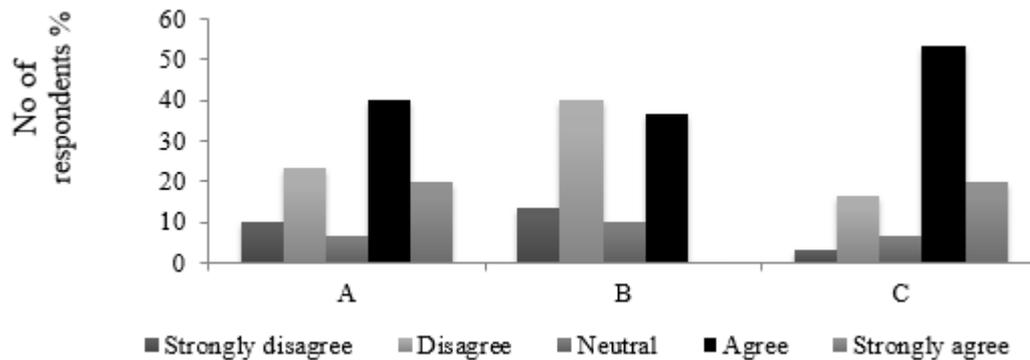


Figure 12: Strategies used by the contractors to mitigate the losses due to failures of delay claims

Most of the contractors agreed with the consultants' view that contractors include a measure of over valuation as a negotiation. This is consistent with the opinion of Thomas (2001), that even the most professionally prepared claim includes a measure of over valuation as it is a fact that the claim is unlikely to be paid in full.

CONCLUSIONS AND RECOMMENDATIONS

The research primarily investigated the reasons for contractors' delay claims unsuccessful in Sri Lanka and strategies the contractors adopt to mitigate the effects. Views collected through questionnaires distributed to contractors and consultants indicated that contractors' claims are mostly under settled, less than contractor's full entitlement. Contractors' claims are unsuccessful due to most frequent reasons of: inadequate documents to substantiate the claims, delayed submission of the claim details by contractors, failure to establish link between cause and effects of the claims and failure to use appropriate delay analysis method. Apart from past research findings, this study indicates that failure to use appropriate delay analysis method and contractors failing to mitigate the effects of the delays are contributory factors for the unsuccessful delay claims.

In order to mitigate the effects due to failures of delay claims, Sri Lankan contractors use the strategies of over valuation as a negotiating margin when preparing the claim at first time and include a contingency for the amount of claim failures under preliminaries or mark up at bidding stage.

This research therefore suggests that the following would minimise the failure of claims and enable settling claims with minimum cost without any party being disadvantaged adversely.

- Both parties to the contract need to behave professionally in submitting and evaluating the claims and treat the claim align with the contract. Contractors need to submit genuine documentations and consultants shall fairly evaluate those documents.
- Contractors need to anticipate the steps which could be taken by the clients or their representatives in evaluating claims. An independent review of the

strengths and weaknesses of claims prior to submission of the claims would make the claim success.

- Programme updates need to be treated as a crucial aspect of projects and newly developed computer systems could be employed to update construction programme as well as in providing detailed and accurate records of the project history.
- Contracting organisations could develop their own strategies and policies which could expedite the substantiation of EOT entitlements.

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ISN'T ALL LOSS CONSEQUENTIAL? A REVIEW OF RECENT CASE LAW AND ITS RELEVANCE TO CONTRACTUAL PRACTICES WITHIN THE BUILT ENVIRONMENT

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The term “consequential loss” frequently arises during contract negotiations in the context where one party is seeking to limit their liability should they subsequently breach that contract. Parties may have different understandings of the term and typically an exclusion clause will not solely relate to consequential loss, but will also include other heads of losses for which the party will not be liable for, such as loss of profit, loss of revenue and loss of business. The question emerges as to whether the term consequential loss has a definitive legal meaning in its own right. This study seeks to ascertain the definition of the term consequential loss within the construction industry through a review of the legal position regarding liability for breach of contract and consequential loss through the consideration of the case law relating to this topic and the associated secondary sources of information. The study concludes by elucidating a clear interpretation of the term consequential loss when used in contract law.

Keywords: contract law, consequential loss, damages, exclusion clause.

INTRODUCTION

Parties who enter into contracts are seeking to balance the risk and reward derived from that contract. The normal remedy for breach of contract in English law is to pay damages. Oliver Wendell Holmes wrote “*the duty to keep a contract at common law means a prediction that you must pay damages if you do not keep it - and nothing else,*” (Wendell Holmes, 1897).

However, the ability to recover damages for all losses is likely to discourage commercial transactions (Collins, 1993). Therefore it is common when negotiating contracts that the party providing goods or services will seek to limit their liability arising from a breach. This is where the problem develops though as according to Forfaria “*the law of damages ...suffers from an abundant terminology. In many cases, the words have lost their original meaning [and] require some elucidation,*” (Forfaria, 2006).

There are various ways in which liability can be limited. It may be by way of providing a financial cap on liability or by defining the types of losses that the party will be liable for as a result of a breach. Adopting the latter option, in defining the

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type of losses that the party will be liable for, the traditional approach is to define liability by exclusion. However, in doing this the parties “often rely on concepts and terminology which are not readily understood ...[and] ...are not necessarily relevant to the commercial risks of that particular deal,” (Sumroy *et al.*, 2010).

One such particular concept is that of consequential loss, which would appear to be a type of loss a party commonly seeks to exclude from their liability. The hypothesis examined in this paper is that the definition of the term consequential loss, and the type of losses to which it relates is unclear, or not understood at all. Therefore, clarification is required in order that its use is beneficial to those negotiating contracts can do so from an informed position.

THE CASE LAW REVIEWED

The renowned case of *Hadley v Baxendale*², sought to address the complete indemnity suggested by the decision in *Robinson v Harman*³. This case was also heard by Alderson, B, who in his decision provided further clarification of the position, narrowing the obligations established in the earlier case.

The case of *Hadley v Baxendale*⁴ concerned an appeal by a firm of carriers, Baxendale, who had been employed by the owners of a mill, Hadley, to transport a broken mill shaft to an engineering company. The engineering company were to use the broken mill shaft as a model for a replacement shaft. As this was the only shaft the mill possessed, the mill could not work until the shaft was replaced, and so the mill owners requested the shaft be delivered to the firm of engineers the next day.

However, the carriers did not deliver the shaft to the firm of engineers for seven days, during which time the mill lay idle. The owners of the mill therefore sought damages from the carriers for the loss of profits for the period that the mill was unworkable as a result of the delay in delivery of the mill shaft.

During the case, it was considered that the fact that the mill owners only had one mill shaft, so the mill could not operate until the broken shaft was replaced, were “*special circumstances [which] were...never communicated by the plaintiff to the defendants.*”⁵ Therefore, the case was found for the appellant, and it was held that they were not liable for the loss of profit incurred, as they were not aware that such damage may arise from a result of their breach.

In reaching his decision, Alderson, B established the rule governing the principle of remoteness, which was to apply in circumstances other than those for “*breach of contract in the non-payment of money, or in the not making of a good title for land,*”⁶ thus distinguishing this judgment from that he made in the case of *Robinson v Harman*⁷. The rule is as follows:

“Where two parties have made a contract, which one of them has broken, the damages which the other party ought to receive in respect of such breach of contract should be such as may fairly and reasonably be considered either arising naturally, i.e. according to the usual course of things, from such breach of contract itself, or

² *Hadley v Baxendale* (1854) 9 Ex 341

³ *Robinson v Harman* (1848) 1 Ex 850

⁴ *Hadley v Baxendale* (1854) 9 Ex 341

⁵ *Hadley v Baxendale* (1854) 9 Ex 341, 356.

⁶ *Hadley v Baxendale* (1854) 9 Ex 341, 355.

⁷ *Robinson v Harman* (1848) 1 Ex 850

such as may reasonably be supposed to have been in the contemplation of both parties, at the time they made the contract, as the probable result of the breach of it."⁸

This established the two categories of damages arising from a breach of contract that a party will be liable for, namely: those damages which "*may fairly and reasonably be considered to arise naturally from the breach*"⁹ and those damages "*as may reasonably be supposed to have been in the contemplation of both parties, at the time they made the contract, as the probable result of the breach of it.*"¹⁰

These two categories are commonly known as the first and second limbs of Hadley v Baxendale,¹¹ and this opinion of the court became known as the foresee-ability test, which is described as meaning "*you cannot be held liable for losses that you could not reasonably have anticipated,*" (Brewer, 2004).

It is 160 years since the decision in Hadley v Baxendale¹² was reached and the phraseology of the judgement has come under much criticism during this time, (McGregor, 2009), which has revolved around the understanding of the terms "*arising naturally*", and "*as the probable result*". Whilst many alternative terms were suggested, these were also heavily criticised and only led to further confusion. There was therefore a requirement for a restatement of the principle, which was provided by the judgement in Victoria Laundry (Windsor) Ltd v Newman Industries Ltd¹³.

The case concerned a contract where the defendant Newman, was to supply the plaintiff, Victoria Laundry with a replacement boiler for their laundry business. Newman was due to deliver the boiler on June 5th 1946; however prior to delivery the boiler was damaged so was not delivered until November 8th 1946, some 5 months later. The plaintiff therefore brought an action to recover damages arising from the late delivery of the boiler, and whilst they were successful in the first instance, the extent of damages they were able to recover, particularly in respect of lost profits went to appeal.

In his judgement, Asquith LJ, re-stated the principles established in Hadley v Baxendale¹⁴ as the following:

The first factor in assessing whether the damages are recoverable by the aggrieved party is the question of whether the damage arising from a breach of contract is "*loss actually resulting as was at the time of the contract reasonably foreseeable as liable to result from the breach.*"¹⁵

The second factor is that what is "*reasonably foreseeable*" depends on the knowledge possessed by the parties which can be either imputed or actual knowledge.

Imputed knowledge is that which "*everyone, as a reasonable person, is taken to know [in] the 'ordinary course of things,*"¹⁶ which is the type of loss contemplated by the

⁸ Hadley v Baxendale (1854) 9 Ex 341, 354.

⁹ Hadley v Baxendale (1854) 9 Ex 341, 354.

¹⁰ Hadley v Baxendale (1854) 9 Ex 341, 354.

¹¹ Hadley v Baxendale (1854) 9 Ex 341

¹² Hadley v Baxendale (1854) 9 Ex 341

¹³ Victoria Laundry (Windsor) Ltd v Newman Industries [1949] 2 K.B. 528

¹⁴ Hadley v Baxendale (1854) 9 Ex 341

¹⁵ Victoria Laundry (Windsor) Ltd v Newman Industries [1949] 2 K.B. 528

¹⁶ Victoria Laundry (Windsor) Ltd v Newman Industries [1949] 2 K.B. 528, 539

first limb of *Hadley v Baxendale*.¹⁷ Such knowledge is assumed to be possessed whether or not it is actually possessed.

In addition to imputed knowledge, the actual knowledge the contract breaker possesses may provide for “*special circumstances outside the ‘ordinary course of things,’ of such a kind that a breach in those special circumstances would be liable to cause more loss.*”¹⁸ Such loss in this event is the loss contemplated by the second limb of *Hadley v Baxendale*¹⁹ and in which event will be recoverable by the aggrieved party.

Asquith LJ, went further to explain that in assessing whether the loss was foreseeable, and hence recoverable, it is not necessary that the party “*should actually have asked himself what loss is liable to result from a breach*”²⁰. The question is whether a reasonable man, having considered the situation, would “*have concluded that such loss would be liable to result from the breach,*” and that it is not a requirement to “*foresee that the breach must necessarily result in that loss. It is enough, if he could foresee it was likely so to result*”.²¹

A recent challenge on the principles set out in *Hadley v Baxendale*²² was made in the decision of the case of *Transfield Shipping Inc V Mercator Shipping Inc (The Achilles)*²³. This case concerned the damages recoverable for the late redelivery of a ship by the charterers, Transfield, to its owners Mercator.

The redelivery was due for 2nd May 2004, and Transfield confirmed that it would be redelivered by that date. On the basis of this, Mercator entered into a new charter at the rate of \$39,500 a day starting 8th May 2004. During this time, the market was exceptionally volatile, and the daily rate for this new charter was significantly higher than was normal in the market. Due to a delay in the final voyage Transfield did not redeliver the ship until 11th May 2004, so Mercator were unable to fulfil the new charter. They entered into a replacement charter, but at a reduced rate of \$31,500 per day, and sought to recover damages from Transfield for the late redelivery, on the basis of the difference in the charter rates for the duration of the new charter.

The level of damages sought were in excess of \$1.3m, for a delay in redelivering the ship of 9 days, and so the extent of the damages called into question the commercial realities of the principles of *Hadley v Baxendale*²⁴.

However, the extent of the damages has never been a bar to recovery under the first limb of *Hadley v Baxendale*²⁵. This principle was upheld in the judgements of *Jackson v Royal Bank of Scotland*²⁶ where the House of Lords considered it incorrect to limit loss of profits to a one year period, and of *Brown v KMR Services*²⁷ where it was considered immaterial that the degree of loss was unforeseeable, as it was not unlikely that the claimant may suffer some financial loss. Therefore, the claim made by Mercator was initially accepted by the first instance arbitration hearing, on the

¹⁷ *Hadley v Baxendale* (1854) 9 Ex 341

¹⁸ *Victoria Laundry (Windsor) Ltd v Newman Industries* [1949] 2 K.B. 528, 539

¹⁹ *Hadley v Baxendale* (1854) 9 Ex 341

²⁰ *Victoria Laundry (Windsor) Ltd v Newman Industries* [1949] 2 K.B. 528, 540

²¹ *Victoria Laundry (Windsor) Ltd v Newman Industries* [1949] 2 K.B. 528, 540

²² *Hadley v Baxendale* (1854) 9 Ex 341

²³ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

²⁴ *Hadley v Baxendale* (1854) 9 Ex 341

²⁵ *Hadley v Baxendale* (1854) 9 Ex 341

²⁶ *Jackson v Royal Bank of Scotland* [2005] UKHL 3

²⁷ *Brown v KMR Services* [1995] 4 All ER 598

basis that the loss of a subsequent charter, through the late redelivery of a vessel, was a “*not unlikely*” occurrence. This judgement was also upheld by the High Court and Court of Appeal so went to the House of Lords.

The House of Lords overturned the previous judgement, and whilst this was a unanimous decision, the reasoning of the Lords was divided. The judgement of Lord Hoffman, with support from Lord Hope is of particular interest and is considered by Doe to “*suggest a potential development in law which may have important implications when drafting all kinds of commercial agreements, including construction and engineering contracts,*” (Doe, 2008). This potential development was the principle of the assumption of risk, which Lord Hoffman first identified in the case of *South Australia Asset Management Corporation v York Montague Ltd*²⁸, and required a test where “*one must first decide whether the loss for which compensation is sought is of a kind or type for which the contract breaker ought fairly to be taken to have accepted responsibility.*”²⁹

Lord Hope provided support for the views of Lord Hoffman stating:

*“The fact that the loss was foreseeable – the kind of result that the parties would have had in mind, as the majority arbitrators put it – is not the test. Greater precision is needed than that. The question is whether the loss was a type of loss which the party can reasonably be assumed to have assumed responsibility.”*³⁰

In order to apply the assumption of responsibility test, it is necessary to undertake an “*interpretation of the contract as a whole against its commercial background, and this, like all questions of interpretation, is a question of law*”³¹ which requires an understanding of implied terms on the basis developed in *Liverpool City Council v Irwin*³²

The views expressed by Lord Hoffman and Lord Hope are considered by Halladay to be a broad approach to grounds for allowing the appeal, the benefit of which “*is that you are not seeking to find what the parties would have said, but rather trying to find the ideal default position for that type of contract,*” (Halladay, 2009).

However Lord Rodger and Baroness Hale, with support from Lord Walker took a narrower approach in allowing the appeal, with Lord Rodger summarising this opinion:

*“neither party would reasonably have contemplated that an overrun of nine days would ‘in the ordinary course of things’ cause the owners the kind of loss for which they claim damages. That loss was not the ‘ordinary consequence’ of a breach of that kind. It occurred in this case only because of the extremely volatile market conditions ... this loss could not have been reasonably foreseen as being likely to arise out of the delay in question. It was, accordingly, too remote to give rise to a claim for damages for breach of contract.”*³³

²⁸ *South Australia Asset Management Corporation v York Montague Ltd* [1997] AC 191

²⁹ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL) 68

³⁰ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL) 73

³¹ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL) 71 (Lord Hoffman)

³² *Liverpool City Council v Irwin* [1977] AC 239

³³ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL) 81

Lord Walker referred to the principles established in the previous cases of *Victoria Laundry*³⁴ and *The Heron II*,³⁵ considering that it would be contrary to those judgements to hold the parties liable for losses relating to “*circumstances where the charterers had no knowledge or control over the new fixture entered into by the new owners.*”³⁶

Whilst the narrow approach was reached on the principles established in previous cases, the broad approach taken by Lords Hoffman and Hope had the potential to question previous understanding of the position with regard to liability for damages for breach of contract and it “*took the view that the notion of foresee-ability was not a sufficient test for remoteness of damage,*” (Lee, 2009).

However, there are specific facts in relation to this case, which are likely to have influenced the Lords in reaching their judgements, so must be considered. In the commercial world of shipping, the liability for loss for the late re-delivery of a chartered ship, in the usual course of events, has been confirmed in a variety of cases including *Hyundai Merchant Marine Co Ltd v Gesuri Chartering Co Ltd (The Peonia)*³⁷ as the difference between the charter rate and the market rate, for the period of delay in returning the ship.

Therefore, it could be considered that the owners of the ship were seeking to recover an extraordinary loss which was not a loss that “*might be reasonably expected in the ordinary course of things to flow from the non-fulfilment of the contract.*”³⁸ As such, they would not be entitled to recovery without knowledge of the special circumstances. The judgement is therefore consistent with the principles laid down in *Hadley v Baxendale*.³⁹

To avoid any doubt brought about by Lord Hoffman and Lord Hope as to whether the principles of *Hadley v Baxendale*⁴⁰ were still relevant following the case of *The Achilles*⁴¹, the judgement in the case of *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd*⁴² confirmed that the assumption of responsibility test was not a test to apply in the general course of things.

This case also related to the chartering of ships, however in this case, the ship’s owners failed to make the ship available to the charterers, which resulted in the loss of a sub-charter. The charterer’s claimed against the ship owners for the loss of the sub-charter, and contrary to the decision in *The Achilles*⁴³ the claim was allowed as it was considered that the loss of the sub-charter was a loss that was foreseeable as sub-chartering was common practice within the shipping industry. It therefore fell within the first limb of *Hadley v Baxendale*⁴⁴ as it arose naturally, according to the usual

³⁴ *Victoria Laundry (Windsor) Ltd v Newman Industries* [1949] 2 K.B. 528

³⁵ *Koufos v C. Czarnikow Ltd.: The Heron II* [1969] 1 AC 350

³⁶ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL) 88

³⁷ *Hyundai Merchant Marine Co Ltd v Gesuri Chartering Co Ltd (The Peonia)* [1991] 1 Lloyd's Rep 100

³⁸ *Cory v Thames Ironworks & Shipbuilding Co Ltd* (1868) LR 3 QB 181, 190 (Blackburn J)

³⁹ *Hadley v Baxendale* (1854) 9 Ex 341

⁴⁰ *Hadley v Baxendale* (1854) 9 Ex 341

⁴¹ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

⁴² *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd* [2010] C.L.C 470

⁴³ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

⁴⁴ *Hadley v Baxendale* (1854) 9 Ex 341

course of things, and as stated in *The Heron II*⁴⁵ was “*not unlikely to result from the breach*”⁴⁶.

Hamblen, J confirmed in his judgement in *Sylvia Shipping*⁴⁷, that contrary to suggestions in *The Achilleas*⁴⁸, the principles of *Hadley v Baxendale*⁴⁹ still apply. He stated that the application of those principles were the “*orthodox approach*”⁵⁰ which remains the “*standard rule, and it is in only relatively unusual circumstance, such as The Achilleas itself, where a consideration of an assumption of responsibility may be required... it is important to be made clear, that there is no new generally applicable legal test of remoteness in damages.*”⁵¹ The relatively unusual circumstances he referred to, in which a test of the assumption of responsibility may apply would be those “*where the application of the general test leads or may lead to an unquantifiable, unpredictable, uncontrollable or disproportionate liability or where there is clear evidence that such a liability would be contrary to market understanding and expectations*”⁵²

Whilst the *Sylvia Shipping*⁵³ case has confirmed the principles of *Hadley v Baxendale*⁵⁴ a further challenge to this, and further reference to the test of assumption of responsibility was made in the case of *Supershield Ltd v Siemens Building Technologies FE Ltd*,⁵⁵ where Siemens were contracted to install a sprinkler system and they sub-contracted the installation of the tank to Supershield. Due to a failure in a float valve that was installed by Supershield, water escaped into a bunded area; however, the drains to that area were blocked causing water to overflow the bund and damage electrical equipment.

Siemens made claim against Supershield, who argued that the flood arising from the overflow of the bunded area, was too remote a consequence for them to be liable under the proper application of the rules in *Hadley v Baxendale*⁵⁶. However, Supershield were found to be liable for the losses arising from the flood, and whilst some discussion was made of the assumption of responsibility test raised in *The Achilleas*⁵⁷, Toulson, J succinctly summarised the position with regard to liability for breach of contract as follows:

“Hadley v Baxendale remains a standard rule but it has been rationalised on the basis that it reflects the expectation to be imputed to the parties in the ordinary case, i.e. that a contract breaker should ordinarily be liable to the other party for damage resulting from his breach if, but only if, at the time of making the contract a reasonable person in his shoes would have had damage of that kind in mind as not unlikely to result from a breach. However, South Australia and Transfield Shipping are authority that there may be cases where the court, on examining the contract and

⁴⁵ *Koufos v C. Czarnikow Ltd.: The Heron II* [1969] 1 AC 350

⁴⁶ *Koufos v C. Czarnikow Ltd.: The Heron II* [1969] 1 AC 350, 382 (Lord Reid)

⁴⁷ *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd* [2010] C.L.C 470

⁴⁸ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

⁴⁹ *Hadley v Baxendale* (1854) 9 Ex 341

⁵⁰ *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd* [2010] C.L.C 470, 477

⁵¹ *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd* [2010] C.L.C 470, 481

⁵² *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd* [2010] C.L.C 470, 479

⁵³ *Sylvia Shipping Co Ltd v Progress Bulk Carriers Ltd* [2010] C.L.C 470

⁵⁴ *Hadley v Baxendale* (1854) 9 Ex 341

⁵⁵ *Supershield Ltd v Siemens Building Technologies FE Ltd* [2010] 1 CLC 241

⁵⁶ *Hadley v Baxendale* (1854) 9 Ex 341

⁵⁷ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

the commercial background, decides that the standard approach would not reflect the expectation or intention reasonably to be imputed to the parties."⁵⁸

Not only does this confirm that *Hadley v Baxendale*⁵⁹ remains the appropriate test, but also provides clarification regarding the decision in *The Achilleas*⁶⁰ which considered the defaulting party's liability in respect of their imputed knowledge, a requirement that was established by Asquith, LJ in *Victoria Laundry*⁶¹, and which in the case of *The Achilleas*⁶² reduced the party's liability.

In summary, despite the judgement being handed down 160 years ago, the two limbed test of *Hadley v Baxendale*⁶³ remains the overriding principle for establishing liability for damages as a result of a breach of contract. This provides that a party to a contract shall be liable for those losses arising from a breach of that contract which firstly arise naturally, in accordance with the usual course of things, and secondly which are in the contemplation of the parties at the time of entering into the contract as the probable result of the breach.⁶⁴ Those losses which occur in the usual course of things are determined by the imputed knowledge, that a reasonable person is taken to know, and also the actual knowledge of special circumstances which will be in the contemplation of the parties at the time of entering into the contract.⁶⁵ Such losses shall not be unlikely a result of the breach, which is a lesser obligation from that in tort, except where the special circumstances giving rise to the breach have been made known to the parties at the time of entering into contract.⁶⁶ In exceptional circumstances, imputed knowledge can impose an assumption of responsibility which can either reduce, or increase, the liability of the defaulting party.⁶⁷

CONCLUSIONS

There is no succinct, all-encompassing and conclusive definition of the term consequential loss under English law, but the courts have sought to determine a definition through the application of principles established in the case of *Hadley v Baxendale*.⁶⁸ This case has received widespread and enduring acceptance over the years and has been described as "*a fixed star in the jurisdictional firmament*," (Gilmore, 1974). However it is a case which did not concern the term consequential loss, and it could be argued did not even concern a breach of a specific contract.

The current position in English law is that the division between direct and consequential loss has been drawn along the lines of the first and second limbs of *Hadley v Baxendale*,⁶⁹ yet the divisions between these is not clear cut. The second limb requires knowledge of special circumstances, yet once these special circumstances are known there is the potential for the damages to be considered direct rather than consequential, so the two limbs become one. Sedley LJ acknowledged this

⁵⁸ *Supershield Ltd v Siemens Building Technologies FE Ltd* [2010] 1 CLC 241, 253

⁵⁹ *Hadley v Baxendale* (1854) 9 Ex 341

⁶⁰ *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

⁶¹ *Victoria Laundry (Windsor) Ltd v Newman Industries* [1949] 2 K.B. 528

⁶² *Transfield Shipping Inc v Mercator Shipping Inc* [2009] 1 A.C 61 (HL)

⁶³ *Hadley v Baxendale* (1854) 9 Ex 341

⁶⁴ *Hadley v Baxendale* (1854) 9 Ex 341

⁶⁵ *Victoria Laundry (Windsor) Ltd v Newman Industries* [1949] 2 K.B. 528

⁶⁶ *Koufos v C. Czarnikow Ltd.: The Heron II* [1969] 1 AC 350

⁶⁷ *Supershield Ltd v Siemens Building Technologies FE Ltd* [2010] 1 CLC 241

⁶⁸ *Hadley v Baxendale* (1854) 9 Ex 341

⁶⁹ *Hadley v Baxendale* (1854) 9 Ex 341

in *Hotel Services*⁷⁰ stating that the limbs of *Hadley v Baxendale*⁷¹ were “*not a dichotomous but rather a continuous classification.*”⁷² Conversely, it could be argued that if there was no knowledge of the special circumstances which enabled the loss to arise, there would be no liability in any case, and so a reference to consequential loss would become redundant.

The courts have clearly struggled with interpreting the definition of consequential loss, and this is evident by the fact that there is difficulty in identifying any case precedent where the judgement has disallowed recovery of a loss on the basis of it being excluded by a consequential loss clause.

Based on the above study, the meaning of consequential loss remains elusive and ultimately unnecessary and the principles of liability arising from causation, foreseeability and knowledge, both imputed and actual, would be no less effective without it. Therefore the use of the term consequential loss in limiting liability is of little benefit, and the “*best way forward*” and the only way to be sure of reducing ones liability “*is to specify in exclusion clauses precise definitions of the possible damages that are excluded or included*” (Chetwin, 2011).

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⁷⁰ *Hotel Services Ltd v Hilton International Hotels (UK) Ltd* [2000] BLR 235

⁷¹ *Hadley v Baxendale* (1854) 9 Ex 341

⁷² *Hotel Services Ltd v Hilton International Hotels (UK) Ltd* [2000] BLR 23, 240

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PLANNING LAW REFORM AND FAST-TRACKING DEVELOPMENT IN AUSTRALIA

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Statutory planning and building systems in Australia, like many other countries, have undergone significant reform in recent years. A key focal point of these reforms has been to streamline, simplify and progress the assessment and approval of building and other development projects. Generically referred to as ‘fast-tracking’, this element of the reform agenda is typically set within a discourse which uses terms, for example, of removing ‘red tape’ and ‘delay’, and of promoting ‘simplification’ and ‘appropriate assessment’ of planning approvals. While considering the area of planning reform in Australia generally, emphasis in the paper is placed on the state of New South Wales (NSW), Australia’s most populous state. From a contextual case study analysis of statutory planning reform in NSW over the past two decades, this paper seeks to demonstrate that there has been a paradigm shift in the nature and purpose of town planning which has been driving this reform process. Increasingly reform of statutory planning and building systems are perceived by governments as essential for the stimulation of economic activity.

Keywords: development assessment, fast-tracking, planning approvals, statutory planning reform.

INTRODUCTION

In 2014 the Planning Institute of Australia devoted a special edition of its journal *Australian Planner* to topic of planning reform in Australia. Specifically, the catalyst for this publication was a decade of sustained reform of planning systems across Australia (Ruming and Gurran 2014). Under the Australian Constitution planning is primarily a state, rather than a national, responsibility, and all six state governments have been engaged in a lengthy process of reform at both the strategic and statutory planning levels. A number of similar themes are apparent in terms of both the drivers of these reforms, and also the type or character of the changes proposed and adopted. Further, a fundamental consistency is apparent in the planning reform occurring in Australia and that evident in countries with a similar planning heritage such as England and New Zealand (Gunn and Hillier 2012, 2014; Goldfinch and Roberts 2013; Gurran et. al. 2014). A key point of difference with planning reform in Australia however is the fragmented and complex characteristic of planning systems in that country, with planning jurisdiction divided amongst the six state, two territory, and national governments.

The aim of this paper is to demonstrate that there has been a paradigm shift in the nature and purpose of town planning which has been driving the reform process. Increasingly reform of statutory planning and building systems is perceived by

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governments as essential for the stimulation of economic activity. Thus, a focal point of statutory planning and building systems reforms in Australia has been to streamline, simplify and progress the assessment and approval of building and other development projects (Williams 2012). Generically referred to as ‘fast-tracking’, this element of the reform agenda is typically set within a discourse which uses such terms as removing ‘red tape’ and ‘delay’, and of promoting ‘simplification’ and ‘appropriate assessment’ of planning approvals.

Context for this paper is provided through the background of neo-liberalism and micro-economic reform, and draws in particular on the previous work in this area of Gleeson and Low (2000). More specifically, the theoretical framework of corporate liberalism and the entrepreneurial state can explain historically, the manipulation of the statutory planning system to fast-track approvals to permit investment in large infrastructure and development projects. Moreover, this reform agenda has progressively extended to include other (smaller) development and building projects so as to promote the level of investment, employment and construction activity across the property development sector generally. Following a broad consideration of planning reform in Australia, focus is directed to the state of New South Wales (NSW), Australia’s most populous state. Much of the reform in NSW has centred on the primary planning statute, the *Environmental Planning and Assessment Act 1979* (‘EP&A Act’), which is analysed in detail.

CONTEXT TO STATUTORY PLANNING REFORM IN AUSTRALIA

Set against increased stakeholder expectations in the service delivery of planning systems, is the added presence of general political pressures driving planning reform. In a specific sense, planning systems have been impacted upon through states’ neo-liberal requirements for the fast-tracking of the planning process, the privatisation of many public industries and services, and the reduction in public spending (Blowers 2000). Considered here are the historical, political and philosophical contexts within which planning reform has taken place in Australia. Regulatory reform of the development control process – the statutory framework within which development proposals are assessed and determined – is a common theme across the planning systems in the states and territories of Australia. Gleeson and Low (2000) perceive this kind of regulatory reform as consistent with the latest form of urban governance in Australia, which they term ‘corporate liberalism’. They argue that corporate liberalism is a response to the pressures of globalisation and note that it ‘combines handing over the social functions of government to the private sector with strong direction from the political level and close relations with business’ (Gleeson and Low 2000: 5). Corporate liberalism denotes a form of governance in which the state envisages itself as a corporation engaged in the business of attracting business, thereby creating an ‘entrepreneurial state’. The resulting competition between state governments to attract international and domestic capital – caused in part by the perceived forces of globalisation – has been a driving force for planning system reform (Williams 2012).

Governments want their states and capital cities to be attractive places for national and international investment, economic activity, employment generation, and development. Therefore they have embarked on ‘reform’ by removing unnecessary regulatory red tape and delay; manifestations of corporate liberalism in the field of statutory planning reform in Australia include:

- Greater commercialisation of state and local government administrative (including planning) departments, most typically through their designation as ‘business units’, and outsourcing of government functions to the market/private sector.
- The increasing role of the private sector in the regulatory control of development (witnessed by the rise of private certification of some proposals and building work, a move justified on the grounds of promotion of competition, greater efficiency and responsiveness to the needs of business).
- ‘De-politicisation’ of both state and local level planning and development decision-making through increasing use of expert independent panels (for example planning panels assuming significant decision-making roles previously undertaken by local councils).
- Provision for the ‘appropriate assessment’ of development proposals (examples include ‘code assessable development’ and ‘exempt and complying development’).
- Streamlining and the fast-tracking of development proposals (examples include ‘integrated development assessment’; assigning proposals as ‘state significant development’, which is determined through a specific, generally less transparent and robust assessment regime at the state or ministerial level; and special purpose legislation for particular types of development such as infrastructure).

At the national level, the Council of Australian Governments (COAG), established by the Commonwealth Government in 1992 as the peak intergovernmental forum in Australia, has been an influential player in setting the broad contours of policy reform. In 1995 COAG ratified the National Competition Policy recommendations arising from the 1993 Hilmer Report, which saw the incorporation of significant reforms into state planning systems (including responses such as private certification). Also of significance was the establishment in 1998 of the federally led and funded Development Assessment Forum (DAF) in response to the 1996 Bell Report on small business regulation (Commonwealth of Australia 1996). Membership of DAF includes Commonwealth, state and local government; the development industry; and related professional associations. DAF provides recommendations to Commonwealth and state planning and local government ministers and has promoted leading practice regulatory reform including goals such as private sector involvement and professional determination for most development applications.

Finally, the Productivity Commission and its predecessor the Industry Commission have been central to shaping the agenda for planning reform in Australia since the mid-1990s. In its 1995 assessment of the benefits to economic growth and revenue-raising from the implementation of the National Competition Policy, the Industry Commission (1995) identified regulatory reform in the development approvals system as potentially capable of delivering annual efficiency gains worth AU\$750 million nationally. More recently, during 2010 the Productivity Commission (2011) undertook a benchmarking study of the states’ and territories’ planning and zoning systems. Initiated at the request of COAG, the Productivity Commission report endorsed COAG’s regulatory reform agenda, and acknowledged the ongoing work of DAF, particularly in creating a leading practice model for planning systems (DAF 2005).

FAST-TRACKING DEVELOPMENT ASSESSMENT IN NSW

Described and analysed below, in broad chronological order, are the reforms to the NSW statutory planning system. Focus is placed on those reforms which relate, either specifically or incidentally, to fast-tracking the assessment and determination of development projects. Like other states, the regulatory reform agenda in NSW has been relentless, with major changes to legislation and planning instruments since 2005

in particular reflecting the aim of facilitating both large- and small-scale developments through streamlining and fast-tracking approvals. Yet the period under consideration stretches over 20 years: beginning in 1993 with amendments to the EP&A Act, to the present day with the formulation of proposed new planning legislation, the Planning Bill 2013 (see Table 1).

Integrated development assessment

On 1 July 1998, the reforms contained in the *Environmental Planning and Assessment (Amendment) Act 1997* (the Amendment Act) came into force in NSW. The Amendment Act repealed the previous Part 4 ('Environmental Planning Control') of the EP&A Act and replaced it with a new Part 4 ('Development Assessment'). This legislative action represented the response by the NSW Government to a series of national and state proposals and policy initiatives for microeconomic reform and a reduction of government red tape pertaining to regulatory bodies involved in development approvals processes. These included implementation of national competition policy reforms arising from the Hilmer Report (NSW Government 1996) and an inquiry into government regulations affecting development (Sturgess 1994).

Table 1: The course of statutory planning reform in NSW: 1993-2013

Year/Period	Reforms	Key reform documents	Key legislative changes
1993-1994	'Proto-reforms' to the development and building assessment systems	<i>Thirty Different Governments: Report of the Commission of Inquiry into Red Tape</i> (1994)	<i>Local Government Act 1993; Local Govt (Consequential Amendment) Act 1993</i>
1997-1998	Integrated development assessment	<i>Regulatory Innovation: Regulating for Results</i> (1996); <i>Towards an Integrated Land Use, Planning and Natural Resources Approvals Policy for NS W</i> (1996); <i>Integrated Development Assessment White Paper</i> (1997)	<i>Environmental Planning and Assessment (Amendment) Act 1997</i>
1999-2001	'Plan First' – Plan Making in NSW	<i>Plan making in NSW: Opportunities for the future – discussion paper</i> (1999); <i>Plan First: Review of plan making in NSW</i> (2001)	
2003-2004	Ministerial Taskforces	<i>Improving Local Development in NSW</i> (2003); <i>Planning System Improvements</i> (2003)	<i>State Environmental Planning Policy (Repeal of Concurrence and Referral Provisions) 2004</i>
2005-2006	Part 3A, EP& A Act; Standard Instrument LEP	<i>Improving the NSW planning system</i> (2004)	<i>Environmental Planning and Assessment Amendment (Infrastructure and Other Planning Reform) Act 2005; Standard Instrument (Local Environmental Plans) Order 2006</i>
2007-2008	Housing, Commercial and Industrial Development Codes	<i>Improving the NSW planning system</i> (2007)	<i>State Environmental Planning Policy (Exempt and Complying Development Codes) 2008</i>
2009-2010	Nation Building-Economic Stimulus Package	<i>Review of Implementation of the Nation Building and Jobs Plan</i> (2010)	<i>Nation Building and Jobs Plan (State Infrastructure Delivery) Act 2009</i>
2011-2013	New Planning Act	<i>The Way Ahead for Planning in NSW? Issues Paper</i> (2011); <i>The Way Ahead for Planning in NSW</i> (2012); <i>Green Paper - A New Planning System for NSW</i> (2012); <i>White Paper – A New Planning System for NSW</i> (2013)	Planning Bill 2013

Source: Compiled by authors.

Related 'proto-reforms' by the NSW Government included major legislative change in the form of the *Local Government Act 1993* and consequent amendments to the EP&A Act (to partially integrate the types of approvals available under both statutes). These were soon followed in May 1996 by the release of two Green Papers by the Department of Urban Affairs and Planning (DUAP 1996a, 1996b). The Green Papers invited public comment and culminated in the release in February 1997 of a White

Paper titled *Integrated Development Assessment* and an accompanying Exposure Draft Bill (DUAP 1997), a modified version of which was gazetted in 1997 as the abovementioned Amendment Act. It commenced in July 1998.

Three principal areas of reform were introduced by the 1998 integrated development assessment amendments. These were integrated development consents, provisions for appropriate assessment, and an increased role for the private sector in the assessment process. Integrated development consents involved the introduction of a new single assessment system for development, building and subdivision control; rationalisation of other local government approvals relating to building work with a development consent granted under the EP&A Act; and linking of approval requirements under other Acts with a development consent granted under the EP&A Act. This latter aspect of integration of development approvals sought a more coordinated and integrated approach to development assessment among state agencies. In terms of provisions for appropriate assessment, amendments to the EP&A Act to implement this reform goal included simplification and rationalisation of assessment criteria for development applications; clarification of assessment procedures for 'local development' and 'state significant development'; creation of a new category of 'exempt development' (that is, minor proposals not needing any form of approval); and introduction of a specific assessment process for a newly created category of routine 'complying development'. Finally, regarding the increased role for the private sector in the assessment process, new Parts – 4A, 4B and 4C – were introduced to the EP&A Act to create a system of private certification of development within the NSW planning system. Reforms included appointment of 'accreditation bodies', which enabled professional associations to act in partnership with government in the implementation scheme. It also enabled (private) accredited certifiers to perform compliance functions formerly conducted by consent authorities, enabling 'accredited certifiers' to issue five new types of certificates: complying development, compliance, construction, occupation and subdivision certificates.

Plan First and Ministerial Taskforces

The next step in planning system reform came in 1998-2001 with a review of the statutory plan-making system existent under Part 3 of the EP&A Act. A Green Paper was released by DUAP in February 1999 and finally a White Paper titled *Plan First: Review of plan making in NSW* in February 2001. This package of reforms was branded as 'Plan First' and not only proposed to rationalise the State's land use planning controls, but also sought to integrate into the statutory planning framework (and hence place under greater control by DUAP), the growing array of natural-resource-based plans that were being created outside the EP&A Act by other Government bodies. Laudable as these concerns over the growing fragmentation of the land use planning and natural resource management systems were, this integrative element of the Part 3 reforms was overshadowed by opposition to Plan First from within the State bureaucracy and local government: the threats to established bureaucratic interests which this program posed would prove insurmountable (Freestone and Williams 2012). In addition, there was growing dissatisfaction within local government, the community and developers, that the earlier integrated development assessment reforms had not realised their anticipated benefits (DIPNR 2003a). It was in this context that from the middle of 2003 the NSW Planning Minister announced the establishment of a number of Ministerial Taskforces to review the operation of key aspects of the NSW planning system

In order to guide reform, during 2003, eight taskforces were established to review and report on aspects of the NSW planning system that had been of concern. Relevantly, the areas of local development assessment (DIPNR 2003a), statutory and strategic plan making (DIPNR 2003b), and major development and infrastructure projects, were examined by three of the taskforces. The concerns of the development industry had been accorded significant weight in the review process (evident, for example from the composition of membership of the taskforces) and these would be factored more explicitly in the next and more decisive round of reform emanating from the taskforce recommendations (Piracha 2010; Freestone and Williams 2012). These reforms were flagged in 2004 (DIPNR 2004) and initiated in 2005-2006 and included the Standard Instrument – provision for the production of standardised environmental planning instruments; introduction of Part 3A of the EP&A Act for ministerial determination of major and contentious developments; improvement of development assessment by removing unnecessary concurrences; and an extension of exempt and complying development through adoption of state-wide codes for housing, industrial and commercial development.

The Standard Instrument

The adoption of the Standard Instrument as part of the NSW Government's response to the recommendations of the planning reviews undertaken by the various Ministerial taskforces was initiated with the enactment of the *Environmental Planning and Assessment Amendment (Infrastructure and Other Planning Reform) Act 2005* ('the 2005 Amendment Act'). The Standard Instrument reform allowed for a standard Local Environmental Plan (LEP) template for the entire state. The specific form and content – i.e. 'template' – that principal LEPs were to adopt was subsequently prescribed in March 2006 in the *Standard Instrument (Local Environmental Plans) Order 2006*. The LEP template uses standard: zones (including standard zone objectives and mandated permitted and prohibited uses); definitions; clauses; and format. Councils can choose from 35 standard zones when preparing new principal LEPs for their local government area. The intention of the Standard LEP was to create 'a common and simplified vocabulary to facilitate faster development assessment' (Freestone and Williams 2012: 202). Its main drivers have been argued by Australian planning commentator and lawyer John Mant (2008) to be lobbying from producers of standard urban products (subdivisions, project homes, shopping centres and fast food outlets) and the mitigation of bureaucratic workloads. Implementation of the Standard LEP has been a resource-intensive exercise for local councils in NSW – although the exercise was intended to occur over a 2-5 year time period, as at April 2014 approximately 10% of councils were still to finalise standard instrument LEPs (DPI 2014a).

Part 3A

Also with the passage of the 2005 Amendment Act the government created a separate 'streamlined' assessment regime – Part 3A – for major projects, including state government infrastructure projects and state-significant development. Part 3A was established by the government in recognition of the complexity of a planning system of its own making. The application to major projects of the integrated development assessment provisions of the EP&A Act introduced in 1998, was dramatically curtailed by Part 3A. Confronted also by indicators pointing to a serious economic downturn, the intention of Part 3A was to consolidate the maze of numerous assessment and approval pathways for major projects determined by the Minister for Planning then possible under the EP&A Act.

The key aims of Part 3A were to enable business “*to work with certainty, a minimum of risk, low transaction costs, and appropriate level of regulation*”; to assist in the NSW Government’s “*desire to afford opportunities for the private sector to participate in the delivery*” of infrastructure such as projects for roads and transport, schools, hospital upgrades, and water and energy projects; and to cut red tape and to facilitate major private sector development and public infrastructure delivery “*quickly and efficiently*”. *State Environmental Planning Policy (Major Development) 2005* was enacted simultaneously, and defined the types and scale thresholds for state significant development, and designated specific sites considered to be important in achieving state or regional objectives. Hundreds of projects eventually were identified and assessed under Part 3A procedures, including some controversial sites. However, Part 3A was criticised for limiting public participation and reducing environmental scrutiny, and thus undermining the objectives of the EP&A Act (Campbell-Watt 2006; Carr 2007). Moreover, the number of outright refusal of Part 3A approvals overall was miniscule relative to the large number of applications (EDO 2010). Even some sections of the development industry were becoming concerned, with the Urban Development Institute of Australia by early 2001 suggesting that Part 3A had “*reached its use-by date*” (SMH 2011). It came as no surprise that one of the first policy decisions made following the NSW State Election in March 2011 was for the incoming Government to repeal Part 3A in June 2011, replacing it with new provisions for state significant development (Part 4, Division 4.1) and state significant infrastructure (Part 5A).

Exempt and Complying Development SEPP

The next series of significant reforms began in 2007 with the release by the Department of Planning (DoP) of a detailed discussion paper titled *Improving the NSW planning system*. Included amongst the wide ranging reform proposals was the aim of increasing the level of exempt and complying development in NSW. These categories of development had existed since the 1997-98 reform, but had not reached the levels (a target of 60% of all developments) hoped for by the State Government (DoP 2007). By 2001 the number of development applications had increased by two and a half times whilst usage of complying development had fallen, with complying development certificates accounting for only 11% of all development decisions (DoP 2008). The main reason for this poor take-up was identified as local councils’ reluctance to embrace exempt and complying development in their local planning controls (DoP 2007). At the same time the NSW Independent Pricing and Regulatory Tribunal *Report on the Investigation into the burden of regulation in NSW and improving regulatory efficiency* included recommendations that DoP needed to consider ways to increase the use of, and achieve a more consistent approach to exempt and complying development (IPART 2006).

In response, the Department identified the preparation of a common set of standards – a ‘new mandatory default code for NSW’ – for different development types, with the goal of achieving 50% complying and exempt development (DoP 2007).

Consequently, the vehicle employed to operationalise this code was *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* (‘the Codes SEPP’), which commenced in February 2009. Specifically, the SEPP gives legal effect to a State-wide code for exempt development and a series of State-wide codes for complying development. Since its commencement the Codes SEPP has undergone numerous amendments and additions: so that currently embedded in the SEPP are codes for general housing; rural housing; housing alterations; general development; commercial and industrial alterations; commercial and industrial (new

buildings and additions); subdivision; and demolition. The effectiveness of the Codes SEPP may be measured by the steady increase, to 25% in 2012-13, in the percentage of development determined as complying development (DPI 2014b).

Nation-Building Economic Stimulus Package

In response to the 2008 Global Financial Crisis (GFC), the Australian Government announced a range of stimulus measures between October 2008 and March 2009. Collectively known as the Nation Building-Economic Stimulus Plan (NBESP), the primary initiatives were the December 2008 AU\$10.4 billion Economic Stimulus Plan and the February 2009 AU\$42 billion Nation Building and Jobs Plan. The *Nation Building and Jobs Plan (State Infrastructure Delivery) Act 2009* ('NBJP Act') was enacted by the NSW Government on 13 March 2009 to ensure the timely delivery in NSW of infrastructure projects funded by the Australian Government under the NBESP. A key objective of the NBJP Act was to fast track projects and the subsequent expenditure of NBESP funds, so that a steady flow of jobs was secured. Developments falling under the provisions of the Act included school buildings, social housing, community infrastructure and land transport infrastructure. The Act required the appointment of a NSW Infrastructure Coordinator General, to plan and oversee a program for the delivery of the infrastructure projects and also to exempt these projects from development control legislation (including the EP&A Act) where there was a demonstrated risk that a project would not meet deadlines imposed by the Australian Government for delivery.

The NBJP Act was intended to be a fixed-term legislative response to the NBESP, which itself was of a short-term duration (funding was limited to between 2008-9 and 2011-12). As such, the NBJP Act was subject to a scheduled 12 month review, which the NSW Government announced in March 2010. Included in the terms of reference of the review was whether the legislation should be retained and extended to cover approvals to other significant projects in NSW. The general tenor of responses to the review was that the legislation be repealed once NBESP funding had been exhausted and that the Act not be extended to cover approvals for other major projects such as significant commercial and residential private sector projects (see for example PIA 2010). The report of this review was released late in 2010 and while delivering positive findings – it supported the action of the NSW Government in legislating for the implementation of the NBESP in NSW and recommended that these planning powers remain until the stimulus program was completed – also recommended that the fast track planning powers under the NBJP Act not be extended to other types of development (Australian Government 2010). Accordingly, the NBJP Act was repealed on 1 June 2013.

Planning Bill 2013

By 2009 there were growing calls for a fundamental overhaul of the NSW planning system – effectively for a completely new planning act – emanating from bodies such as the NSW Legislative Council Standing Committee (2009), the Planning Institute of Australia and the Environmental Defenders Office (SMH 2009). Despite successive reform initiatives, the EP&A Act had become 'a sclerotic labyrinth of tunnels' (Broyd 2011: 35). Unrelenting reform – by early 2011 there had been 139 amending Acts (Productivity Commission 2011) – had created a planning system that, rather than cutting 'red tape', was perceived as both 'fragmented and complex' and 'complicated and disconnected' (Gurran 2007: 213). In this environment, planning reform became an issue at the March 2011 NSW State Election, with the incoming Liberal-National Coalition Government making a new planning act one of its goals. A period of

extensive consultation commenced in July 2011 with the establishment of an independent review of the planning system which published two issues papers in December 2011 and May 2012 (NSW Government 2011; 2012a); the release of a Green Paper (NSW Government 2012b), and an accompanying review of planning system best practice (Stein 2012), and finally a White Paper and Exposure Draft Planning Bill 2013 (NSW Government 2013a).

Despite this consultation process, the reforms and the Planning Bill met with strong opposition, particularly from an umbrella community group, the Better Planning Network (2013). Relevant areas of concern included issues such as the bill's underlying pro-growth philosophy/objects, and fast tracking provisions such as proposed new categories of code assessable development. The Property Council of Australia for example in its submissions to the Draft Exposure Planning Bill succinctly surmised that the Planning Bill is the 'primary land use and economic growth legislation for NSW' (PCA 2013). A target of 80% code assessable development was proposed in the White Paper; significantly following opposition to this proposed target, the application of code assessable development was limited in the Exposure Draft Bill to nominated growth areas only. The bill was introduced into the NSW Parliament on 22 October 2013, but stalled as a result of significant amendments made on 27 November 2013 by the Legislative Council, including the complete excision of code assessable development. These amendments – 51 in total – were not acceptable to the Government, and further debate on the bill was deferred by the NSW Lower House (Hazzard 2013). At the time of writing, this political impasse has still not been resolved, with indications that further action may not be undertaken until after the upcoming State Election in March 2015.

CONCLUSIONS

Governments in Australia have undertaken planning reform by streamlining, fast-tracking and providing for 'appropriate' assessment procedures, and by simplifying planning controls. Greater commercialisation of state and local government administrative (including planning) units has occurred, while there has also been a distinct move to privatise planning decisions and regulatory functions through bodies such as expert independent panels and the private certification of building and development (Williams 2014).

Despite these reforms – or, its critics would say, because of them – the NSW Government has undertaken persistent changes to the development assessment regime as part of its ongoing attempts to 'simplify' that State's planning and development system. A sustained twenty year period of planning reform which has largely been characterised by attempts to fast-track and streamline development approvals, has, in recent years experienced significant community and political reaction, as witnessed by local council resistance to exempt and complying development, the repeal of Part 3A of the EP&A Act and opposition to key elements of the Planning Bill 2013 such as code assessable development. Whether future attempts to continue the long-standing neo-liberal theme of regulatory reform of the NSW planning system are successful will depend on factors such as the resolution of the Planning Bill standoff, the possibility of attempting reform through further amendments to the EP&A Act, the recent appointment of a new State Planning Minister, and the outcome of the next State Election in March 2015.

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LEGAL RISK IDENTIFICATION FOR SMES IN THE CONSTRUCTION INDUSTRY

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This research contributes to a European Union (EU) funded project "*Risk Management Software System for SMEs in the Construction Industry (RiMaCon)*." The aim was to identify relevant legal risks with a view to manage them. A critical literature review was undertaken and the themes that emerged included procurement, building information modelling, building regulation and construction contract issues including delay, claims and dispute resolution. A case study approach was adopted as the researcher benefitted from a secondment to an SME contractor in Italy where pilot interviews were undertaken. The paper concludes that the literature review seems to have identified legal risks relevant to construction SMEs which will be investigated further.

Keywords: building regulation, contract law, dispute resolution, procurement, risk.

INTRODUCTION

Kwawu and Hughes (2005) explain that the UK construction industry includes a very large number of small and medium-sized specialist firms with many strategies for the client to procure design or construction work.

"*Risk Management Software System for SMEs in the Construction Industry (RiMaCon)*" is an EU FP7 Industry-Academia Partnerships and Pathways Programme. The project aims to develop a risk management system which evaluates, monitors and reviews risks for SMEs in the construction sector. It is led by the University of Wolverhampton and one of the participants is an SME contractor ("*SME*") based in Padua, Italy. A case study approach was adopted as the researcher benefitted from a secondment to the SME where an engineer and its lawyer were interviewed.

Legal Risk Identification

The first stage of risk management and focus of this paper is the identification of legal risks (Forbes *et al.* 2008). The subsequent stages are analysis followed by response and monitoring. Edwards and Bowen (1999) advocate their preferred definition of risk "*the probability that an adverse event occurs during a stated period of time*". They identify human risks as including legal risk.

A critical literature review of construction legal risks identified the following topics: procurement, building information modelling, building regulation and construction contract issues including delay, claims and dispute resolution. As this is an EU funded

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project, EU relevant papers were particularly sought and those reviewed included Dutch, Italian, French, Belgian, Portuguese and Swedish perspectives. Although relevant, environmental and health and safety law and insolvency are not considered further in this paper.

PROCUREMENT

The first legal challenge faced by an SME in the construction industry is procurement. Marique (2013) explains that "*Procurement relates to the diffuse relationships between market players in their race towards a contract*". Clients have their choice of many different procurement routes (Charlson and Chinyio, 2013).

The European Court of Justice has emphasised that public procurement primarily aims to ensure undistorted competition (Marique, 2013).

Procurement policies change for example in the Netherlands, the exposure of collusion influenced procurement policy and cooperation between client and contractor for a number of years (Boes and Doree, 2013).

As a response to corruption, the Italian building sector operates under new regulations for awarding of contracts for public works. The basic objectives of the legislative reform included transparency and competition. ANCE (Associazione Nazionale Costruttori Edili), the long-established association of building firms primarily composed of medium and small firms sees the transparency as a positive factor for an increase in their work (Bologna and Nord, 2000).

Kwawu and Hughes (2005) suggest relational contracting to facilitate collaborative working relationships. However, Warra (2008) warns that for most public sector purchasers, open competitive tendering is legally mandatory.

Campagnac (2000) explains that although French legal system is derived from Roman law which has distinct principles from the English common law system, the French contracting system includes both traditional "*professional model*" and design and build "*industrial model*" procurement methods.

Despite the potential of e-procurement to save the construction industry time and cost, Wong and Sloan (2006) found scant interest from the surveyed construction SMEs for implementation of e-procurement.

BUILDING MODELLING AND REGULATIONS

Building Information Modelling

McAdam (2010) explains that Building information Modelling (BIM) has been defined as "*a digital representation of physical and functional characteristics of a facility*". The aspiration is that the model would provide reliable costing and fabrication drawings. However, this requires collaboration by key stakeholders: contractors, engineers, architects and employers. The legal challenges include design liability and ownership/protection. For the moment, it seems unlikely that SMEs in the construction industry will be mandated to comply with BIM.

Building Regulation

The characteristics of building control systems in EU Countries are similar. Public bodies set the regulatory framework, check planning applications, issue building permits, conduct final inspections, grant completion certificates and supervise the

operation of the system (Pedro *et al*, 2010). Ang *et al* (2005) advocate the Dutch initiative to formulate National (instead of Municipal) technical building regulations.

Legislative reform in Italy introduced a substantial body of regulations to ensure compliance with environmental and town-planning regulations (Bologna and Nord, 2000)

CONSTRUCTION CONTRACT

Claims and Delay

Hughes and Shinoda (1999) emphasise the importance of getting contractual and legal issues resolved at the beginning of the project. Nevertheless, claims are widespread and Love *et al* (2010) endeavour to classify their causes. However, on-site staff often do not have the proficiency to identify claims (Moura H. and Teixeira, 2007). Their research on Portuguese public construction projects identified the leading cause of claims was change followed by delay.

Champion (2011) contends that delays to the completion of construction projects are prevalent with customary claims by the contractor to recover their prolongation costs. Furthermore, Gorse (2004) advocates that all project managers should understand the disparate methods used in delay and disruption claims.

Brawn (2012) argues that knowledge of the effect delaying events have on a contractor's right to an extension of time and employer's entitlement to liquidated damages is vital for successful project completion.

Sub-contracts

Wong and Cheah (2004) explain that the frequent use of sub-contracting in the construction industry results in the following typical issues: undesirable payment terms for sub-contract work, incompatibility with the main contract and deficient terms and conditions of sub-contracts. Kwawu and Hughes (2005) identify onerous one-sided conditions at the sub-contract level.

DISPUTE RESOLUTION

The UK construction industry has suffered high levels of disputes which expend significant money, time and resources in their resolution (Bowes, 2007). These traditionally have been resolved through arbitration or litigation but they have been criticised for their costs, delay, procedural complexity and adversarial approach (Brooker, 1999).

Brooker (2009) explains that alternative dispute resolution (ADR) was given a central role in the UK Civil Procedure Rules to encourage the settlement of cases and reduce costs for the parties. She concluded that mediation has been shown to be beneficial and many Technology and Construction Court judges believe it should be normal practice for construction disputing parties to discuss and use the process.

The Housing Grants, Construction and Regeneration Act 1996 provided a statutory entitlement for parties to a construction contract to appoint an adjudicator to reach a binding decision (Brooker, 2009). Adjudication is now an established and successful construction dispute resolution process (Bowes, 2007). She concluded that respondents agreed with the cost effective advantage of adjudication.

CASE STUDY

Research methodology

A case study approach (Denscombe, 2010) was adopted as the researcher benefitted from a secondment to an SME contractor in Padova, Italy. The case study method enabled investigation of *"the richness of the phenomenon and the extensiveness of the real-life context"* (Yin, 2009, p.2).

Projects were reviewed (Cresswell, 2013) and pilot (Cresswell, 2009) interviews semi-structured (Jankowicz, 2007) around the themes identified from the literature review (procurement, building information and modelling, construction contract and dispute resolution) were undertaken.

Secondment to construction SME in Padova, Italy

The construction SME based in Padua, Italy was founded in 1955. The business constructs and renovates residential and commercial premises. The researcher was seconded to the SME from 31 March to 4 April 2014. During this visit, projects reviewed comprised:

- 1) The repair and replacement of the roofs of houses;
- 2) A new build 4 terraced house development where concrete/wood blocks with polystyrene insulation had been used;
- 3) A pre-start site meeting for an extension to provide a product sample store for a pharmaceutical factory; and
- 4) The refurbishment of an elegant Palazzo Bovio apartment, near St Antonio's Church in the centre of Padua.

The SME has previous experience of EU research projects. On 31 March 2014, the A+ House project completion presentation was attended at the Fenice Green Energy Park (FENICE). The project compared construction with sustainable and traditional materials. The sustainable building included earth bricks, hemp and wood contrasted with a traditional concrete structure. The project has now moved to the market phase.

Interviews with the SME's Lawyer and Engineer

Semi-structured pilot interviews (Creswell, 2013) were undertaken separately with the SME's lawyer and engineer. The SME's lawyer (avvocato) graduated in 2001 and then worked for a Padua law firm which supported businesses. In 2009, she set up on her own. She is a civil lawyer and employment law specialist. The SME's engineer has worked for the company for 7 years.

Results

Procurement

The engineer emphasised that the relationship with the client is important. The first job is special because it can lead to another project. The best investment is with existing clients.

He continued that finding new clients is a different challenge. The SME checks an internet site for public tenders and also Padua details planning permissions awarded so potential clients identified can be approached. This amounts to 10% of the SME's work. However, networking with existing contacts is the most successful strategy.

The SME's lawyer explained that the Italian Civil Code is supplemented by many specific laws for construction. Under the Civil Code, if a contract's objective is a building then a written contract is required. The SME has a draft house building contract primarily for use with home owner clients. Real estate/ developer clients have their own forms of contract.

The engineer expounded that 60% of the SME's projects are on their conditions but these are the smaller ones with 40% of the larger ones on the clients' conditions. 70-80% of the SME's turnover comes from the larger projects. Projects on client's conditions are more risky. For example, the SME's conditions do not include penalties for late completion and they can stop the job if they are not being paid.

He continued that the SME has two draft contracts: Measurement which includes a price for each step and Fixed Cost which is higher risk as measure and cost need to be calculated. If work is forgotten then its cost cannot be recovered.

Building information modelling

The engineer outlined that the SME produces 2D information including architectural and structural drawings but not 3D details.

Building regulation

The lawyer confirmed that there are national building regulations but every town has its own additional ones. Such issues are normally solved before procurement and on site construction. The public administration must firstly give permission to build and only then does procurement proceed.

The engineer elaborated that the SME's core business is residential. Development follows inception, design, construction and sale stages. The SME is usually only involved in the construction phase. Building regulation requirements are addressed at the earlier design stage leading to planning permission. The regulations include National, Regional, Town and specialist ones. The regulations are not clear as (sometimes) they conflict with each other.

He continued that last year a new law entitled clients to increase house volume by 20% to 45% (with renewable sources). This was intended to improve business for the construction sector. Unfortunately, this instead led to clients postponing projects due to start on site while they increased the size of the house resulting in a 3-5 month delay for building regulation approval.

He complained that building regulations for the construction sector keep changing. For example, crane and machine regulations can change 10 to 15 times per year.

Construction contract

The lawyer explained that the client and contractor can agree an amount payable by the contractor for each day a project is delayed. This amount can either be deducted from the amount payable to the contractor by the client otherwise the contractor may have to pay back money to the client. Other damages may be payable in addition.

The engineer argued that the most important issue is the contract. "*You can make more money with the pen than with construction projects.*" Money can be lost on a good project due to a bad contract.

He has advised not to take on a supermarket project due to the penalty charges for late completion. Penalty charges are acceptable provided that there is an achievable Gantt chart. Overall there is a balance between time, cost and quality.

He explained that variations are a benefit to the SME as they are not in a competitive environment. They are, however, difficult to manage and the client should be asked to pay at the time and not at the end of the project.

He disclosed that it is difficult to recover money if the project is on site too long. For example, the SME had to wait for 2 months for the client to choose the roof and during this period the scaffolding remained on rent for an additional cost of about 1,000 Euros.

He concluded that a project is better without claims as they are risky.

Dispute resolution

The lawyer complained that it can take 5 years to reach judgment at the first level in the Italian courts. In Italy there are many disputes but not enough judges. Moreover, Italy does not have enough money to pay for more.

She expounded that arbitration is very expensive. This makes it uneconomic to pursue smaller sums of money. In addition to paying the Arbitrator, the State requires payment of 16 Euros for every 4 pages.

She continued that there was no mediation in Italy. However, there was an EU law about mediation in 2008/9 which was brought into Italian law in 2010. Mediation on certain issues for example, car crashes, medical negligence and inheritance is required before the courts. However, this does not apply to construction.

The engineer described that there is a choice between a judge or arbitration (3 arbitrators). Obtaining a judge's decision takes a long time. Arbitration is quicker but more expensive. Arbitration is better for the client because he can oppose payment even if there are no defects. A contractor would therefore prefer to choose to have a payment dispute to be decided by a judge.

Payment

The lawyer explained that there is no credit protection so payment by the employer is not guaranteed. Clients tend to stop paying at the end of a project.

The engineer complained that clients can be slow to pay. The SME agreed with one client that they would only be paid when the units were sold. Another client explained that he was unable to pay until he had sold the apartments. "*No money, you can do nothing.*" The biggest problem is payment by clients.

The engineer described that it is difficult to secure advance payment. There has been a big drop in work from 2010. Before 2005, advance payment was available but recently clients would choose a contractor that did not demand advance payment. However, about 40% of construction companies have become bankrupt. Advance payments are returning due to the credit crunch.

Other risks

The lawyer advised that safety is seen by the State as a very important risk area for construction. An employer is required to eliminate risks for the workers on site. This documentation must be kept on site and is liable to inspection.

She expounded that under public law, the workers are given payment protection. A general contractor is jointly and severally liable with a subcontractor to pay the subcontractor's workers. This obligation applies even if the general contractor has already paid the subcontractor who has not subsequently paid their workers. A general

contractor can ask for the subcontractor's documentation but, in the past, false papers have been provided resulting in a criminal trial of the subcontractor.

Future Research

The lawyer suggested that ANCE (Associazione Nazionale Costruttori Edili) has a lawyer who may agree to be interviewed.

Analysis

The limitations of this research are recognised as according to Stake (2003, p.156) "*The purpose of a case report is not to represent the world, but to represent the case*". Nevertheless, whether these findings can be generalized will be tested in the future research outlined below (Denscombe, 2010).

FUTURE RESEARCH

A further secondment to the SME is scheduled. The plan is to gather data on the broader SME experience of legal risk. A probable sample is members of ANCE (Associazione Nazionale Costruttori Edili).

A workshop at FENICE disseminating the research is proposed. The intention is to follow this with data collection by interview or a focus group (Litoselliti, 2003). One significant challenge is that the researcher does not speak Italian.

An EU-wide survey of legal risk is contemplated. Research on evaluation, monitoring and review of legal risks will also be required.

CONCLUSIONS

The SME identified and distinguished between public and private sector procurement and traditional and design and build contracting. It also introduced the concept of procurement by networking.

As anticipated, the SME was not required to contribute to 3D building information models but made some insightful comments about the challenges of complying with building regulations.

The SME understood variation and delay claims and late completion penalties. Sophisticated delay and disruption methodology seems too complex for an SME.

The SME demonstrated commendable knowledge of the distinctions between litigation and arbitration together with an appetite for ADR including mediation.

Although not asked about payment by clients, this is a high priority for the SME. Interestingly, health and safety and subcontracting risks were also mentioned.

The pilot interviews confirm that the literature review seems to have identified relevant legal risks for construction SMEs. This is particularly encouraging because the literature reviewed was in English whereas the SME operates in Italy.

ACKNOWLEDGMENT

The authors wish to thank the EU for sponsorship of this research through the FP7 Marie Curie Industry-Academia Partnerships and Pathways.

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STANDARD FORM CONSTRUCTION CONTRACTS; WHY THE NEED FOR REGULAR CHANGES?

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Publications of the Joint Building Contracts Committee® (JBCC®) are revised periodically to comply with changing statutory and industry requirements in the interests of standardisation and good practice with an equitable distribution of contractual risk. The latest JBCC® edition was published in March 2014. This paper will highlight the changes that were made in this edition with reasons why such changes were deemed necessary, and, in addition, will look at changes that were recently made to other selected local and international standard forms of construction contracts. The related JBCC® documents have consequently been revised. This include the various JBCC® payment certificate forms, the JBCC® security forms and the JBCC® completion certificate forms. The Association of South African Quantity Surveyors has revised the 'Preliminaries' and has prepared a Model Bill of Quantities Preliminaries trade incorporating the new JBCC® edition 6.1. The Adjudication Rules have also been updated in consultation with the Association of Arbitrators of Southern Africa and the Construction Adjudication Association of South Africa. The content of standard forms of construction contracts and the respective industry model documentation used in South Africa and elsewhere, portray the consensus view of constituent bodies representing building owners and developers, professional consultants, and general and specialist contractors which are aimed at bringing about uniformity in construction procurement documentation. The discussion in this paper is about the question why regular changes are necessary to these standard forms of construction contracts. The discussion will be limited to building contracts with the design provided by the employer and to recent changes incorporated in the JBCC®, the GCC 2014 (RSA), the JCT (UK) and the AS 4000 (Australia). More particular emphasis will be placed on the changes between the JBCC® edition 6.1 (2014) and its predecessor, the JBCC edition 5.0 Reprint 1 (2007).

Keywords: construction contracts, contractual risk, procurement, revisions, standardisation.

INTRODUCTION

Construction Contract Law is an increasingly well-developed division of law described by Bruner cited in Baily and Bell (2011) as a 'primordial soup in the melting pot of the law...consisting of centuries-old legal theories fortified by statutory law and seasoned by contextual legal innovations reflecting the broad factual realities of the modern construction process'. Construction Contract Law is, by its nature, diverse and complex (and occasionally controversial) - a reflection of the character of the building and construction industry itself.

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Standard forms of contract

Standard forms of contract are popular amongst both project owners and industry because their use helps reduce procurement and contract administration costs and they are generally well understood by users, thereby resulting in fewer disputes on matters of interpretation. The purpose of standard forms of contract is therefore to facilitate the contractual arrangements between parties in a project. Standard forms of contract are ready-made terms and conditions when making a contract. These standards are commonplace in construction transactions and generally accepted by the different contracting parties. It would, however, be practically impossible to devise a standard form of contract that would account of all eventualities that might occur in a construction project as there are several factors that affect what type of contract is suitable for a certain project, e.g. the amount of involvement from the client, technical complexity, the location and size of the project. In the initial stage of the design phase, the client has to adopt a suitable contractual arrangement for the project and a corresponding standard form of contract. The advantage of using standard forms of contract may, however, be impaired when amendments and supplementary or 'special' conditions are included that significantly alter the standard general conditions, as there is a complex interaction between many of the terms (Ndekurgi and Rycroft, 2009). The Latham Report recommended the use of standard contracts without amendments (Latham, 1994) and amendments to standard forms were also criticized by Lloyd QC in *Royal Brompton Hospital National Health Service Trust v. Hammond and Others*²: *'A standard form is supposed to be just that. It loses its value if those using it or, at tender stage those intending to use it, have to look outside it for deviations from the standard'*

Advantages of standard form construction contracts:

- The standard form is usually negotiated between the different bodies that make up the industry in the interests of standardisation and good practice. As a result the contractual risks are spread equitably;
- Using a standard form avoids the cost and time of individually negotiated contracts;
- Changes made to the provisions of the standard form should be clearly identified in the procurement documents, failing which they shall be null and void;
- Contracting parties should be familiar with the terms and conditions of the standard form as seminars and workshops are organised on a regular basis that are presented by experts with extensive knowledge of the standard documentation and the construction industry; and
- Tender comparisons are made easier since the risk allocation is the same for each tenderer. Parties are assumed to understand that risk allocation and their pricing can be accurately compared.

Disadvantages of standard form construction contracts:

- The forms may be cumbersome, complex and difficult to understand for someone lacking regular exposure to its use; and
- Because the resulting contract is often a compromise, they are resistant to change. Much-needed changes take a long time to bring into effect.

What is a construction contract?

Construction projects are unique in nature and every situation and every problem in construction is different and contains unique facts that may require a different approach and solution from that of another apparently similar situation or problem.

² *Royal Brompton Hospital National Health Service Trust v. Hammond and Others* [2001] EWCA Civ, [2001] BLR 297, [2001] Lloyd's Rep PN 526

In *Modern Engineering (Bristol) Ltd v. Gilbert-Ash Northern*³, Lord Diplock described a building contract as:

'... an entire contract for the sale of goods and work and labour for a lump sum price payable by instalments as the goods are delivered and the work done. Decisions have to be made from time to time about such essential matters as the making of variation orders, the expenditure of provisional and prime cost sums and extension of time for the carrying out of the work under the contract'

The need for standard forms of contract arises from the foregoing to provide written contracts that can be economically executed, usually without the need for extensive legal services, and from a desire to standardise certain relationships and practices according to the general agreement about contract fundamentals reached by the representatives of the parties involved.

'What is written endures; things spoken speed away' (Peters and Pomeroy, 1938)

The construction industry standard forms of contract differ in material respects from other standard form contracts in use in the commercial world, as the former seek to define the risk profiles of the parties to the contract, whilst the latter – such as supply agreements and credit agreements – are often extremely one-sided.

Standard form construction contracts seek to regulate the relationships between the contracting parties, particularly in respect of risk, management and responsibility for design and execution. Most conditions of construction contracts incorporate a set of conditions whose primary purpose is to lay down procedures of general application to a variety of types of work. There is no rule to what should be included in conditions of contract, but according to Uff (2009: 277) most sets of conditions follow a standard pattern. Typically, conditions deal with:

- General obligations to perform the works;
- Provisions for instructions, including variations;
- Valuation and payment;
- Liabilities and insurances;
- Provisions for quality and inspections;
- Completion, delay and extension of time
- Role and powers of the certifier or project manager
- Disputes; and
- Reference to specific legal principles

Standardisation attempts to ensure that certain fundamental and recognised practices are always followed in construction contracts, and that better agreement is achieved by using a form of contract with which the parties are already familiar.

The Association of South African Quantity Surveyors (ASAQS) and the Construction Industry Development Board (CIDB) both firmly support standardisation, as the large number of documents published by these bodies specifically dealing with standardisation and uniformity in the construction industry clearly indicate. One such example is the extract hereunder that is from the (then) executive director of the ASAQS (Wortmann, 2010) regarding standardised Procurement Documentation Guidelines. These Guidelines are based on the CIDB Standard for Uniformity in Construction Procurement, which engenders a culture of consistency and predictability within the procurement process, and which aims at bringing about standardisation and uniformity in construction procurement documentation, practices and procedures.

³ *Modern Engineering (Bristol) Ltd v. Gilbert-Ash Northern* [1974] AC 689 at 717

'The Association is committed to and supportive of the CIDB regulations which are aimed at bringing about standardisation and uniformity in construction procurement documentation and appeals to members and practises to be supportive of the regulations and to refrain from making unnecessary amendments to the documents'

Brief overview of the development of building contracts in South Africa

Conditions of building contracts in South Africa are founded largely on British conditions and applicable English case law that has been found to be highly analogous to and compatible with the South African law system. The most important of the exceptions manifest themselves where construction contract law, as applicable to conditions of building contract, is interpreted in conjunction with other measures, such as insolvency laws, legislation relative to the standards and validity of warranties, the passing of ownership of materials, etc. Thus, while British judgements may not be formally authoritative under South African law in the accepted legal sense of the term, they have a strong persuasive influence and are generally followed by the South African courts (Finsen, 2005).

The first recorded standard form of contract, comprising of articles of agreement and conditions of contract, to which the NFBTE (National Federation of Building Trade Employers, the precursor of BIFSA (Building Industries Federation South Africa) and subsequently MBSA (Master Builders South Africa) had access was introduced in England in 1909 by agreement between RIBA (Royal Institute of British Architects), the Builder's Society and the Central Association of the Master Builders of London (Lipshitz and Malherbe, 1979).

After using the 1909 form unaltered for some time in Britain consideration was given to amend the document by a committee that was especially set up for this task, and a document, with appropriate annotations, was published in 1928 under the heading "*Agreement and Schedule of Conditions of Building Contract*". The document had been published with the idea to replace the 1909 RIBA form. However it later transpired that although the document had met with agreement at the level of a representative negotiating and drafting committee, it had failed to gain approval of the general membership of RIBA and, as such, it was never used in practice. The result was that in Britain the revision of the 1909 RIBA form was tackled de novo, while on the South African scene discussions were deferred until such time as the approved revised RIBA edition became available. The first published annotation appeared in Britain in 1931 that substantially revised and brought up to date the 1909 RIBA form. Subsequent annotations appeared regularly thereafter (Lipshitz and Malherbe, 1979).

Although standard conditions of contract were introduced in South Africa to a restricted extent in some regions shortly after the establishment of the NFBTE in 1904, it was only during the late 1920s that serious attempts were initiated to prepare and enforce standard conditions of contract on a national basis in the private sector (Lipshitz and Malherbe, 1979).

The 1931 RIBA form (supra), was found acceptable to the Institute of South African Architects, the Chapter of South African Quantity Surveyors and the NFBTE, and according to NFBTE's annual report published in 1932 it was adopted by all the interests concerned, subject to the introduction of such amendments as were necessary to satisfy the requirements of differing local conditions. Thus this form became the basis of the first standard form of contract in South Africa – the 1932 edition. It carried the endorsement "*Approved and Recommended by the Institute of South African Architects, the Chapter of South African Quantity Surveyors and the National Federation of Building Trade Employers in South Africa*" and was entitled

‘Agreement and Schedule of Conditions of Building Contract’. This cumbersome name required a nickname. As the ‘with quantities’ version was printed on white paper and the ‘without quantities’ on blue, the two versions became known as the ‘white form’ and the ‘blue form’ respectively.

This 1932 agreement was revised and re-issued on no fewer than fifteen occasions, with major redrafts undertaken in 1957, 1960 and 1980 (Finsen, 1989) as the South African building industry developed and became more sophisticated. A permanent review committee was appointed for this purpose, known as the Joint Study Committee, constituted of representatives of the Institute of Architects, the Chapter of Quantity Surveyors and (then) BIFSA (*supra*). The last amendment of this agreement was published in 1981 and re-issued in 1988 with minor amendments; shortly afterwards the Joint Study Committee, rent asunder by internal dissent, was dissolved. In 1984 a new committee was established, the Joint Building Contracts Committee or JBCC for short. The JBCC released its first standard building contract documentation into the marketplace in 1991 that included some material differences from its predecessor, e.g. the introduction of the Construction Guarantee in lieu of the Retention Fund. This contract quickly gained acceptance in most quarters and is today the foremost contract document suite in use in the Republic of South Africa for building related work (Maritz, 2009). The primary contract documentation is comprehensive and fully integrated with over 25 support Forms and Guides.

It was recognised from the outset that an enormous advantage could be gained by employers, contractors and professionals should the document meet the needs of both the private and public sectors. A joint committee was set up with the National Department of Public Works (NDPW) and over a number of months the apparent differences of requirements were reduced to manageable proportions that could be accommodated without impairing readability.

This led to an intensive re-examination and re-drafting of the documents by the Review and Main committees and in 1998 the new documents, designated JBCC Series 2000, were published (the Second Edition). These replaced all the documents published in 1991. In order to further broaden the scope of the JBCC Series 2000, a minor works document was published in 1999.

JBCC published the Third Edition in January 2003 primarily to update the Series 2000 documents. There were, however, some significant changes; e.g. in cases where the employer in the agreement is an organ of the State specific requirements that differ from those required by the private sector were set out in a single clause for ease of reference. This clause provided for the substitution by these clauses in the document when so required.

JBCC published the Fourth Edition in March 2004. The primary purpose of this revised edition (that followed so soon after the publication of the Third Edition) was to satisfy the requirements of the office of the State Attorney, which were regarded to be inadequate provided for in the Third Edition. The content of the State clause was substantially expanded to further accommodate aspects where the State differs in its approach from the private sector. To distinguish this edition from its predecessors it featured on the front cover the wording ‘including State provisions’ to make it clear that it had been accepted by the NDPW.

Another significant change in the Fourth Edition was the introduction of ‘adjudication’ as an alternative dispute resolution (ADR) process to bring it in line with other modern agreements such as the NEC. This had the result that the dispute clause had to be completely redrafted.

A further edition (edition 4.1) was published in March 2005, which included further expansion of the State Provisions and the Dispute Provisions were once again redrafted to allow for adjudication to be the default dispute resolution process in private sector contracts.

JBCC published the Fifth Edition in August 2007 featuring some major modifications to previous editions; with the removal of the substitution provisions applicable to State in the various documents certainly representing the most significant of these modifications.

ABOUT JBCC®

JBCC® was established in 1984 (supra) and is representative of building owners and developers, professional consultants, and general and specialist contractors who contribute their knowledge and experiences to the compilation of the suite of documents. All JBCC® documents portray the consensus view of the constituent members and are published in the interests of standardisation and good practice with an equitable distribution of contractual risk.

JBCC® is a committee comprising of nominees from its current eight constituent members, namely:

- Association of Construction Project Managers (ACPM)
- Association of South African Quantity Surveyors (ASAQS)
- Consulting Engineers South Africa (CESA)
- Master Builders South Africa (MBSA)
- South African Black Technical and Allied Careers Organisation (SABTACO)
- South African Institute of Architects (SAIA)
- South African Property Owners Association (SAPOA)
- Specialist Engineering Contractors Committee (SECC)

The Association of Arbitrators and the Construction Adjudication Association of South Africa are represented by nominees holding dual portfolios.

The major changes between the new sixth and fifth edition will be discussed in more detail hereinafter and reasons will be provided why such changes were deemed necessary.

ABOUT GCC (RSA)

The South African Institution of Civil Engineering (SAICE) has a strong tradition of developing, publishing and maintaining conditions of contract and has, over several decades, published six editions of the General Conditions of Contract for Civil Engineering Works, the last one in 1990. The 1990 edition was replaced in 2004 by the publication of the General Conditions of Contract for Construction Works, First Edition - abbreviated to GCC 2004. To satisfy the CIDB's requirements for uniformity in procurement documentation that followed after Focus Group 6, an advisory body set up by the NDPW after the 1994 elections, identified in their Report to the NDPW in 1996 that only a limited number of standard contracts be considered for use by the State for construction procurement.

GCC 2014 – What is new?

GCC 2004 was replaced in 2010 by the Second Edition (abbreviated to GCC 2010) to clarify inter-responsibilities and to make provision for a wider spectrum of construction works. This edition could deal with civil, mechanical, electrical and building projects, or a combination of various types of projects. However, after four

years of application, it became clear that certain amendments were necessary and the GCC Second Edition, Revised 2014 was published (SAICE, 2014). Some of the most important amendments in this edition are:

- It permits the Contractor to suspend the Works if the Employer fails to make payment on a payment certificate;
- It adds a Variable Construction Guarantee to the list of securities;
- It allows for the selection of inflation indices that are appropriate to the type of Works; and
- It replaced Engineer with Employer's Agent throughout the document because of the wider application of the contract.

The following organisations endorse the GCC Revised 2014:

- Consulting Engineers South Africa
- Electrical Contractor's Association of South Africa
- Institute of Municipal Engineers of Southern Africa
- South African Black Technical and Allied Careers Organisation
- South African Federation of Civil Engineering Contractors
- South African Institute of Electrical Engineers
- South African Institute of Mechanical Engineers

ABOUT JCT (UK)

The Joint Contracts Tribunal (JCT) was established in 1931 by the Royal Institute of British Architects (RIBA) and other leading bodies and has for over 80 years produced standard forms of contracts, guidance notes and other standard documentation for use in the construction industry (Hibberd, 2011).

JCT Contracts (published by Sweet and Maxwell Thomson Reuters) represents all parts of the UK construction industry and is the leading provider of standard forms of building contract (<https://www.jctcontracts.com> accessed 26/03/2014). The following are members of JCT:

- British Property Federation Limited
- Contractors Legal Grp Limited
- Local Government Association
- National Specialist Contractors Council Limited
- Royal Institute of British Architects
- The Royal Institution of Chartered Surveyors
- Scottish Building Contract Committee Limited.

The JCT Council is comprised of five Colleges representing employers/clients, (including local authorities), consultants, contractors, specialists and sub-contractors, and Scottish building industry interests.

JCT 2011 – What is new?

The principal purpose of the 2011 edition is to reflect the coming into force of amendments to the Housing Grants, Construction and Regeneration Act 1996 ('the Construction Act') made by the Local Democracy, Economic Development and Construction Act 2009, insofar as they relate to payment terms and payment-related notices (JCT, 2014).

Other changes include:

- Insolvency definition in the Termination section has been amended to include the definition in section 113 of Construction Act;

- The revised Terrorism Cover provisions included in JCT's December 2009 Update has been incorporated;
- The provision for appointment of the principal contractor under CDM Regulations has been extended to cover that function under the Site Waste Management Plans Regulations 2008 also;
- Statutory reference has been updated for the Bribery Act 2010;
- Regarding PI insurance, entries relating to asbestos and fungal mould have been removed as cover for these items is limited and not readily available to contractors; and
- Revised retention provisions have been included in the sub-contracts.

ABOUT ABIC AND AS 4000 (AUSTRALIA)

The Australian Building Industry Contracts (ABIC) are jointly published by Master Builders Australia Ltd and the Australian Institute of Architects. They are intended for use in building projects where an architect administers the contract. The Major Works Contract (ABIC MW-1 2003) – a lump sum contract for use on projects with a value of more than \$2 million - is the most comprehensive contract in the ABIC suite of building contracts (<http://www.masterbuilders.com.au/abic-contracts> accessed on 03/03/2014).

The suite of Australian Standards for contract conditions (AS 4000) provides a guide to the general conditions of contracts for a range of contractual agreements, including design and construct, minor works, major works and supply of equipment. The AS 4000 – general conditions of contract for use on commercial projects – is the most common contract in the Australian Standards suite of building contracts (<http://www.contracts.com.au/~contracts/standard.htm> accessed on 03/03/2014).

Sharkey (2014) confirmed that the original AS 2124 – 1992 was superseded and re-designated as AS 4000 – 1997 with minor amendments in 1999, 2000 and 2005. Sharkey added that Standards Australia is undertaking an extensive review of the AS 4000 at the moment, which will be the first major revision of the form since it was launched in 1997.

In the Policy Document submitted to the Attorney-General on Australian Contract Law by the Civil Contractors Federation (CCF) in July 2012 the CCF made some recommendations in relation to the Standards Australia AS 4000-1997 contract. It is evident from the document that construction law in Australia, as in most other countries, is in a continuous process of development.

In relation to the Australian Standard AS 4000- 97 General Conditions of Contract the CCF recommends that:

- a) Standards Australia should be asked to examine whether there should be a monetary limit below which Australian Standard AS 4000- 97 should not be amended. This should be related to Risk.

That the Australian Standard AS 4000-1997 General Conditions of Contract be specifically reviewed as to ensure that:

- a) Payment provisions reflect the Security of Payment regime by excluding damages and other claims from the calculation of progress payments.
- b) Payment schedule should be amended so that certification is required within 7 days of a claim being submitted and payment by the Principal within 7 days of certification.

- c) The provisions dealing with Superintendents are strengthened to further support the role of the Superintendent in being fair and impartial by imposing a positive duty to do so.
- d) There should be a strengthening of the clause which provides for retention of payments and/or bank guarantees to ensure the prompt return of retention payments and/or guarantees occur in practice.
- e) What constitutes practical completion under the definition section and in particular paragraph (c) of the contract needs to be rewritten to reflect the fact that not all of the documents and information is under the control of the contractor.

DIFFERENCES BETWEEN THE 2007 JBCC® PRINCIPAL BUILDING AGREEMENT (PBA) 5.0 EDITION AND THE NEW 2014 6.1 EDITION

JBCC® published Edition 6.1 PBA in March 2014 (JBCC, 2014). The changes from the 2007 edition are extensive and involve major redrafting to, inter alia, shorten and tidy up the suite. The main modifications include:

- The removal, adding or rewording of some of the definitions
- The rewording and repositioning of certain clauses
- The removal or incorporation of a number of clauses (30 vs. 42)
- The reduction of default periods in a number of instances
- The omission of ‘domestic’ subcontractors - relationship managed by the contractor
- The compaction of the insurance and security clauses into fewer clauses but more sub-clauses
- The removal of ‘Works Completion’ as a completion stage
- The introduction of a ‘suspension’ clause
- The collapsing of the previous four ‘termination’ clauses into a single clause
- The complete redrafting of the Employer-Contractor and Contractor-Employer data documents into a single Contract Data document.

The redrafting and publication of the JBCC® 2014 edition will, as with previous redrafting exercises, endeavour to serve the building industry better by providing a modern reconstructed suite of documents using contemporary simple English, splitting long clauses into sub-clauses resulting in greater clarity of the legal agreement and a more user-friendly contract administration tool.

See Annexure A for a list of the more detailed changes between the 2007 and 2014 editions.

CONCLUSION

There is a large array of different standard forms of construction contracts, drafted for a multitude of different construction and procurement types. Standard forms are valuable and convenient as they reduce the time and cost at the negotiation stage and provide a sound framework for project success as they attempt to distribute the risk equally amongst the parties. Regular modifications can create legal uncertainty which may result in the courts interpreting terms in an unintended way. It is therefore important to consider the ramification of amendments, question whether changes are necessary and ensure that the terms do not have a detrimental effect on other interlinked clauses or on the contract as a whole.

However, it is evident from the foregoing that minor or major redrafts of standard form construction contracts will be undertaken on a regular basis wherever these contracts are being applied, and it is unlikely that current editions will remain

unchanged in use for any length of time. For instance, since the publication of the JBCC 2007 edition South Africa has seen the introduction of the Consumer Protection Act, the enactment of revised building regulations, and revisions to the Occupation Health and Safety Act to name but a few. Such new acts, regulations, etc. will necessitate amendments to be made to terms and conditions in standard form construction contracts in order to keep pace with an ever changing built environment in which these terms and conditions are applied.

Because of the paper's limitation not to exceed ten pages it was not possible to address other critical issues such as the continuous changing structure of the construction industry, which consequently implicated on the ways in which contracts are structured and the role of various technical committees constituted over time and how that implicated on the ways changes were introduced. A follow-up study can look more closely at these, and other, reasons as to why there is a need for standard forms of construction contracts to change over time.

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A STUDY OF THE MANAGEMENT OF TIME BY COMPARING AND EVALUATING THE PROVISIONS FOR THE MANAGEMENT OF TIME IN THE JCT STANDARD BUILDING CONTRACT (JCT SBC), THE NEW ENGINEERING AND CONSTRUCTION CONTRACT (NEC3) AND THE NEW COMPLEX PROJECTS CONTRACT 2013 (CPC2013)

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The aims of this study are to compare the management of time provisions of CPC2013 with those of two analogous construction contracts and to theoretically evaluate and comment on the different contributions made by three construction contracts to the management of time of a construction project. This study used a desk-based approach to analyse the respective provisions of the three contracts to be compared and evaluated. In so doing, the study took account of decided case law that impacts on the legal matters associated with the management of time on construction projects. The findings offer a framework that may be used for the theoretical evaluation and comparison of the provisions for the management of time amongst construction contracts and which may be used for practical evaluation and comparison of the same.

Keywords: construction contract, evaluation, time provision.

INTRODUCTION

The second annual NBS National Construction Contracts and Law Survey (RIBA Enterprises, 2013) asked the question (P17): '[D]uring the construction phase of the project, which of the following matters did you find to be the most difficult or recurrent in 2012'. 'Assessment of delay and extensions of time' was the top response from Contractors and Clients and the second top response from Consultants.

This study was inspired by the recent publicity surrounding the publication of the new Complex Projects Contract 2013 (CPC2013) published by the Chartered Institute of Building (CIOB). This new contract is marketed as the "*World's first Time Management Contract for Complex Projects*" (CIOB, 2013). This article states that CPC2013:

focuses on managing time to ensure projects are delivered to specification on budget and without delays. Unlike existing contracts, which target failure through only

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through (sic) persuasion and financial compensation for failure, CPC2013 provides the procedures to enable parties to manage time (and cost) risk events in a modern and proactive fashion.

The article argues that “[C]urrent standard forms of contract do not encourage, and in some cases actually inhibit, the competent management of time making them unsuitable for controlling the risk of time and cost escalation on complex projects”. As a rationale for the contract, it goes on to stipulate that “[A]ccording to CIOB research, less than 20% of complex building projects were completed on time, 60% were completed more than 4 months late, and 55% more than 6 months late” and to quote from Keith Pickavance, a Past President of the CIOB and lead author of CPC2013 who said: “[T]he causes and consequences of delay are the single most common reason for uncontrolled loss and cost escalation in complex building and engineering projects, where the design is produced by the employer or contractor.” Carnell (2005, P1) applies the adage ‘time is money’ with the explanation that ‘[N]o two construction projects are alike; ... The cost of a project will be determined by an equation which balances time, materials and labour against the conditions under which the works are to be executed and the requirements of the person for whom the works are being carried out’. Balancing this equation with time as a prime factor is the function of project management.

THE AIMS OF THE STUDY

The aims of this study are to compare the management of time provisions of CPC2013 with those of two analogous construction contracts and to theoretically evaluate the different contributions made by three construction contracts to the management of time of a construction project.

METHODOLOGY

This study used a desk-based approach to analyse the respective provisions of the three contracts to be compared and evaluated. In so doing, the study took account of decided case law that impacts on the legal matters associated with the management of time on construction projects.

THE JCT STANDARD BUILDING CONTRACT (SBC 2011)

This title actually refers to three different contracts that can be used as the contractual arrangement between an Employer (client) and a Contractor, each designed for a different procurement route and contract strategy including pricing. The three contracts are:

1. The JCT Standard Building Contract With Quantities which may be used for complex construction projects that follow the traditional or conventional procurement path, which are lump sum contracts with the price determined in advance and based on drawings and a bill of quantities;
2. The JCT Standard Building Contract Without Quantities which may also be used for complex construction projects that follow the traditional or conventional procurement path, which are lump sum contracts with the price determined in advance but based on drawings and a specification;
3. The JCT Standard Building Contract With Approximate Quantities which may be used for complex construction projects that follow the traditional or conventional procurement path, but which are measurement contracts with the

price determined after completion on a pre-agreed basis using drawings and bills of approximate quantities.

This study will use the JCT Standard Building Contract With Quantities (SBC/Q 2011) for the comparison and evaluation.

The parties involved

The key parties involved in the management of time under the provisions of SBC/Q 2011 are:

1. The Employer and the Contractor who are the parties to the contract;
2. The Architect/Contract Administrator (A/CA), whose function is to administer the provisions of the contract;
3. The Employer's representative who may be appointed to exercise all the functions ascribed to the Employer in the conditions of contract.

Terms and provisions for the management of time

Schedule 8 of SBC/Q 2011 provides optionally that: '[T]he Parties shall work with each other and with other project team members in a co-operative and collaborative manner, in good faith and in a spirit of trust and respect. To that end, each shall support collaborative behaviour and address behaviour which is not collaborative'.

Clause 2.9.2 obliges the Contractor to provide the A/CA with his master programme for the execution of the Works with an optional provision to identify the critical path and/or providing such other details as are specified in the Contract Documents.

Under clause 2.1 of SBC/Q 2011, the Contractor is required to 'carry out and complete the Works in a proper and workmanlike manner and in compliance with the Contract Documents...'. Under clause 2.4, the start date of the Works is the 'Date of Possession' and '[O]n the Date of Possession possession of the site ... shall be given to the Contractor who shall thereupon begin the construction of the Works ... and regularly and diligently proceed with and complete the same on or before the ... Completion Date'. This clause 2.4 places a contractual obligation, a condition, on the Employer to give possession of the site to the Contractor on the Date of Possession. In turn, a contractual obligation, a condition, is placed upon the Contractor both to progress the works by way of proceeding 'regularly and diligently', a phrase whose interpretation gave rise to a dispute in *West Faulkner Associates v London Borough of Newham* (1994) 71 BLR 1, and to complete the Works on or before the Completion Date. There is an optional provision that allows the Employer to defer giving possession of the site for a period not exceeding six weeks calculated from the Date of Possession. This provision may be critical in avoiding repudiation of the contract at the outset by the Contractor in circumstances where the Employer is hindered in handing over possession of the site. Completion is signified by the issue of the Practical Completion Certificate which is issued '[W]hen in the Architect/Contract Administrator's opinion practical completion of the Works is achieved...'. There is no contractual definition of Practical Completion but the Courts have considered the matter over the years in several cases. For example: In *J. Jarvis and Sons -v- Westminster Corporation* (1978) 7 BLR 64 HL, Lord Justice Salmon defined practical completion as completion for the purpose of allowing the employers to take possession of the works and use them as intended. In *H.W. Neville (Sunblest) Ltd -v- William Press and Son Ltd* (1981) 20 BLR 78, it was held that practical completion meant that if there were any patent defects the Architect should not give a certificate

of practical completion but did not mean that very minor de minimus work had to be carried out. In *Mariner International Hotels Ltd v Atlas Ltd (2007) HKCFA*, it was considered that practical completion is a state of affairs in which the works have been completed free from patent defects, other than ones which can be ignored as trifling.

The Rectification Period, the default period for which is six months, follows the issue of the Practical Completion Certificate. Under clause 2.38: '[I]f any defects, shrinkages or other faults in the Works ... appear within the ... Rectification Period due to materials, goods or workmanship not in accordance with the contract ... such defects, shrinkages and other faults shall be specified by the Architect/Contract Administrator in a schedule of defects which he shall deliver to the Contractor as an instruction not later than 14 days after the expiry of (the) Rectification Period. Within a reasonable time after receipt of such schedule or instructions, the defects, shrinkages and other faults shall ... be made good by the Contractor'. Clause 2.39 then states: '[W]hen in the Architect/Contract Administrator's opinion the defects, shrinkages and other faults in the Works ... have been made good, he shall issue a certificate to that effect (a Certificate of Making Good) ...'. The issue of the Certificate of Making Good signifies the end of the construction phase of the contract.

The Completion Date may be adjusted to accommodate delays caused by events that are outside the control of the Contractor. SBC/Q 2011 terms such events as Relevant Events of which there are fourteen specified in clause 2.29. Clause 2.26 provides for a 'Pre-agreed Adjustment' which means the fixing of a revised Completion Date for the Works by the Confirmed Acceptance of a Variation Quotation or an Acceleration Quotation. Clauses 2.27 and 2.28 deal with the 'normal' circumstances. Clause 2.27 places strict obligations on the Contractor to give timely notice of the material circumstances, including the cause or causes of the delay to the A/CA and to identify in the notice any event which in his opinion is a Relevant Event. The Contractor shall, if practicable in such notice or otherwise in writing as soon as possible thereafter, give particulars of its expected effects, including an estimate of any expected delay in the completion of the Works beyond the Completion Date. The Contractor has to keep the A/CA informed of any material change in the estimated delay and supply any further information as the A/CA may require. It is contended that the following of these administrative procedures is condition precedent to having the extension of time granted. Clause 2.28 places a similar strict obligation on the A/CA to make a timely decision and to inform the Contractor within 12 weeks of receipt from the Contractor of the required particulars. If the Contractor fails to complete the Works by the Completion Date, the A/CA shall issue a Non-Completion Certificate. The Employer may then give notice to the Contractor that he requires the Contractor to pay liquidated damages at the rate stated in the Contract Particulars.

Key terms associated with the management of time under SBC/Q 2011, for comparison with the other contracts are: Contract Particulars, Contract Documents, the Works, master programme, Date of Possession; Deferment; Date for Completion / Completion Date; Practical Completion, Rectification Period, defects, shrinkages or other faults in the Works, schedule of defects, Certificate of Making Good, delay, extension of time, Relevant Events, Non-Completion Certificate, liquidated damages.

THE NEW ENGINEERING AND CONSTRUCTION CONTRACT (NEC3)

This title is somewhat misleading as it is no longer 'new': there have been three editions: the first, NEC, in 1993, the second, NEC2, in 1995 and the most recent,

NEC3, in 2005. In addition, NEC3 is not a contract but rather is a ‘family’ of different standard form contracts. Pinsent Masons (2011) have described NEC3 as a:

“stimulus to good management: overall, NEC3 focuses on 'real time' management of the project rather than looking back on what the parties should have done. However it is very heavy on administration, and requires good understanding of its procedures and sufficient resources from both the employer and the contractor to make it a success”.

The standard form construction contract for the contractual arrangement between a Client and a Contractor in the NEC3 family is the NEC3 Engineering and Construction Contract (ECC). Like the JCT Standard Building Contract, the ECC has options, each also designed for a different procurement route and contract strategy including pricing. The six options are:

- A: Priced Contract with Activity Schedule;
- B: Priced Contract with Bill of Quantities;
- C: Target Contract with Activity Schedule;
- D: Target Contract with Bill of Quantities;
- E: Cost Reimbursable Contract;
- F: Management Contract

One option, from A to F, must be selected.

This study will use the NEC3 Engineering and Construction Contract (ECC) with Option B, Priced Contract with Bill of Quantities, using the abbreviation ECCB for the comparison and evaluation.

The parties involved

The key parties involved in the management of time under the provisions of ECCB are:

1. The Employer and the Contractor who are the parties to the contract;
2. The Project Manager who represents the Employer’s interests and whose role is to manage the contract for the Employer.
3. The Supervisor who is responsible for ensuring that the Contractor satisfies the quality standards stated in the Works Information.

Terms and provisions for the management of time

Clause 10.1, the first term of the contract, states that the Employer, the Contractor, the Project Manager and the Supervisor shall act as stated in this contract and in a spirit of mutual trust and co-operation. There has been debate in the construction law literature as to what is meant by this term and whether such a contractual provision could be enforced. ECCB places significant emphasis on the programme. The programme is a key management tool. If the Contractor fails to provide a programme at the start of the project, 25% of the sums due under the contract can be withheld until a programme is submitted. The Contract Data has provision for a programme to be identified either in the Contract Data part two, i.e. that provided by tenderers as part of their offer, at the Contract Date or to be submitted by the Contractor within a period stated in the Contract Data part one, i.e. that provided by the Employer. Section 3 of the Contract Data part 1 provides that the Contractor submits revised programmes at intervals no

longer than a number of specified weeks. The Project Manager, as well as the Contractor, use the programme to monitor progress and to assess the time effects of compensation events. Clause 11 defines terms. Clause 11.2(1) refers to the Accepted Programme and defines it as the programme identified in the Contract Data or the latest programme accepted by the Project Manager. The Contract Date is defined in clause 11.2(4) as the date when the contract came into existence. The Starting Date is when the contract comes alive; the Contractor may begin off-site work associated with the project. The Access Date is when the Contractor can have access to the site. The Completion Date is the date by which the Contractor has to achieve Completion. Completion is defined in Clause 11.2(2) as occurring when the Contractor has done all the work which the Works Information states he is to do by the Completion Date and has corrected notified Defects which would have prevented the Employer from using the works. Clause 30.1 provides that the Contractor does not start work on the Site until the first access date and does the work so that Completion is on or before the Completion Date. There is no provision for progress. Clause 30.2 provides that the Project Manager decides the date of Completion and certifies Completion within one week of Completion. The Completion Date may be extended under Clause 6 of the Core Clauses owing to the occurrence of one or more 'compensation events' of which there are 19 listed in clause 60.1 Compensation events are events for which the risk in terms of both time and money is transferred from the Contractor to the Employer. Clause 62.2 provides for the Contractor to submit quotations for any delay to the Completion Date due to the occurrence of a compensation event. Completion marks the start of the defects correction period. A Defect is defined in 11.2(5) as a part of the works which is not in accordance with the Works Information. The defects date is specified in the contract data as a number of weeks after completion. The 'defects date' and the defect correction period' may be confusing terms. The 'defects date' defines how long the Contractor will be liable to rectify defects in the works. Typically, a 'defects date' might be 52 weeks after Completion. The 'defect correction period' is the period in which the Contractor must rectify a defect which has been notified to him. Different 'defect correction periods' may be specified for different types of defects, depending on the kind of defect and the urgency of the Employer's need for correction. At the defects date or at the end of the last defect correction period, the Supervisor issues the Defects Certificate, one of the most important certificates required by ECCB, which brings most of the Contractor's obligations to an end and signifies the end of the construction phase of the contract. ECCB has an option, X7, for delay damages. These are liquidated damages to be paid by the Contractor to the Employer if he fails to complete the works by the Completion Date for reasons that are the Contractor's own fault.

Key terms associated with the management of time under ECCB, for comparison with the other contracts are: Contract Data, Works Information, the Site, the works, Accepted Programme, Contract Date, Starting Date, Access Date, Completion, Completion Date, compensation event, defects date, defect correction period, Defects Certificate, delay damages.

THE CIOB CONTRACT FOR USE WITH COMPLEX PROJECTS CPC2013

This contract is described as being suitable for:

- Works of high value or complexity
- Major Real estate projects

•Engineering/Infrastructure Projects

The Contract consists of the: Contract Agreement, Conditions of Contract, Appendices to the Conditions of Contract. It may be used where the procurement method is: build only of a design prepared under the direction of the Employer; build only of a design prepared under the direction of the Employer, but with the Contractor's design of parts, and, design and build or turnkey projects in which the Contractor is responsible for both the design and construction of the Works. There are 7 Appendices to the Contract:

Appendix A – Definitions

Appendix B – Contract Data

Appendix C – Building Information Modelling

Appendix D – Working Schedule and Planning Method Statement

Appendix E – Progress Records

Appendix F – Events

Appendix G – Issue Resolution

Keith Pickavance, co-author of CPC2013, writing for NBS, stated:

'Underpinning CPC2013's more practical and effective approach to time management is the requirement of a dynamic, critical path network time model (or 'Working Schedule', as it is called). This is published together with a Planning Method Statement which sets out the rationale underpinning the Working Schedule, the assumptions on which it is based and the calculations used in its preparation.' (Pickavance, P. 2014)

The parties involved

1. The Employer and the Contractor who are the parties to the contract;
2. The Contractor's Authorised Representative, who, under clause 14.1 'shall be empowered to act with the Contractor's full authority in all matters relating to the contract'.
3. The Employer's Authorised Representative, who, under clause 14.2 'shall be empowered to act with the Employer's full authority in all matters relating to the contract'.
4. Contract Administrator who administers the provisions of the contract on behalf of the Employer
5. Project Time Manager – the Contract Administrator's advisor on project time-related matters.
6. The Time Management Expert (Auditor) whose role includes the examination of the Contractor's Planning Method Statement, Working Schedule and Progress records before work commences and at regular intervals during the progress of the Works.

Terms and provisions for the management of time

Clause 5.1 states that the parties shall work together in the manner set out in the contract and shall co-operate in a spirit of mutual trust and fairness.

CPC2013 places great emphasis on a dynamic time model. Appendix D provides for the Working Schedule and Planning Method Statement. D3 states that the Working Schedule shall conform to the Planning Method Statement and shall describe the durations and sequence of all Activities planned to be carried out in the future, and those completed in whole or in part, and is to comprise, inter alia, all Activities necessary for the effective completion of the Works. The Working Schedule is the name given to the Contractor's critical path network and, together with the Planning Method Statement, function as the Contractor's time model for the Works. On submission, it needs to be checked for compliance by the Project Time Manager and also independently audited from time to time. The Auditor is person named in Appendix B as the time management expert. The role is to examine before work commences and at specified intervals, the state of the Contractor's Planning Method Statement, Working Schedule and Progress Records. The Working Schedule is required to be updated regularly with actual progress from the Progress Records and will be used for the calculation of any extension of time and any time related compensation. The Working Schedule must conform to the standards in the CIOB's Guide to Good Practice in the Management of Time in Complex Projects.

The start of the construction phase of the contract is signified in clause 5.4 which provides that on the Access Date, the Employer shall afford access to and grant possession of the Site to the Contractor. Clause 5.5 provides that the Contractor shall commence the physical Works on Site on the Access Date, proceed to carry out the Works in a good and workmanlike manner and in accordance with the contract and to complete the Works by the Date for Substantial Completion. Progress is thereby expressly, contractually accommodated. Clause 47.1 provides that as soon as it has formed the opinion that the Works have ... achieved Substantial Completion, the Contract Administrator shall notify the Contractor and Employer of its intention to issue a Certificate of Substantial Completion ... and its opinion as to when Substantial Completion was achieved. If there are no disagreements, Substantial Completion will be deemed to be agreed to have been achieved in accordance with the Contract administrator's opinion. Clause 47.3 provides that the Contract Administrator shall issue the Certificate of Substantial Completion to the Contractor within 5 business days of the notice given under the provisions of clause 47.1. The date of the Substantial Completion Certificate marks the start of the Post-Completion Retention Period, the period of which, in weeks, is specified in the Contract Data, Appendix B. Within 20 Business days of the end of the Post-Completion Retention Period, the Contract Administrator shall issue to the Contractor a list of all the defects, shrinkages and other faults of which the Contract Administrator is then aware (Clause 48.2.1). The Contractor shall then commence and carry out the specified making good of the defects, shrinkages and other faults and notify the Contract Administrator when it is complete (Clause 48.3). Within 5 Business Days, the Contract Administrator shall issue a Certificate of Making Good Defects (Clause 48.6). This certificate specifies the date upon which the Contractor's obligations for making good defects are discharged and effectively signifies the end of the construction phase of the contract.

The Early Warning provisions (Clause 36) and the Risk Management provisions (Clause 37) mitigate the risk of delays.

An 'Event' is defined in Appendix A as 'an occurrence which is ... an Employer's Time Risk Event'. Events are listed in Appendix F. An Employer's Time Risk Event is defined as an occurrence identified as such in Appendix F which is not caused or contributed to by the Contractor or anyone for whom the Contractor is responsible.

CPC2013 accommodates delays caused by Events through Clause 38 which sets down a mechanism for calculating the effect of an Event on Time. Clause 40 then provides a process by which the Project Time Manager considers the information produced from the provisions of Clause 38, and ultimately obliges the Contract Administrator to award an Extension of Time if appropriate. The process purports to obviate a subjective 'fair and reasonable' assessment because the Contractor must demonstrate an entitlement to an extension of time by showing records of performance as evidence and by calculation using the updated working schedule. Under the provisions of 49.1, if the Contractor fails to achieve Substantial Completion by the Completion Date, the Contract Administrator shall issue to the Contractor a Certificate of Failure to Complete. Liquidated Delay Damages for failure to complete will then be applied as compensation to the Employer for the period from the date signified on the Certificate of Failure to Complete and the Substantial Completion Date.

Key terms associated with the management of time under CPC13, for comparison with the other contracts are: Contract Data, Access Date, possession, Site, Works, Date for Substantial Completion, Substantial Completion, Certificate of Substantial Completion, Substantial Completion Date, Certificate of Making Good Defects, Certificate of Failure to Complete, Events, Extension of Time, Liquidated Delay Damages.

COMMENTARY

The nature of this commentary is to pose some questions. The first is to ask whether there is a real difference amongst the three forms. Each form, in essence, provides the same procedures albeit using different terminology and demanding somewhat different administrative methods. A criticism of all of the forms might be that each is overburdened with detail to the extent that there are too many opportunities for minor breaches. Each form imposes micro-management on the parties; the greater number of provisions in each of the contract set out in detail how the parties are to conduct the administrative matters associated with managing the project. Is this helpful or bureaucratically confusing? Can relationships of mutual trust, co-operation, good faith, spirit of trust and such-like be embedded contractually, or do these emanate from good management practices associated with careful and sensible procurement and good contract administration? Perhaps the issue is the nature of a standard form. In order to deal with the management of projects that are continually different, would it not be better to simplify the contract and leave the management expertise to the team who are professionally trained to manage the process. For example, would it not be sufficient for the construction contract and those contracts with all involved in the procurement, design, construction and delivery of the building to be stipulated as being entire contracts with payment conditional upon delivery of the completed building by the defined date. Such a stimulus would focus the minds of the 'team' on the final product and induce collaborative working to minimise disputes and allowing management flexibility led, probably, by the Project Manager. In any case, in terms of managing time, it might promote good project management to have a contract that states simply: *"The contractor and the design team shall work together to produce the building by the designated date and will be paid when the building is produced"*.

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ARE AUSTRALIAN STANDARD FORMS OF CONSTRUCTION CONTRACT CAPABLE OF DEALING WITH THE ISSUE OF EXTENSIONS OF TIME EFFICIENTLY AND EFFECTIVELY?

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The efficient and effective management of time on complex construction projects (especially when concerned with the development and resolution of extension of time claims) has long been considered a major issue in construction contracts. Recent research has culminated in the production of a new standard form of contract drafted specifically as an attempt to overcome these issues. This research identifies the perceived critical success factors that are recommended to be included in, and addressed by the new standard form of construction contract in an attempt to alleviate these issues, and reviews a selection of Australian standard forms of construction contract for the presence of the perceived critical success factors. A review of current literature was carried out to identify the perceived critical success factors for the effective and efficient management of time with respect to extension of time claims, together with a qualitative analysis of the new standard form of construction contract as verification of the identified critical success factors and their management and application. A comparative analysis was undertaken of the extension of time provisions of a selection of Australian standard forms of construction contract as a means of determining their efficiency and effectiveness for resolving extension of time claims in a modern construction industry. The research identified 69 critical success factors that should be present in the clauses of standard forms of construction contracts to efficiently and effectively enable the resolution of extension of time claims for the benefit of all parties involved. The selected Australian standard forms of construction contract were found to be vague with respect to the content and inclusion of the perceived critical success factors, providing a greater opportunity for an extension of time claim to evolve into a dispute between the contracting parties.

Keywords: claims, conflict, contract law, litigation.

INTRODUCTION

Disputes involving the management of time on construction projects causing delay and cost overruns are considered to be an ubiquitous feature of the industry (Love, Tse *et al.* 2005; Blake Dawson Waldron 2006) that are not unique to Australia, but are also present in other developed economies with adversarial based legal frameworks (Cooperative Research Centre for Construction Innovation 2009).

The costs involved in resolving these disputes are said to be substantial. In Australia it is estimated to be in excess of AU\$7 billion per year (Cooperative Research Centre for Construction Innovation 2009), in the United Kingdom (UK) it estimated to be in

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excess of eight billion pounds per annum (Pickavance 2003), whilst in the United States (US), the cost of construction litigation alone (not including the indirect costs associated with resolving these issues) are estimated to be in excess of US\$5 billion a year (DeSai 1997; Michel 1998).

There has been extensive research carried out to identify and classify the causes of disputes (as summarised in Love, Davis *et al* (2010)) and the processes of avoiding/resolving disputes in general (National Public Works Conference and National Building and Construction Council 1990; Yip and Chan 2004; Brand and Uher 2008; Cooperative Research Centre for Construction Innovation 2009), yet project delay disputes are still prolific and considered to be one of the most expensive and difficult to resolve.

Risk Management

The preferred industry risk management tool relied upon for dealing with the issue is typically the application and adherence to the requirements of the clauses of standard forms of contract, which are drafted with a presumption that delay 'events' will occur, and attempt to provide a mechanism for resolving such issues by including an extension of time clause that allows the employer (or the employer's representative) to extend the project completion date due to the occurrence of certain 'events', to protect the client from the contract becoming 'at large' in accordance with the prevention principle (Pease 2007).

Typically extension of time clauses are drafted in a straight forward manner and enable the contractor to apply (make a 'claim') for an extension of time to the agreed completion date of the project (plus any loss and expense incurred) as a result of the occurrence of an identified 'event'. The provisions of the contract clauses are meant to allocate the risk management/responsibility of the occurrence of such 'events' that may cause project delay in such a way as to ensure the successful, economical, and timely resolution of such issues to the satisfaction of all parties involved.

The identified 'event' has typically been agreed between the parties as an employer risk event, in which the employer accepts the responsibility for ensuring that the event does not occur, thereby, if the event does occur, the contractor will be given the additional equivalent amount of time to complete the project (without incurring liquidated damages), and any possible loss and/or expense incurred as a result of the 'event' causing delay to the project (there are variations to this principle depending upon the drafting of individual contract clauses and the occurrence of 'events' that neither party can control (neutral events)).

If the employer agrees with and accepts the contractors claim, the contractual remedy is undertaken, and the matter is resolved. However, where the employer does not agree with and accept the contractors claim, then, subject to the failure of negotiations between the parties, the matter would be considered to be in dispute.

The disagreement and non-acceptance of the contractors claim for an extension of time is the crux of the growth of the issue into a dispute.

Typically the contractual clauses require the contractor to substantiate the claim. This requires the production and collation of suitable evidence/witnesses/experts (normally undertaken by both parties as a means of substantiating or defeating the claim), often from inadequate and poorly kept and disorganised project records and disbanded project teams, to determine exactly what events took place, when, where, and what their likely or actual consequences to the outcome of the project were.

The compiling of suitable evidence is another element of the issue. The quality and comprehensiveness of construction organisations records and record keeping practices have often been criticised (Wood 1975; Brewer 1993; Kangari 1995; Vidogah and Ndekugri 1998; Chappell, Powell-Smith *et al.* 2005). This is said to be due to the complex nature of the construction process, where “*few events ... occur in a way or at a time they were intended to occur*” (Pickavance 2000), and the fact that “*the construction industry is notorious for not documenting procedures and transactions ... [with] ... most of the information being of a cost accounting nature ... [that] ... does not contain information relating directly to resource usage on scheduled project activities but only indicates apparent fluctuations in the cost of the project*” (Vidogah and Ndekugri 1997). The cost implications due to the time and effort involved in the retrospective identification, collection, validation, and collation of suitable evidence from unsuitable construction project records can be excessive.

The availability of comprehensive project documentation that fully records what events actually took place, when those events occurred, what resources were involved, and what the likely consequences of those events were, would provide the information necessary for the parties to agree on the outcome of those events and hence resolve the issues and minimise the risks of claims escalating into disputes.

Typically standard forms of construction contracts rarely state the type, form, and frequency of the gathering and updating of project records that if carried out would provide suitable evidence to assist in the establishment and quantification of delay 'events', and potentially reduce the number of delay and disruption disputes.

Add to this the growing opinion that the majority of the drafted clauses of current standard forms of construction contracts are no longer representative of, or reflect, the modern processes and technologies that are used (or available to be used) by the modern construction industry (Chartered Institute of Building 2011), increases the dilemma, causing one to consider if these clauses are adequately drafted and suitable for the effective and efficient resolution of delay issues by the modern construction industry.

There is broad support within the construction industry for the availability and use of standard forms of contract which are capable of being used without substantial amendment. However, in Australia, there is evidence to suggest that there is no such form available, with extension of time clauses, and delay damages clauses being the most common and frequently amended contractual clauses (Sharkey, Bell *et al.* 2014).

Establishing Entitlement

Where a claim due to the occurrence of certain 'events' arises, objections to the claim (which elevates the matter to a dispute) are normally on the grounds of:

- The claimants right to make a claim for the 'event' in question;
- Disagreement as to:
 - If, how and/or when the 'event' in question happened;
 - The effects of the 'event' on the construction project;
 - Responsibility for the occurrence of the 'event';
 - Quantification of the effects of the 'event' (time and/or money).

To establish entitlement due to the occurrence of an 'event', the claimant typically needs to:

14. Establish or prove that the contract allows an extension of time (and/or loss and expense) for the occurrence of the 'event';

15. Comply with the procedural requirements of the contract with regard to notices and notification of the party's intention to make a claim;
16. Prove that the claimed 'event' was the cause of the delay;
17. Identify who was responsible for the occurrence of the 'event';
18. Quantify the consequences of the occurrence of the 'event' (time and/or money);

The essential part of this process is for the parties to provide evidence in support/rejection of the claim (typically mirroring the legislative requirement for the production of evidence), that when tested would demonstrate 'on the balance of probabilities' indisputable support/rejection of the claim. This is where the difficulty in agreeing the disputed issues arises. The contract clauses may clearly identify the legal rights, obligations and duties of the parties involved, but rarely go into sufficient detail as to give guidance as to what (and what format) the submissions should be in order to be accepted as being indisputable evidence by both parties.

Typically the contract clauses would be expected to address these issues in such a way as to enable an adequate resolution. The effective contractual approach of doing so would be to clearly express, in the wording of the contract, the prescribed outcome should an 'event' occur that causes delay. The wording of the 'expressed' terms would be in such a format as to ensure that there could be no misinterpretation of their meaning as to what and how suitable evidence should be provided and accepted as way of proof. In reality however, expressed terms specifically addressing the occurrence of such 'events' and issues, and how to handle them, are rarely present in current standard forms of construction contracts. Instead, amendments to the existing clauses of the standard forms are typically made (by way of altering existing contract provisions, and/or adding additional clauses/specifications into the contract) that are usually untested by the courts, leaving the parties open to the discretion of those attempting to apply the amended/additional clauses/specifications by way of interpreting their meanings, or 'implying' the interpretation of the amendments with the original contract provisions (either individually or together), that have typically originally been drafted and included in the contract to deal with completely different issues. Needless to say, this increases the likelihood of disagreement between the parties, and an increased likelihood of the disagreement evolving into a dispute.

CRITICAL SUCCESS FACTORS

In October 2002, after a two year consultation period with the UK construction industry, the Society of Construction Law (SCL) produced a Delay and Disruption Protocol (Society of Construction Law 2002) aimed at addressing these issues, which McCredie (2002) identified as being:

- Preparation, approval and updating of the contract programme;
- Entitlement to an extension of time;
- Ownership of float built into the programme;
- Concurrent delays attributable to separate employer and contractor risk events;
- Delay analysis techniques;
- Compensation payments.

Additional research into the problem was undertaken by the Chartered Institute of Building (2008). The thesis underpinning this research was that, despite the advice of the SCL Protocol and availability of advanced computerised facilities, little had changed in the practice of time management since the development of the bar chart nearly 100 years ago. The essence of the research was to gain an understanding of

industry performance, the techniques used, and the competence of those engaged in the process of time management. This led to the publication of a *"Guide to Good Practice in the Management of Time in Complex Projects"* whose purpose was to set down the strategy and the standards necessary in order to facilitate the effective and competent management of time in complex projects (Chartered Institute of Building 2011) by:

- Defining the standards by which project schedules are to be prepared, quality controlled, updated, reviewed and revised in practice;
- Describing the standards of performance which should reasonably be required of a project scheduler, as well as forming the basis for the education of project schedulers; and
- Without compromising its primary purpose, will be developed as a scheduling reference document capable of wide application.

The Chartered Institute of Building extended this work by drafting and publishing a new standard form of construction contract: *"The Contract for use with Complex Projects"* (Chartered Institute of Building 2013) aimed at overcoming such issues.

RESEARCH AIM AND OBJECTIVES

The aim of this research was to review and analyse a selection of Australian standard forms of construction contracts to assess their suitability for use with the processes and technologies available to a modern construction industry, by comparing and contrasting the clauses of those contracts that deal with extensions of time claims, with those perceived to be the essential critical success factors (CSF) for successfully dealing with extension of time claims, effectively and efficiently, that are available for use by the modern construction industry.

Research Objectives

The objectives of this research were to:

19. Carry out a literature review to identify the perceived critical success factors that should be present in standard forms of construction contracts for dealing with extension of time claims that are representative of the processes and technologies available to a modern construction industry;
20. Review, analyse, compare, and contrast the extension of time clauses of a selection of Australian standard forms of construction contract for the presence of the perceived critical success factors.

METHODOLOGY

A comparative analysis of the following standard forms of construction contracts (chosen for their perceived popularity of use and similarity for the types of project undertaken (Sharkey, Bell *et al.* 2014)):

- CIOB Contract for Use With Complex Projects (UK);
- Australian Standards 4000 (1997) General Conditions of Contract;
- Australian Standards 2124 (1992) General Conditions of Contract;
- NSW Government GC21 Edition 2;
- Property Council of Australia PC-1 1998.

Was undertaken by:

21. Carrying out a literature review to identify the common issues associated with delay disputes;

22. Identifying and tabulating the perceived critical success factors that enable the successful resolution of delay results (Table 1);
23. Carrying out a comparative analysis of the clauses of several Australian standard forms of construction contracts for the presence of the critical success factors;
24. Tabulating the results of the analysis (Table 1) to identify, categorise, and assess if the selected Australian standard forms of construction contract contained equivalent or suitable provisions for dealing with the critical success factor by:
 - a. Express Term: where the contract explicitly deals with the issue in detail within the wording of the contract clause;
 - b. Implied Term: where the contract deals with the issue by relying on the application and/or interpretation of one or more other contract clauses;
 - c. At the discretion of the Employer: where the contract provides for the matter to be dealt with at the discretion of the employer.

Where the contract was silent on the issue, or provided for the matter to be dealt with at the discretion of the contractor, no categorisation was made as it was considered that the contractor was free to use whatever process (if any) they considered suitable, which could have included those prescribed by the critical success factors. However, the opportunity for the contractor to apply their own perceived 'best practice' approach and procedures for documenting, presenting, and administering a claim could provide further opportunity for disagreement between the parties, and more potential disputes.

Table 1: Comparative Analysis of Australian Standard Forms of Construction Contract

Critical Success Factor	Contract				
	CPC 2013	AS 2124	AS 4000	GC21	PC 1
PROGRAMME					
Requirement for provision of a programme	a	c	c		a
Requirement for programme to be a critical path method	a	c	c	b	c
Mechanism for specifying programming software	a	c	c		
Programme to be prepared to specified guides/codes	a	c	c		c
Within a specified timescale	a		c		a
Specify information to be included in programme	a		c		c
Approval of programme procedures	a				a
Mechanism for non-provision of programme	a				
Regular QA procedures for programme	a				
METHOD STATEMENT					
Requirement for provisions of a method statement	a				
Within a specified timescale	a				
Specify information to be included in progress records	a				
Approval of method statement procedures	a				
Mechanism for non-provision of method statement	a				
Regular QA procedures for method statement	a				
PROGRESS					
Requirement for progress meetings	a			c	
Requirement for maintaining progress records	a			c	
Within a specified timescale	a				
Approval of progress record procedures	a				

UPDATING OF PROGRAMME

Requirement for updating of programme	a	c	c	a
Within a specified timescale	a	c	c	a
Specify information included in updated programme	a	c	c	c
Approval of updated programme procedures	a			c
Requirement for final programme on completion	a			c
Mechanism for non-provision of updated programme	a			
Regular QA procedures for programme	a			

UPDATING OF METHOD STATEMENT

Requirement for updating method statement	a			
Within a specified timescale	a			
Specify information to be updated in method statement	a			
Approval of updated method statement procedures	a			
Mechanism for non-provision of method statement	a			
Regular QA procedures for method statement	a			

ENTITLEMENT

Mechanism for identifying/agreeing events	a	a	c	a
Procedures for early notification of "event" occurrence	a	a		a
Determine actions for "event"	a	a	c	c
... within a specified time	a	a		a
Update programme due to "event" occurrence	a			
Update method statement due to "event" occurrence	a			
Give instructions as a consequence of the "event"	a		c	
... within a specified time period	a			
Amend consequences due to more accurate data	a		c	

FLOAT

Defines meaning of float	a			
Identifies ownership of float	a	b	b	
Defines meaning of contingency	a			
Identifies ownership of contingency	a			

CONCURRENCY

Defines concurrency	a			
Clearly identifies entitlement due to concurrency	a	a	a	

DELAY ANALYSIS TECHNIQUES

Detailed breakdown of time effects of "event"	a			a
... within a specified time	a		a	a
Prepare a logically linked <u>fragnet</u> for each "event"	a			
Detailed identification of work suspension periods	a	a		a
Update programme with suspension periods/ <u>fragnets</u>	a			
Identify effects on draft impacted working schedule	a			
Publish draft working schedule (DWS)	a			
... within a specified time	a			
Approval procedures for DWS	a			
Procedures for non-publishing of DWS	a			
Publish draft impacted planning method statement	a			
... within a specified time	a			

Approval procedures for DIPMS	a			
Procedures for non-publishing of DIPMS	a			
Mechanism for calculating the effects multiple events	a			
COMPENSATION PAYMENTS				
Notification of "event" loss and/or expense procedures	a	a	a	a
... within a specified time	a			
Notification of "event" non-completion procedures	a			
... within a specified time	a			
Detailed description of the "event"	a			a
Detailed valuation of the "event"	a			a
Calculation procedures due to failure to provide detail	a			

RESULTS

Sixty nine perceived critical success factors that provided for the effective and efficient processing and resolution of delay claims were identified (and tabulated in Table 1).

A summary of the results of the comparative analysis of the selected contracts are tabulated in table 2.

Table 2: Summary of the Analysis of Australian Standard Forms of Construction Contract

Contract	Expressed No. (%)	Implied No. (%)	Employer Discretion No. (%)
CPC 2013	69 (100)		
AS 2124	7 (10)	1 (1)	7 (10)
AS 4000	3 (5)	1 (1)	13 (19)
C21	8 (12)	1 (1)	3 (5)
PC1	5 (7)		6 (9)

Of the standard forms of construction contracts analysed, only the new CPC 2013 contract dealt explicitly with all of the perceived critical success factors in detail.

Of the Australian standard forms of construction contracts analysed:

- AS 2124 only dealt with 15 of the perceived 69 critical success factors, of which 7 were clearly expressed, 1 was implied, and a further 7 were left to the employers' discretion, providing a high potential for disagreement between the parties concerning the issues a contractor may raise in support of an extension of time claim.
- AS 4000 only dealt with 17 of the perceived 69 critical success factors, of which 3 were clearly expressed, 1 was implied, and 13 were left to the employers discretion, providing a high potential for disagreement between the parties concerning the issues a contractor may raise in support of an extension of time claim.
- C21 only dealt with 12 of the perceived 69 critical success factors, of which 8 were clearly expressed, 1 was implied, and 3 were left to the employers' discretion, providing a high potential for disagreement between the parties concerning the issues a contractor may raise in support of an extension of time claim.
- PC1 only dealt with 11 of the perceived 69 critical success factors, of which 5 were clearly expressed, and 6 were left to the employers' discretion, providing a high potential for disagreement between the parties concerning the issues a contractor may raise in support of an extension of time claim.

CONCLUSIONS

The selected Australian standard forms of construction contracts analysed have a high potential for disagreement between the parties when trying to effectively and efficiently resolve an extension of time claim, with a high potential for the matter to evolve into a dispute due to lack of agreement between the parties when compared with the new CPC 2013 standard form of contract.

The selected Australian standard forms of construction contract are typically vague as to the use of modern processes and technology available to the modern construction industry for the effective and efficient resolution of an extension of time claim when compared with the new CPC 2013 standard form of contract.

The vagueness of the selected Australian standard forms of construction contract towards the use of modern processes and technology available to the modern construction industry for the effective and efficient resolution of an extension of time claim, and their reliance and adherence to contractual clauses and terms that give an implied understanding as to the meaning and application of one or more clauses, and to contractual clauses and terms that give the client, and/or the contractor discretion as to how to resolve any disagreements with respect to any claim, provide a greater opportunity for the issue to evolve into a dispute.

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ALLIANCE CONTRACTING: ENFORCEABILITY OF THE CONSENSUSDOCS 300 MUTUAL WAIVER OF LIABILITY IN US COURTS

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Project alliances are on the leading edge of innovation in alternative project delivery methodologies and the mutual waiver of liability is a central canon thereof. Enforceability of this waiver, however, has yet to be tested in any court of law. If enforcement can be relied upon it has the effect of making claims and dispute resolution processes irrelevant as between the parties to the project alliance whereby the project alliance agreement fulfils one of its principal purposes, elimination of claims. This research examines the mutual waiver of liability that flows from safe-harbour decisions under the ConsensusDocs 300™ Standard Tri-Party Agreement for Integrated Project Delivery in order to determine its potential for enforceability in the courts of the US. It adopts a classic legal research methodology focused upon primary and secondary legal research sources and designed to provide balanced findings in the form of a memorandum of law. Case history findings reveal that courts have increasingly found implied duties of good faith and fair dealing in both design services contracts and construction contracts; that courts have also found fiduciary relationships in cost-plus construction contracts; but that courts have been unwilling to find fiduciary relationships in all design services contracts. Enforceability hinges upon the likelihood of courts finding common law fiduciary relationships and duties of good faith and fair dealing for both design and construction services within the express words of ConsensusDocs 300™. The research concludes with an appeal to the academic community to educate industry participants in the common law meaning of both good faith and fair dealing and the expectations of a fiduciary.

Keywords: contract law, liability, claims, fiduciary duties, good faith and fair dealing.

INTRODUCTION

The ConsensusDocs 300™ Standard Tri-Party Agreement for Integrated Project Delivery (“*ConsensusDocs 300*”) is a multi-party form contract for owner, designer, and constructor. Multi-party contracts can be constructed to form a project alliance or for integrated project delivery depending upon how the parties allocate liability between them. When the parties agree to a conventional allocation of liabilities, their multi-party agreement is said to be for integrated project delivery. But when the parties agree to a mutual waiver of liability, their multi-party agreement forms a project alliance. A mutual waiver of liability clause distinguishes the project alliance methodology from the integrated project delivery methodology. A mutual waiver of liability clause commits the parties to release each other from all liability arising out

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of the project, except for wilful misconduct (Sweet and Schneier 2013: §14.13) (AIA National and AIA California Council (AIACC) 2007: §6.1.1).

Project alliances are on the leading edge of innovation in alternative project delivery methodologies and the mutual waiver of liability is a central canon thereof. Enforceability of this waiver, however, has yet to be tested in any court of law. If enforcement can be relied upon it has the effect of making claims and dispute resolution processes irrelevant as between the parties to the project alliance. Thus, ConsensusDOC 300™ has potential to fulfil one of its principal purposes, elimination of claims.

This research examines the mutual waiver of liability that flows from safe harbour decisions under ConsensusDOCS 300 in order to determine its potential for enforceability in the courts of the United States. Its methodology is analytic, adopting a classic legal research methodology focused upon primary and secondary legal research sources and designed to provide balanced findings in the form of a memorandum of law.

BACKGROUND

ConsensusDOCS 300

ConsensusDocs 300 was first published in 2007 as one of a comprehensive set of standard form contracts endorsed by twenty-two leading U.S. contractor, specialty subcontractor, owner and academic organization under the brand name ConsensusDocs. On its introduction, two of the largest U.S. construction stakeholder organizations, the Associated General Contractors of America (the “AGC”) and the Construction Owners Association of America (the “COAA”) converted their standard construction contract sets to conform to ConsensusDocs. The ConsensusDocs coalition claims to protect the best interests of the project rather than a singular party, yielding better project results and fewer disputes (ConsensusDocs, n.d.).

ConsensusDocs 300 was itself the result of pioneering work by Mr. Will Lichtig, construction management attorney with the firm of McDonough, Holland and Allen, PC, of Sacramento, California. Mr. Lichtig, a member of the Lean Construction Institute, drafted a novel agreement that became known as the Integrated Form of Agreement (the “IFOA”). This IFOA was then successfully employed on several building construction programs, most notably those established by the Sutter Health Systems of California (AIA *et al* 2012).

A brief history of integrated project delivery

The first use of the term “*Integrated Project Delivery*” (“IPD”) has been attributed to Owen Matthews of Westbrook Air Conditioning and Plumbing. Matthews’s use of the term described a team-based, lean project delivery methodology that was first used in a chiller plant installation project in Orlando, Florida (Matthews and Howell 2005). This project involved a multi-party agreement between Westbrook and its key subcontractors. The contract with the owner was a typical design-build form of agreement as between two parties, the owner and Westbrook (Forbes and Ahmed 2011).

Although the term IPD was first used for the Westbrook project, Westbrook did not conform to what is today generally recognized as the contractual model for IPD. Today’s generally accepted contractual model for IPD has a multi-party agreement

between owner, constructor and design professional. The American Institute of Architects defines this type of IPD as

“...a method of project delivery distinguished by a contractual arrangement among a minimum of owner, constructor and design professional that aligns business interests of all parties” (AIA/AIA California Council (AIACC) 2010).

Westbrook deviated from this model in that its multi-party agreement did not involve the owner. Yet even the AIACC, despite its crystal clear definitional trilogy, acknowledges that very few IPD projects are “*pure*” IPD (AIA *et al.* 2012). Many IPD projects adapt the collaborative relationships, management and organizational strategies of IPD while foregoing the multi-party agreement.

Given an owner-included multi-party agreement as a discriminator, however, the AIA identifies nine “*pure*” IPD projects: Sutter Health’s Cathedral Hill Hospital of San Francisco and Fairfield Medical Office Building of Fairfield, California; the MERCY Master Plan Facility Remodel of Lorain, Ohio; the Lawrence and Schiller office remodel of Sioux Falls, South Dakota; the SpawGlass Regional Office of Austin, Texas; the Autodesk, Inc. interior renovation in Waltham, Massachusetts; Cardinal Glennon Children’s Hospital Expansion of St. Louis, Missouri; the St. Clare Health Center of Fenton, Missouri; and Encircle Health Ambulatory Care Center in Appleton, Wisconsin (AIA *et al.* 2012).

A brief history of project alliances

The first known project to use the term “*Alliancing*” was a small offshore oil platform built in 1990 in the Andres field, a relatively small reservoir in the North Sea about 230 km northeast of Aberdeen (Thomsen and Sanders 2011: 199). A highly successful endeavour the project came in six months ahead of schedule at a cost of £290 million against an initial estimate of £450 million (Thomsen and Sanders 2011: 200).

The oil and gas industry produced the second alliance contract, also an offshore project, the Wandoo Oil Field Project, in Western Australia. Thomsen and Sanders report that Wandoo “*...was delivered \$13 million under the target budget of \$377 million, and in 26.5 months against an industry norm of 34 months.* (2011: 200).”

The National Museum of Australia, completed in 2001, was the first major building project awarded on the basis of a joint alliance contract (Hauck *et al.* 2004). Museum construction was completed one day before its scheduled opening and the project was brought in under budget while winning many awards (Thomsen and Sanders 2011: 200).

In the U.S., the AIA has identified only three IPD projects that can be classified as project alliances: Sutter Health’s Cathedral Hill Hospital; the SpawGlass Regional Office of Austin, Texas; the Autodesk, Inc. interior renovation in Waltham, Massachusetts;

Defining features of these project alliances included the following:

- A rigorous, qualifications-based selection process;
- Substantial design development after joining the alliance;
- Joint budget and cost/time targets;
- Shared risk/reward formulas;
- Abatement of change orders; and
- Superior communication between parties (Hauck *et al.* 2004).

THE MUTUAL WAIVER OF LIABILITY

Safe harbour decisions within the project alliance

The defining features of project alliances, described above, are also defining features of IPD projects. Project alliances and IPD projects are the same if defined only by these features. A salient feature of a project alliance, however, something separates it from every other IPD project, is that the parties to a project alliance contractually agree to release each other from all liability arising out of the project, except for wilful misconduct (Sweet and Schneier 2013: §14.13) (AIA National and AIA California Council (AIACC) 2007: §6.1.1).

The mutual waiver of liability is a central canon of project alliances. If this waiver is enforceable in the courts, it makes claims irrelevant and it takes the vitality out of disputes. To accomplish that is to satisfy at least one purpose, if not the principal purpose, of a project alliance.

But is this waiver enforceable? When asked if the mutual waiver of liability clause is enforceable, Christopher Noble of Noble and Wickersham LLP in Cambridge, England, a nationally respected construction attorney and one of the negotiators of the project alliance agreement for the Nation Museum of Australia cited hereinabove, replied, “*Who the hell knows. But it sure encourages people to work out problems.*” (Thomsen and Sanders 2011: 163) It is good that owners, designers and constructors will, and have, worked out their problems. But what happens if they don’t? The mutual waiver of liability has not yet been tested in any court of law. This inquiry seeks to answer this question: Is the mutual waiver of liability enforceable in US courts?

The risk allocation choice clause of ConsensusDocs 300

ConsensusDocs 300 enables the contract drafter to choose between the mutual waiver of liability or traditional risk allocation. §3.8.2 is the risk choice clause. §3.8.2 (1) activates the so-called safe harbour clause. This safe harbour clause asserts, as follows:

“1. [] SAFE HARBOR DECISIONS For those Project risks arising from collaboratively reached and mutually agreed-upon Project decisions made by the Management Group (Safe Harbor Decisions), the Parties agree to release each other from any liability at law or in equity for any act, omission, mistake or error in judgment, whether negligent or not, acting in good faith, in performing its obligations under this Agreement except to the extent such act or omission amounts to a willful default of an obligation under this Agreement.”

IPD projects that are not project alliances will feature a more traditional allocation of risks between the parties. The AIACC expresses this in §6.1.3 as follows:

“...*The parties [to a multi-party IPD agreement that is not a project alliance] may agree to limit their liability to each other, but it is not completely waived. If errors are made, conventional insurance is expected to respond. Thus, there is a measure of traditional accountability...*”

§3.8.2 (2) activates traditional risk allocation, asserting, in pertinent part, as follows:

“2. [] TRADITIONAL RISK ALLOCATION Each Party shall be fully liable for its own negligence and breaches of contract and warranty arising from the performance of this Agreement, to the extent provided for under the law of the jurisdiction in which

the Project is located, except to the extent as otherwise limited as set forth below (Indicate Applicable Exception):“

Collaboratively reached project decisions

This inquiry starts by contemplating what is meant by collaboratively reached decisions because §3.8.2 (1) imputes these are the fountainhead of project risks. Article 3 defines collaborative principles, providing context for understanding §3.8.2. (1). In particular, §3.4 asserts, in pertinent part, as follows:

“3.4 COLLABORATIVE RELATIONSHIP The parties each accept the relationship of mutual trust, good faith and fair dealing established by the Agreement and covenants with each other to cooperate and exercise their skill and judgment in furthering the interest of the Project... The Owner, Constructor, Designer and all member of the [Collaborative Project Delivery] Team agree to adhere to principles of collaboration based on mutual trust, confidence, good faith and fair dealing...”

Project Alliance, has been described by others, as follows:

“...an agreement between entities which undertake to work cooperatively, on the basis of a sharing of project risk and reward, for the purpose of achieving agreed outcomes based on principles of good faith and trust...” (Abrahams and Cullen 1998).

The words “good faith and fair dealing” are terms of art in law. Good faith and fair dealing is increasingly being found to be an implied duty in contracts. In the project alliance it is evident that this duty is express.

GOOD FAITH AND FAIR DEALING

Lord Chief Justice Baron Bingham of Cornhill had, some years ago, explained, “In many civil law systems, and perhaps in most legal systems outside the common law world, the law of obligations recognises and enforces an overriding principle that in making and carrying out contracts, the parties should act in good faith.” (Interfolio Picture Library v Stiletto Visual Programmes Ltd. 1989 (Interfolio v Stiletto)). Yet while tasteful to the civil law world, obligations of good faith and fair dealing were, until recently, repugnant to the common law world. This reflected the common law’s “belief that the written contract was [sacred, that] contracting parties should take care of themselves, and good faith is imprecise” (Sweet and Schneier 2013: §17.02D).

David Thomas QC, member of Keating Chambers in London informs us of a different view in the jurisprudence of Australia and New Zealand, asserting: “It may be said that the courts of Australia and New Zealand are perhaps more advanced in their understanding of the notion of good faith and the obligations it encompasses...” (Thomas 2012)

In England, as recently as 1992, the House of Lords still rejected the notion of any obligation of good faith and fair dealing (Walford v Miles 1992). Yet in the latest decade, English jurisprudence has changed its views. In the landmark case of CPC Group Ltd v Qatari Diar Real Estate Investment Company Mr. Justice Voss, in the High Court of Justice Chancery Division at London, citing contemporary English, Australian and US case law, announced the view of the modern common law, finding “a contractual obligation to observe reasonable commercial standards of fair dealing in accordance with (the parties) actions which related to the Agreement and also requiring faithfulness to the agreed common purpose and consistency with the justified expectations of (the parties)” ((CPC Group v Qatari) 2010).

In his written opinion, Mr. Justice Voss quoted the United States Restatement (Second) of Contracts §205, defining good faith, as follows:

“The phrase ‘good faith’ is used in a variety of contexts and its meaning varies somewhat with the context. Good faith performance or enforcement of a contract emphasises faithfulness to an agreed common purpose and consistency with the justified expectations of the other party; it excludes a variety of types of conduct characterised as involving ‘bad faith’ because they violate community standard of decency, fairness or reasonableness.” (American Law Institute (ALI) 1987: §205)

In the twentieth century, perhaps in response to §205 but also heavily influenced by the Uniform Commercial Code, jurisprudence in the US began to hold contracting parties to the covenant of good faith and fair dealing (American Law Institute and National Conference of Commissioners on Uniform State Laws (UCC) 2009: §1-304) (Sweet and Schneier 2013: §17.02D). Good faith and fair dealing has manifested itself in various ways. An owner cannot interfere with or cause delay to the work of his contractor (Lewis-Nicholson v. U.S. 1977). Contractors are expected to cooperate with the owner, the architect, engineer, other consulting professionals, other contractors, subcontractors and suppliers (United States f/b/o Wallace v. Flintco, Inc. 1988) (Allied Fire and Safety Equipment Co. v. Dick Enterprises, Inc. 1995) (Crawford Painting and Drywall Co. v. J.W. Bateson Co. Inc. 1988). And a builder must bring design problems to the attention of the architect (American and Foreign Ins. Co. v. Bolt 1997) (Eichberger v. Folliard 1988). According to Professor Sweet, *“The outpouring of cases dealing with this doctrine demonstrates that the doctrine will be an important component of the construction contract obligation”* (2013: §17.02D).

The duty of good faith and fair dealing is expressed in the type of project alliance contemplated in ConsensusDocs 300. Good faith and fair dealing has been applied by US courts as the absence of bad faith (wilful interference with or delay to the work of others), a duty of cooperation, and a duty to inform with respect to design problems. Other, similar applications can be imagined. It behoves the parties to a project alliance to understand their common interests and to remain faithful in the furtherance of those common interests. In failing to do so, the safe harbour of good faith decision-making is breached and that breach will expose the breaching party to liability to the non-breaching parties.

FIDUCIARY DUTIES

The essence of good faith is a new commercial reality that reaches into the guts, or more correctly, into the soul of common law contracts to extol principles of rational common interest. But this stops short of eliminating self-interest. Citing the case of *Overlook v. Foxtell* heard in the Supreme Court of New South Wales, Mr. Justice Vos quotes Dr. Elisabeth Peden of the University of Sydney, who says: *“...the implied obligation of good faith underwrites the spirit of the contract and supports the integrity of its character. A party is precluded from cynical resort to the black letter. But no part is fixed with the duty to subordinate self-interest entirely which is the lot of the fiduciary”* (Peden 2001).

A fiduciary relationship is similar, at least superficially, to a relationship founded on good faith and fair dealing. Unlike the relationship of good faith and fair dealing, however, fiduciary relationship imposes a duty upon the fiduciary to serve the best

interest of others, even if this results in economic or other harm to the fiduciary's interest.

Fiduciary law first appeared in common law jurisprudence in the English case *Keech v. Sandford* (1726). That case, exploring the contours of fiduciary duty to a minor child, established that a trustee owes a strict duty of loyalty. In more recent U.S. jurisprudence, legendary Chief Judge Cardozo established a strict standard of fiduciary conduct (*Meinhard v. Salmon* 1928). In his opinion, Chief Judge Cardozo asserted: "*Many forms of conduct permissible in a workaday world for those acting at arm's length, are forbidden to those bound by fiduciary ties. A trustee is held to something stricter than the morals of the market place*" (1928). The reasoning in *Meinhard v. Salmon* was very similar to the reasoning found in *Keech v. Sandford*: the fiduciary is bound by the rule of undivided loyalty that exists to reinforce the integrity of trusting relationships. In the words of Chief Judge Cardozo, this rule remains "*relentless and supreme.*"

Fiduciary duties may be implied but more commonly they are proscribed in the words of contract. Trust and confidence is the usual standard in a fiduciary relationship (Sweet 2013: §17.02B, p.343). "*...the relationship is fiduciary when one party has superior knowledge and authority and that party is in a position of trust and confidence over the weaker party.*" (Sweet 2013: §11.04B, p.160). Words of trust, confidence, authority and intent are sufficient to proscribe a fiduciary relationship. The words of ConsensusDocs 300 §3.4 and the words of Abrahams and Cullen stated hereinabove, can both be construed to proscribe fiduciary duties upon the parties to the agreement. What is unclear is the scope and application of this fiduciary duty.

A cost-plus contract can impose a fiduciary duty on a contractor. In a case heard in the Maryland Appellate Court it was held that an express provision in the parties' contract for the construction of a home asserted that the contractor "*accepted a 'relationship of trust and confidence'*" with the owners, "*agreed to further their interests by performing 'the Work . . . in the most . . . economical manner consistent with' their interests,*" and promised "*to 'keep . . . full and detailed accounts'*" (*Jones v. J.H. Hiser Construction Co.* 1984). The court found that the contractor had a fiduciary duty to keep the purchasers informed of the rising expenses of the house, particularly when there was no explanation or the difference between the estimated cost and the final cost. The court found that the contractor had breached this duty when he admitted that he did not know until the end of construction what the cost would be.

ConsensusDocs 300 is in essence a cost-plus contract where cost decisions are required by §3.8.2 (1) to consist of collaboratively reached and mutually agreed-upon Project decisions made by the Management Group. "*Collaboratively reached*" attaches §3.4 words of "*mutual trust*" and "*furthering the interest of the Project.*" Thus, cost decisions must be construed as fiduciary duties. To that end the parties must subordinate their self-interest to the interest of the project, even if this results in economic or other harm to them.

Although cost-plus contracts impute a fiduciary relationship, in the design and construction context issues generally revolve around the relationship between the architect and the owner (Sweet and Schneier 2013: §10.02C). When an architect becomes the owner's agent a fiduciary relationship forms around that agency. Such special agency typically involves such things as professional advice during preconstruction and the bidding process and during construction on matters involving cost and performance. Merely providing a design does not make an architect the

owner's fiduciary (Incorporated Town of Bono v. Universal Tank and Iron Works, Inc. 1965). The architect becomes the owner's fiduciary by taking on so-called administrative services, usually as additional services to the basic services proscribed in the owner-architect agreement where the architect has superior knowledge and authority and is in a position of trust and confidence over a weaker owner (Carlson v. SALA Architects, Inc. 2007).

ConsensusDocs 300 §3.6, in defining the designer's responsibilities asserts, in pertinent part: "... *Cost and schedule are design criteria and the Designer, in collaboration with the CPD Team, shall ensure that design fully considers cost and schedule implications...*" As it is with cost-plus contracts, "*in collaboration with the CPD Team*" attaches §3.4 words of "*mutual trust*" and "*furthering the interest of the Project.*" Thus, these decisions must be construed as fiduciary duties. To that end the Designer must subordinate his/her self-interest to the interest of the project, even if this results in economic or other harm to the Designer.

The agency disclaimer clause

In ConsensusDocs 300, both §3.6 Designer's Responsibilities and §3.7 Constructor's Responsibilities conclude with the following disclaimer:

"The [Designer or Constructor] represents that it is an independent contractor and that in its performance of the Services it shall act as an independent contractor. The [Designer's or Constructor's] duties, responsibilities and limitations of authority shall not be restricted, modified or extended without written consent of the Management Group."

Thus, both Designer and Constructor are declared independent contractors and on its face this would preclude them from any fiduciary duties. The trouble is that the courts have a long history of not enforcing such disclaimers, relying instead on the meaning found in the contract as a whole and the actions of the parties thereto. Prudence dictates caution. If a court finds that either Designer or Constructor breached a fiduciary duty, despite the disclaimer, it would breach the safe harbor and expose them to liability.

CONCLUSIONS

The salient feature of a project alliance is a mutual waiver of liability arising from cooperative language. This waiver is enforceable in US courts for its reliance on doctrines of good faith and fair dealing, and fiduciary duties that are increasingly being recognized in all construction contracts. Project alliances - by definition incorporating such waivers - have been spectacularly successful. Yet despite the success of the Andres Field, the Wandoo Oil Field Project, the National Museum of Australia, the Sutter Health program, and others, project alliances have not become commonplace.

If this scarcity of projects emerged from apprehension about the application of good faith and fair dealing then such apprehension is misplaced. Because in both common law and civil law countries the courts have long ago started recognizing the existence of such cooperation in the form of implied duties of good faith and fair dealing. The consequence of the legal recognition is that a project alliance provides a valuable benefit, waiver of liability in exchange for nothing: a subscription to duties of good faith and fair dealing that would exist impliedly, even without the cooperative language of the project alliance agreement.

If, however, the scarcity of projects has emerged from apprehension about the application of fiduciary duties then such apprehension is not misplaced. The fiduciary must meet a strict standard of behaviour, enforced relentlessly and supremely by the courts, that requires complete subordination of the fiduciary's self-interest to the best interest of others, even if this results in economic or other harm to the fiduciary. ConsensusDocs 300 asserts a disclaimer, declaring that neither Designer nor Constructor is a fiduciary of the owner. But courts have overlooked such disclaimers, relying instead on the meaning found in the contract as a whole and the actions of the parties thereto. Case history militates toward a high likelihood that the Constructor will be construed as a fiduciary with respect to cost-plus contractual provisions. That the Designer would be construed as a fiduciary is less certain. Regardless, prudence dictates caution in decision-making in constraint of the reasonable self-interest of either Designer or Constructor.

This inquiry reveals that: 1) good faith and fair dealing is increasingly being recognized as an implied duty in construction contracts; and 2) both designer and constructor may acquire fiduciary duties in the words of contract and their actions thereto. Yet the meanings of both good faith and fair dealing and the fiduciary relationship - how and where they occur - are not widely understood within our industry. This presents a call to the academic community to inform the industry. For to gain an understanding of and appreciation for good faith and fair dealing and the fiduciary relationship would be to gain a better understanding of and appreciation for collaborative relationships. This in itself would succeed to move our industry further away from its adversarial past.

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MOTIVATION AGENDA FOR SOCIAL EMPOWERMENT AND RESPECT FOR PEOPLE DURING THE DRAFTING OF CONSTRUCTION CONTRACTS

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Collaboration is a key element of the UK Government's current construction strategy. Contracts in the UK are evolving to incorporate an increasing number of collaborative features. In construction literature, there are calls for a more robust approach to the selection of such features relating to overall clients' performance requirements, with clients wishing to improve the overall performance of supply chains. The output of the supply chain is dependent on their workforce, with a key element of performance relating to motivation. There is work in psychology that provides an element of generalisation to human motivation, which establishes enablers of intrinsic motivation that improves workplace vitality, health and wellbeing. The aim of this paper is to provide a framework to assist practitioners make decisions that enable intrinsic motivation. The work establishes the basis of the hierarchy from robust work in psychology (self-determination theory); and relates the hierarchy to suites of contracts operating in the UK including the JCT, NEC, FIDIC and ACA suites. Document and summative content analysis evaluates different contractual mechanisms. The research establishes a critical approach to the incorporation of collaborative features in contracts that links to autonomy, competence and relatedness. Further research should be undertaken to explore construction contracts as enablers for social empowerment and respect for people.

Keywords: motivation, contracts

INTRODUCTION

A number of construction industry standards, reports and strategies over the last 30 years place emphasis on contracts to enable teams to meet client deliverables (Egan, 1998; Egan, 2002; Latham, 1994; Cabinet Office, 2011; Cabinet Office, 2012a; Construction Client's Group, 2013). Legal practitioners find themselves with the interdisciplinary question of how to create contractual and legal frameworks that intrinsically motivate people. The changing nature of construction contracts is evident in practice; for example, the JCT adopt a more user-friendly contract drafting style in 2005 and collaborative clauses in 2009. The question emerges is whether the changes in the contracts enable practitioners to meet client deliverables. For example, when Cicmil and Marshall (2005) relate motivation to the construction industry, they find

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that collaborative features can be insufficient to ensure team integration; and encourage further research into collaborative procedures as a social object.

The changing nature of construction contracts is also seen in the emergence of target contracts (RICS and Davis Langdon, 2012; nbs, 2013). With target contracts, there is often financial incentivisation or consequences depending on a project's final account. There is scepticism in literature towards the capacity of incentivisation to achieve performance. With Hughes *et al.* (2009, p. 528), identifying that incentivisation can have a detrimental effect on performance requirements including programme and quality. Where construction contracts focus on incentivising task performance, there is a risk of reducing emphasis on contextual performance, which relates to behaviours that support an environment in which the technical core operates (Griffin, *et al.*, 2000, p. 518; Motowidlo and Scooter, 1994); for example equality and participant satisfaction (Chan and Chan, 2004; Bing, *et al.*, 2005).

In summary, there is a requirement for contractual structures to enable collaboration; and a requirement in practice for critical thinking during the drafting of contracts concerning collaborative clauses. The aim of this paper is to provide an analytical framework to assist practitioners to form legal structures that enable intrinsic motivation. The work is different from many others in the field in that it promotes a research agenda linking robust theory in psychology to construction contracts. The work is socio-legal research that explores the effect of contract law on the social entity of construction practice. There is limited attempt in the work to provide legal doctrines.

CONTEXTUAL INFORMATION

Ryan (1995, p. 401; Ryan and Deci, 2000, p. 61) employs well-established theories in psychology to create “*a taxonomy of human motivation*” as part of self-determination theory. The taxonomy provides regulatory styles for external human motivation, namely 'external regulation'; 'introjection'; 'identification'; and 'integration' (see Table 1). Construction contracts enable a particular or a mixture of regularity styles.

TABLE 3: TAXONOMY OF HUMAN MOTIVATION - EXTRINSIC MOTIVATION

Regularity Style	External Regulation	Introjection	Identification	Integration
Process	Compliance /reactance	Guilt anxiety avoidance	Conscious valuing of activity	Awareness
	Salience of extrinsic rewards or punishments	Self-Esteem maintenance	Self-endorsement of goals	Hierarchical synthesis of goals
	Punishment avoidance	Ego involvement		Congruence
		Focus on approval from self or others		

Source: Based on Ryan (1995) and Ryan and Deci (2000)

Self-determination theory develops from 1990s studies. Earlier work uses students from the United States of America. Later work relates to adults and workplace motivation (Gagne and Deci, 2005; Baard, *et al.*, 2004; Deci, *et al.*, 1989; Moran, *et al.*, 2012; Ankli and Palliam, 2012; Fernet, *et al.*, 2013; Kasser and Ryan, 1996) and evaluates practice (Stone, *et al.*, 2008; Flynn, 2011). In addition, there is intercultural work, outside North America, for example in Russia; South American; Asia; and Europe (Ryan, *et al.*, 1999; DeVoe and Iyengar, 2004).

EXTERNAL REGULATION - relates to a salience of extrinsic rewards or punishment and relies on compliance and reactance (Ryan and Deci, 2000, p. 61). A number of studies identify the negative effect of financial incentivisation on motivation and vitality (Deci, 1973; Deci, *et al.*, 2001). Vitality is the energy that is available to oneself that is both exhilarating and empowering “*that allows people to act autonomously and persist more at important activities*” (Deci and Ryan, 2008). A focus on intrinsic (in contrast to extrinsic) aspirations has positive effects on vitality and health (Kasser and Ryan, 1996; Ryan, *et al.*, 1999; Deci, *et al.*, 1999a; Fernet, *et al.*, 2013).

INTROJECTION - relates to ego involvement and the focus of approval from self and others (Ryan and Deci, 2000, p. 61). Parkin, *et al.*, (2009) identify relationships, responsibility and recognition as areas of motivation that relate to introjection. Feedback that is ego related or controlling has a negative effect on vitality (Nix, *et al.*, 1999, p. 276; Ryan, 1982; Plant and Ryan, 1985; Deci, *et al.*, 2001; Ryan and Deci, 2006). Following work in psychology it is not surprising Hughes, *et al.*, (2009, p. 528) find performance measurement to have a negative effect on other requirements; for example where task performance measures do not consider contextual performance.

IDENTIFICATION - relates to the conscious valuing of activity through self-endorsed goals along with its associated autonomy (Ryan and Deci, 2000). Where people find a sense of autonomy, they find intrinsic motivation (Nix, *et al.*, 1999). This regularity style seeks to improve prosocial motivation, which relates to a person’s willingness to benefit others. Improvements to performance and persistence is available through interpersonal contact, between those undertaking the work and those obtaining the benefit; the improvement occurs where people undertaking the work perceive the value of the deliverable (Grant, *et al.*, 2007).

INTEGRATION - relates to hierarchical synthesis of goals (Ryan and Deci, 2000). Ryan (1995) relates integrated regulatory style to psychological needs of autonomy, competence and relatedness. The involvement of people in decisions relating to them improves performance and mental health and vitality (Deci, 1973; Baard, *et al.*, 2004; Campion, *et al.*, 1993; Nix, *et al.*, 1999); it also reduces the negative effect of external regulation (Moran, *et al.*, 2012). The use of money as management tool relates to integration when ensuring employees achieve their needs; needs hierarchies include security of employment (Maslow 1970). In addition, people find intrinsic motivation through something internal, such as enjoyment, or a calling (Elangovan, *et al.*, 2009). Therefore, corporate social responsibility is a way for organisations to enable intrinsic motivation through relatedness (Skudiene and Auruskeviciene, 2012).

Literature this paper explores (so far) relates to the motivation of people (or practitioners). There is a body of knowledge concerning transactional cost theory, which indicates that organisational partners have a tendency to act opportunistically (Faems, *et al.*, 2008). Therefore, the work suggests the only way to motivate the supply chain is through financial incentivisation, which is a under socialised view on human action (Faems, *et al.*, 2008); organisations operate for other reasons than financial incentivisation; a perfect example being charities and co-operatives. Supporting this there is a body of knowledge that identifies organisations operate with relational perspectives (McDermott, *et al.*, 2005; Faems, *et al.*, 2008; Palaneeswaran, *et al.*, 2003). Therefore, in order to create contextual and intrinsic motivation there is

also a requirement to consider the type of organisation that projects are let, avoiding organisations that place excessive emphasis on financial objectives.

METHOD

The aim of the research serves the requirements of interdisciplinary professional practice, which aligns the work to socio-legal research. This paper forms part of a much larger study that is undertaken pragmatically to answer a real world issue in construction practice. This paper explores empirical and robust work in psychology to establish regularity styles; and relates the styles to motivation and construction contracts. Summative content analysis determines the prescriptive nature of the contracts and document analysis relates the regularity styles to contractual mechanisms. The paper sets out a future research agenda; there is limited attempt to offer overall summaries of the contracts regularity styles. The work explores JCT and NEC contracts due to their popularity in the UK; ACA PPC 2000 as a relatively popular multiparty agreement; and FIDIC as a popular international contract.

DATA

TABLE 4: EXTERNAL REGULATION IN CONTRACTS

Contract	Incentivisation	Pages	Word count
Framework (JCT, 2011b)	Yes cl.17	31	7,448
CE (JCT, 2011a)	Yes cl.7.30	69	19,309
PPC (ACA, 2008)	Yes cl.13	71	28,123
ECC Opt A (NEC3, 2013)	Yes cl.X6,X12.4,X20	76	38,170
SBC/Q (JCT, 2005)	Limited	114	54,299
SBC/Q (JCT, 2011c)	Yes sch.8	127	55,809
Yellow Book (FIDIC, 1999)	Yes add. sub cl.8	130	56,373

TABLE 5: IDENTIFICATION AND INTEGRATION IN CONTRACTS

Contract	Value engineering	Performance indicators	Collaborative working	Environment
Framework (JCT, 2011b)	Yes cl.17	Yes cl.21	Yes cl.5, 9	Yes cl.16
CE (JCT, 2011a)	Yes cl.4.16	Yes s.6	Yes cl.2.1	Yes cl.12.2
PPC (ACA, 2008)	Yes s.17	Yes s.23 ap.8	Yes cl.1.3	Yes cl.16
ECC Opt A (NEC3, 2013)	Yes cl. X12.2-3	Yes, cl.X20	Yes cl.X12.3	Limited
SBC/Q (JCT, 2005)	Limited	Limited	Limited	Limited
SBC/Q (JCT, 2011c)	Yes sch.8	Yes sch.8	Yes s.8	Yes s.8
Yellow Book (FIDIC, 1999)	Yes cl.13.2	Limited cl.5.4	Yes cl.4.6	Yes cl.4.18

DISCUSSION AND LEGAL CONTEXT

EXTERNAL REGULATION - Construction contracts at first glance appear to operate by way of external regulation; for example, where a contractor fails to complete on time there is the potential for the client to recover damages. However, damages are typically, with the exception of some torts, not punitive and seek to achieve 'restitutio in integrum' (Rookes v Barnard [1964] AC 1129 and Kuddus v Chief Constable of Leicestershire Constabulary [2001] UKHL 29). Therefore, penalties in construction contracts are not normal. External regulation (see Table 2) occurs in construction contracts as incentivisation that often focuses on task performance.

INTROJECTION - In construction there is a broad range of professionals that undertake activities with different personality types (Chynoweth, 2009). Different professionals will have different tendencies towards how they provide feedback (Keirse, 1998; Berens and Nardi, 2004). Therefore, to remove risks associating to controlling and ego related behaviour, training and development are a consideration in both contract drafting and administration. To maximise motivation, feedback needs to be informational in contrast to controlling or ego related. Similarly, practitioners may employ contractual documents either as a stimulus to good management (NEC3, 2013) or as a document to achieve their goals through manipulation of egos. For example, in construction it is common to see passive aggressive emails concerning contractual clauses.

IDENTIFICATION - Table 3 identifies contractual mechanisms to promote identification with project and clients requirements. The tendency is for performance measurement to assist suppliers to identify with employer organisations (JCT, 2011c; JCT, 2011b; ACA, 2008). Performance measurement that links to incentivisation relates to external regulation (NEC3, 2013). Performance measurement may also provide information in two directions, between both the employer and supplier, therefore demonstrating relatedness (JCT, 2011a). The potential for relatedness extends to such things as health, safety, ethics and equality.

INTEGRATION - There is a drive for fair payment in UK, which is evident in construction contracts (UK Parliament, 1996; UK Parliament, 2009; Cabinet Office, 2011; Cabinet Office, 2012a). The drive results in standard forms of contracts incorporating fair payment provisions. There are also contractual mechanisms that promote relatedness (see sustainability and collaborative working Table 3). Contractual mechanisms however where overly prescriptive (or controlling) also reduce autonomy. The courts have met collaborative clauses with scepticism and confusion (Birse Construction Ltd v. St David Ltd [1999] EWHC 253 TCC; Costain Ltd and Ors v Bechtel Ltd and Anor [2005] EWHC 1018 TCC). The inclusion of the clauses exhibits controlling behaviour, which reduces intrinsic motivation. Table 2 compares the controlling nature of different contracts by number of words and pages.

CONCLUSIONS

Robust work in psychology identifies that contractual behaviour in industry has the potential to inhibit intrinsic motivation and contextual performance. The work in psychology undertakes empirical work that defines what motivates people as organisms. The question emerges is whether what motivates people is something different from that which motivates supply chains. There is a logical connection between employees and controlling contractual behaviour, after all the employees implement the construction contracts. There is also a logical connection in capacity of

incentivisation to reduce contextual performance, especially as is the case with target contracts where incentivisation is limited to cost performance. In any case, the axiological debate emerges of whether motivation of practitioners should come through incentivisation, as is the case with external regulation.

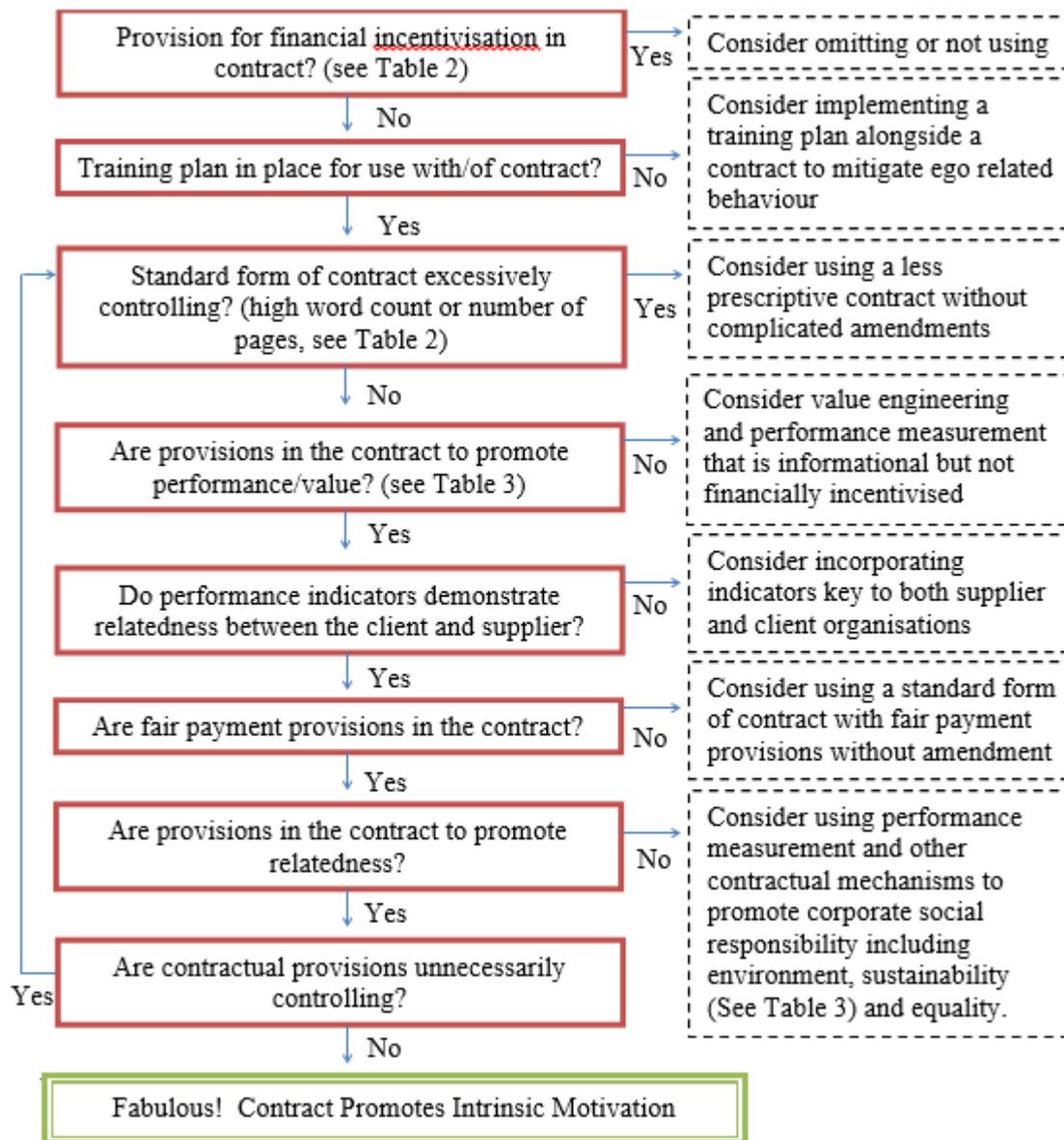


FIGURE 1: FRAMEWORK FOR CONTRACTS TO ENABLE INTRINSIC MOTIVATION

This paper clearly identifies a link between relatedness and intrinsic motivation. The proposal is that further research should be undertaken to make contracts enablers for social empowerment and respect for people through relatedness, which will in turn achieve benefits of intrinsic motivation and corporate social responsibility. Figure 1 provides a framework for practitioners during the drafting and selection of contracts based on robust work in psychology. To keep the Framework simple the regulatory styles are not specifically indicated in the diagram, however it is easy to see how an understanding of the regulatory styles would be of assistance during contract drafting.

FUTURE RESEARCH

The theoretical basis of this paper emerges from robust and empirical work in psychology. There is a requirement to undertake further research to allow the theory to promote best practice in construction contracts. The work recognises that different organisations will provide different levels of emphasis on financial and contextual performance; the work recommends that further research be undertaken concerning the types of organisations in construction, exploring the potential for organisations such as charities and co-operatives with greater emphasis on contextual performance. Table 4 sets out an agenda for future research.

TABLE 4: CONTRACTS THAT ENABLE HUMAN MOTIVATION AGENDA FOR FUTURE RESEARCH

Regularity Style	Recommendation
External Regulation	Undertake an empirical investigation to validate the motivational theory using construction professionals.
Introjection	Undertake further action learning research to develop training programmes and knowledge management to promote social empowerment and mitigate ego-involvement with construction contracts.
Identification	Undertake further constructionist research to validate the link between relatedness (including respect for people) and performance.
Integration	Undertake black letter in combination with research from the social sciences to relate legal complexities of collaborative clauses to client requirements.

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IS EXPERT WITNESS IMMUNITY FROM SUIT A THING OF THE PAST IN CONSTRUCTION LAW?

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Is expert witness immunity from suit a thing of the past in construction law? This article explores whether immunity for expert witness should be abolished or not; whether there is a need to distinguish between immunity from suit from actions in negligence, and immunity from suit from actions in defamation. The analysis from case law shows that it is most likely that in the future, immunity will be largely curtailed. It may be considered just and fair for immunity from suit to remain a significant legal and moral obligation for expert witness in view of human rights and right to a fair trial, although we can see there is evidence of a change in the concept of immunity. It can be argued that parties should ensure they employ competent experts to give them appropriate advice, experts should be accountable for the evidence they provide for the court at trials, and immunity from suit should not be enjoyed by expert witness if Article 6 of the European Convention on Human Rights on the right to a fair trial cannot be upheld. Therefore, it is necessary for the courts to modernise their approach to this particular area of law, and to comply with Article 6 of the European Convention on Human Rights. However, it can be argued that if immunity from suit is removed, very few experts will be prepared to be an expert witness for fear of being liable for negligent evidence. In most circumstances, it would be challenging to please the clients as well as carrying out the overriding duty to the court simultaneously. It makes more sense for the expert witness immunity from suit to be maintained but establishing criteria for departures instead of granting blanket immunity.

Keywords: construction law, expert witness, human rights, immunity.

INTRODUCTION

Is expert witness immunity from suit a thing of the past in construction law? This article explores whether immunity for expert witness should be abolished or not; whether there is a need to distinguish between immunity from suit from actions in negligence, and immunity from suit from actions in defamation.

Cresswell J. in *National Justice Compania Naviera S.A. v. Prudential Assurance Co. Ltd.*² had clearly elucidated the role of expert witness:

“Expert evidence presented to the court should be, and should be seen to be, the independent product of the expert uninfluenced as to form or content by the exigencies of the litigation...”

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² [1993] 2 Lloyd's Rep. 68, 81-82

An expert witness should provide independent assistance to the court by way of objective unbiased opinion in relation to matters within his expertise... An expert witness in the High Court should never assume the role of an advocate.

An expert witness should state the facts or assumption upon which his opinion is based. He should not omit to consider material facts which could detract from his concluded opinion...

An expert witness should make it clear when a particular question or issue falls outside his expertise...

If, after exchange of reports, an expert witness changes his view on a material matter having read the other side's expert's report or for any other reason, such change of view should be communicated (through legal representatives) to the other side without delay and when appropriate to the court."

DUTY OF EXPERT WITNESS

Main Duty

The main duty of an expert witness is to assist the court on specialist and technical issues with his or her expertise, to give independent expert advice and evidence. The duty to the court overrides any obligations to the parties who instruct or pay the expert. In a highway design case of *Carpenter v Pembrokeshire County Council*³,

Pembrokeshire County Council had designed and constructed a fairly steep driveway approach to the claimant's property. Two issues were considered: first, whether the driveway was too steep hence unsafe to be used and second, whether it is negligent to design such driveway. Mr Fletcher, the expert evidence was unacceptable to McKinnon J because he had taken the role as an advocate for the claimant and abandoned his independent role as an independent expert witness. It is submitted that, an expert has to provide impartial opinions devoid of influence from any of the parties. The underlying reason of expert witness immunity from suit is to promote full and frank discussions so that the information an expert witness provides will not be repeated elsewhere or used as evidence against the instructing party.

Stanton v Callaghan - absolute immunity from suit⁴

In *Stanton v Callaghan*⁵, the defendant, a consulting engineer was appointed to prepare a report on the subsidence of the plaintiff's home. He recommended a total underpinning work at an estimated cost of £77,000 was needed. The plaintiff relied on the defendant's report for a claim submitted to the insurers but the claim was rejected. The plaintiff, then, brought an action against the insurers relying on the defendant's expert advice. After a meeting between the parties' experts, the defendant revised his initial report and an agreed solution was made in a joint statement agreeing on a remedy around £21,000 for reducing subsidence by polystyrene infill as an alternative solution. This joint statement gave the plaintiff little room to reject the insurers' payment. For this reason, the plaintiff subsequently sued the defendant in negligence and breach of the implied terms of his contract of retainer. However, the defendant applied to strike out the plaintiff's claim on the ground of the Rules of the Supreme Court Ord.18 r.19 as disclosing no reasonable cause of action or, alternatively, as an

³ [2002] EWHC 1968

⁴ "Is expert witness immunity from suit a thing of the past in construction law?" by Phebe Mann in Cambridge University Law Society Per Incuriam, 88th Edition, Lent 2014, p11

⁵ [1999] 2 WLR 745

abuse of process, but was rejected by the court. The defendant appealed and was allowed to do so because it was in the public interest to encourage full and frank discussion between experts, and that required a freedom to make proper concessions without fear that any departure from previous advice to the retaining party would be considered negligent, and immunity was justified.

Jones v Kaney

The *Stanton v Callaghan*'s principles of the role of expert witnesses seem to have been forsaken in the recent case of *Jones v Kaney*⁶. Mr. Jones alleged that his psychiatric expert, Dr. Kaney, had provided negligent opinion evidence in a previous personal injury claim arising out of a road traffic accident. She signed a damaging joint witness report negligently due to her inadequate preparation, even though she did not agree with the content. The argument Mr. Jones put forward was that *Stanton v Callaghan*⁷ may not be good law any more:

Firstly, the House of Lords had abolished the advocates' immunity in *Arthur Hall v Simons*⁸;

Secondly, it is not compatible with Article 6 of the European Convention on Human Rights.

The extent of *Stanton v Callaghan*'s protection includes the production or approval of the expert's report as well as the joint experts' agreement contents. However, the immunity does not cover advice given by the expert to the client on the benefits of different issues concerning the case. Dr. Kaney applied to have Mr. Jones' claim struck out based on the grounds of expert witness immunity from suit. Blake J considered himself to be bound by the authority of the Court of Appeal case of *Stanton v Callaghan*. Hence, Dr. Kaney succeeded in striking out Mr. Jones' claim.

Although at this instance the judgement of Blake J concluded that *Stanton v Callaghan* is still good law, he is not convinced that the doctrine of expert witness immunity will continue to remain. He granted an Administration of Justice Act 1969 section 12 certificate allowing the appeal to be heard by Supreme Court, if it would wish to, without going through the Court of Appeal.

The decision by the Supreme Court in *Jones v Kaney* [2011]⁹ determined that the duty of expert witnesses applies to tribunals, civil, criminal and family proceedings.

They owe a duty of care to provide honest, independent and unbiased opinions to the court and give advice to their instructed client. The opinions and advice given by the expert witnesses should be within their area of expertise. These include advice on preexpert report, expert witness report, joint meetings and joint reports, and on evidence given in court. Furthermore, the duty includes contractual obligations under section 13 of the Supply of Goods and Service Act 1982, or in negligence (*Hedley Byrne v Heller* [1964]¹⁰).

⁶ [2010] EWHC 61 (QB)

⁷ [1999] 2 WLR 745

⁸ [2000] 3 WLR 543

⁹ [2011] UKSC 13

¹⁰ *Hedley Byrne & Co Ltd v Heller & Partners Ltd* [1964] AC 465

Arthur Hall v Simons

My argument over this issue is that if an engineer who negligently designs an unsafe structure can be sued, why an engineering expert who provides negligent evidence against the above negligent engineer cannot? Two approaches of immunity from suit are considered in *Arthur Hall v Simons*¹¹.

First Approach:

Lord Steyn suggested that if an advocate does not enjoy immunity from suit, would it undermine his overriding duty to the court, in particular if his conduct was bona fide dictated by his perception of his role to the court. The court cannot hold him negligent. This can be applied to an expert witness.

Second approach:

Lord Hobhouse and Lord Hoffmann's approach is that the duty of an expert witness is to provide the truth in court as set out in the Civil Procedure Rule irrespective of which party called or cross-examined him, similar to the role of an advocate.

In the light of the abolition of immunity from suit of advocates as seen in *Arthur Hall v Simons*, where does immunity from suit of expert witness stand? It is likely that it will follow the same trend, so that it would be compatible with Article 6 ECHR relating to the right to a fair trial.

Liability in Negligence

Jonathan Selby¹² had considered whether the ratio in *Arthur Hall v Simons* is relevant to the liability in negligence as an expert witness. He considered the nature of an expert's evidence as opinion evidence as opposed to evidence of fact. The court seeks reliability and correctness of the expert's evidence. Such evidence is similar to that of an advocate. The second area Selby considered is the nature of the expert's loyalty. Both the experts and the advocate are instructed and paid by their client. When they are once instructed by a party, it is unlikely that the other parties to the litigation can instruct them as there is a conflict of interest. The third area Selby discussed is the nature of current immunity provided to expert witnesses. The role of an expert witness is two-fold. On one hand an expert has to advise the client, on the other hand, he has to fulfil his duty to the court. Distinction may have to be drawn between the two purposes. However it is impracticable to distinguish between them because there is not much difference in the expert's advice to the client and the expert's evidence in court: the expert advice given to client would end up as expert evidence given in court. In this respect, there is close resemblance between an advocate and an expert. Selby argued that it is important to draw the distinction between immunity from suit from actions in negligence, and immunity from suit from actions in defamation. If the expert needs protection only in telling the truth, he only needs protection from actions in defamation. Negligence concerns whether the expert has done his job properly. It would be negligent if the expert provides dishonest opinions to the court.

¹¹ [2000] 3 WLR 543

¹² Jonathan Selby's discussion in his winning essay of the inaugural Bar Law Reform Essay Competition titled "Expert Witness Immunity from suit from actions in negligence should be abolished"

Public Policy

The arguments concerning public policy for expert witness immunity are to encourage truthful and fair evidence, and to provide orderly management and conduct of the trial. Holland J in *Landall v Dennis Faulkner and Alsop*¹³ expressed his view on the necessity of the expert immunity, in order to evade the tension between a desire to assist the court and the fear of the consequence of a departure from previous advice given. One of the arguments is that in the public interest the experts can have full and frank discussions before the trial without the fear of any departure from previous advice, given to the party who has retained him, may be considered as evidence of negligence. This is analogous to the concept of legal professional privilege raised by Taylor CJ in *R v Derby Magistrates' Court, ex p B*¹⁴ "... that a man must be able to consult his lawyer in confidence, since otherwise he may hold back the truth. The client must be sure that what he tells the lawyer in confidence will never be revealed without his consent."

The authors of this article disagree with Eady J's reasoning in *Raiss v Palmano*¹⁵ that an expert witness would still entitle to immunity for reasons of public policy even the expert has been dishonest. He indicated that there should be "*no undue inhibition*" on a witness who resiles from his earlier opinion if he subsequently realises that it is wrong. It is submitted that an expert witness should be accountable for his evidence in court and answerable to his client; he should perform his professional duties and be responsible for his professional negligence. In our opinion, "*no undue inhibition*" would have gone too far.

Competence of Expert Witness

The incompetence of an expert witness may jeopardise the right of the defendant to a fair trial. One of such cases is *Pearce v Ove Arup Partnership Ltd*¹⁶. In this case, an architectural student, Pearce, had made some drawings of a town hall in 1986. He claimed that an English civil engineering company together with the Dutch architects and builders as well as the Dutch local authority had infringed his copyright under the Dutch copyright statutes by erecting the Kunsthall in Rotterdam. Pearce claimed that the features of Kunsthall's design had been copied from his Docklands plans, therefore infringing his UK and Dutch copyrights. Mr. Wilkey was an expert witness for this case. He had submitted a report, wearing an expert hat of a professional architect. Jacob J had raised the issue that Mr. Wilkey did not stand back and take an objective view as to how the alleged copying could have been done. He bore an important responsibility for this case ever coming to trial. In considering the 'substantial part' principle, the judge struck out the action on the grounds that there was insufficient similarity between the building and the claimant's drawings. It was held that "*Kunsthall was independently designed with a similar feature to Pearce's design*" hence there was no infringement incurred. In particular the judge held that the degree of similarity between the claimant's drawings and those of the defendants was not sufficient to give rise to an inference of copying. He considered that the claim was based on speculation and accordingly ordered the whole claim against each of the

¹³ [1994] 5 Med LR 268

¹⁴ [1996] AC 487, 507, [1997] 2 WLR 779

¹⁵ [2000] All ER (D) 1266, (2002) 18 Con LJ 348

¹⁶ [2002] ECDR CN2

defendants to be struck out. The judge found Mr. Wilkey's evidence was so biased and irrational that he conclude Mr. Wilkey failed in his duty to the court.

The parties should be entitled to make Mr. Wilkey liable for his substandard expert advice. It can be argued that the enjoyment of Mr. Wilkey's immunity from suit violates the principle of Article 6 of the European Convention on Human Rights on the right to a fair trial.

The first author of this article marshalled¹⁷ Raynor J in the Mercantile Court (Queen Bench Division) in the case of *Growing Capital Limited v Calvert and Calvert*

[September 2010]. This case concerns the selling of a garden centre by the defendant to the claimants. The claimants claimed damages for breach of warranties in the Sale Agreement concerning the state of the premises; the defendants counterclaimed the unpaid balance of the price payable under the Sale Agreement. It was observed that there had been some measure of agreement between the defendant's expert, Mr. Cross, and the claimants' expert, Mr. Appleyard, in the initial experts' joint statement. However, as for the sloping glass roof, there was profound disagreement between the experts. Raynor J recorded that Mr Appleyard's opinion was that the glass is "*brittle and subject to breakage without notice*", and thus presented a substantial risk of very serious injury to members of the public under the glass roof. In Mr Appleyard's opinion, the replacement of the glass was required under the provisions of BS 5516¹⁸. Mr Cross's opinion, on the other hand, was that the glass roof, which had been in situ in the original structure since 1998, presented no real risk to users of the premises and that safety glass was not reasonably required given the nature and degree of risk.

In closing, Mr Bird, Counsel for the Claimant, can only rely on the evidence of the defendant's expert, that the use of safety glass in roof glazing would be advantageous in the event of fire, in support of his argument that the substitution of safety glass was reasonably required under BS 5516 because Mr Appleyard had never suggested that the replacement of the glass was indicated by fire considerations. As an expert witness, his role is to assist the court on specialist and technical issues. In our opinion, Mr. Appleyard did not seem to fulfil his duty because he had not done sufficient preparation for the case; he had not visited the property but relied solely on photographs, therefore his evidence may carry less weight than Mr. Cross' evidence.

Should an expert be in a privileged position protected from action even when carrying out his duties negligently?

No, *Martin v Watson*¹⁹ determined that an expert witness is liable any tort of malicious prosecution such as giving malicious evidence procured the prosecution. An expert witness will be liable for his/her misfeasance in public office, or conspiracy to injure because of giving fabricated evidence (*Darker v Chief Constable of the West Midlands Police*²⁰).

¹⁷ sitting with the judge at the Bench in Court

¹⁸ British Standard BS 5516-1: 2004: Patent glazing and sloping glazing for buildings

¹⁹ [1996] AC 74

²⁰ [2001] 1 AC 435

Liability of Expert Witness

The RICS²¹ advises the expert to consider liability for any negligent acts or omissions concerning an early advice and report, while preparing joint statements with the opponent's expert, giving evidence including anything said or done during the giving of evidence. It would not be surprised that an expert may also be liable for the costs of the litigation if the expert acted unreasonably. Expert witnesses, for obvious reasons, are not immune from criminal offenses such as perjury and perverting the course of justice or for contempt of court.

The decision of *Jones v Kaney* also suggested that the expert should ascertain the position in the jurisdiction where the report will be received as well as the jurisdiction the expert operates.

Article 6 of the European Convention on Human Rights (ECHR)

It is arguable that the immunity from suit of an expert witness is contravening Article 6 of the European Convention on Human Rights (ECHR) on the right to a fair trial. In *Stevens v Gullis and Pile*²² the defendant's expert had persistently been breaching the Court's order and Civil Procedure Rules Part 35 Practice Direction. The court prohibited the defendant to rely on his expert evidence. It is the defendant who lost his right to a fair trial due to the incompetence of his expert witness. On this account, the case law is yet to be further developed on immunity from suit of an expert witness.

CONCLUSIONS

Is expert witness immunity from suit a thing of the past in construction law? Case law shows that it is most likely that in the future, immunity will be largely curtailed. It may be considered just and fair for immunity from suit to remain a significant legal and moral obligation for expert witness in view of human rights and right to a fair trial, although we can see there is evidence of a change in the concept of immunity. We argue that parties should ensure they employ competent experts to give them appropriate advice, experts should be accountable for the evidence they provide for the court at trials, and immunity from suit should not be enjoyed by expert witness if Article 6 of the European Convention on Human Rights on the right to a fair trial cannot be upheld. Therefore, it is necessary for the courts to modernise their approach to this particular area of law, and to comply with Article 6 of the European

Convention on Human Rights. However, it can be argued that if immunity from suit is removed, very few experts will be prepared to be an expert witness for fear of being liable for negligent evidence. In most circumstances, it would be challenging to please the clients as well as carrying out the overriding duty to the court simultaneously. It makes more sense for the expert witness' immunity from suit to be maintained but establishing criteria for departures instead of granting blanket immunity.

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Stevens v Gullis and Pile [1999] BLR 394

WHAT DOES THE DUTY OF UTMOST GOOD FAITH (UBERRIMAE FIDEI) IN INSURANCE CONTRACT MEAN FOR THE CONSTRUCTION INDUSTRY?

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This article aims to understand what does the duty of utmost good faith (uberrimae fidei) in insurance contract mean for the construction industry. In construction insurance contracts, the duty of utmost good faith (uberrimae fidei) plays an important role. The analysis of case law shows that an insurer has the right in law to avoid the contract of insurance in its entirety if the insured was guilty of fraud, non-disclosure or misrepresentation before the contract was entered into. It seems to be unjust because even though the insured may be honest, he could still be in breach of duty. Utmost here means that both the insurer and the insured have the duty beyond the reasonable integrity and honesty. Furthermore, the insurer may also have a claim in the case of a breach of utmost good faith during the contract. It proceeds on the basis that the insurer likewise owes the insured a duty of good faith. While sounding good in theory, it can be argued that it may mean very little in practice. In the last decade, the English courts are turning their eyes towards the mutuality of the duty of good faith owed by the insurers to the insured. There is a new practical focus in the construction industry on inducement to balance the risk on the insured and insurer, where the mutuality of the duty of good faith is shifting towards the obligations on the insurers.

Keywords: construction law, insurance contract, uberrimae fidei.

INTRODUCTION

In construction insurance contracts, the duty of utmost good faith (uberrimae fidei) plays an important role. The analysis of case law shows that an insurer has the right in law to avoid the contract of insurance in its entirety if the insured was guilty of fraud, non-disclosure or misrepresentation before the contract was entered into. It can be argued that even though the insured may be honest, he could still be in breach of duty. “*Utmost*” here means that both the insurer and the insured have the duty beyond the reasonable integrity and honesty. Furthermore, the insurer may also have a claim in the case of a breach of utmost good faith during the contract. It proceeds on the basis that the insurer likewise owes the insured a duty of good faith. While sounding good in theory, it can be argued that it may mean very little in practice.

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In common law, at the pre-contractual stage, each party has obligations to refrain from misinterpreting material facts and in principle, to disclose material facts even there is no questions asked. However, in commercial construction insurance contract, it is an obligation for the parties' caveat emptor not to misinterpret facts, but the parties are not obliged to disclose anything which is not asked. Over the years, the English courts debate on the concept of materiality and the duty of utmost good faith concerning the duty of disclosure and non-fraudulent misrepresentation. Lord Mansfield in *Carter v Boehm*² explained that the insured had the knowledge in assessing the risk:

"The special effects by which the contingent chance is to be computed, lie most commonly in the knowledge of the insured only: the underwriter trusts to his representation and proceeds upon confidence that he does not keep back any circumstance in his knowledge, to mislead the underwriter into a belief that the circumstance does not exist, and to induce him to estimate the risk, as if it did not exist..."

Lord Mansfield in *Carter v Boehm* also recognised the duty of utmost good faith is also reciprocal:

"Good faith forbids either party by concealing what he privately knows to draw the other into a bargain from his ignorance of the fact, and his believing the contrary."

AVOIDANCE

Section 17 of the Marine Insurance Act 1906 indicates that the contract can be avoided by the other party if the utmost good faith has not been observed by either party. Section 17 is, in general, accepted to be equally valid for non-marine insurance contracts such as construction insurance contracts.

For an insurance contract in the construction industry, an insurer has the right in law to avoid the contract of insurance in its entirety if the insured was guilty of fraud, non-disclosure or misrepresentation before the contract was entered into. To avoid the contract means that the insurance policy would be treated as if it had never existed, or come into effect. Hence, the policy is void ab initio regardless of whether the breach was fraudulent, negligent or entirely innocent. Avoidance involves restitution, that is, the parties' position must be restored back to that prior to the contract: the claims paid to the insured should be refunded to the insurers; and the premiums had also to be returned to the insureds by the insurers.

FRAUD

If the insured make a false statement and he knows that it is untrue, he is guilty of fraudulent misrepresentation. He is also guilty of fraudulent non-disclosure if he conceals any material fact wilfully from the insurers. This may also lead to damages claimed under tort because of the insured's deceitfulness. There may be a possibility for the insurers to keep the premium as decided in *Chapman*³. However, it is unenforceable to introduce a clause to protect an insured from fraud in a construction

² (1766) 3 Burr. 1905, 97 ER 1162

³ *Chapman and others, assignees of Kennet v Fraser* B R Trin. 33 Geo 111

insurance contract. In *Chase Manhattan*⁴, the House of Lord did not commit clearly whether a clause could protect the insured from dishonest misrepresentation or non-disclosure by his agent⁵.

NON-DISCLOSURE OR MISREPRESENTATION

“*Non-disclosure*” is when a party has failed to disclose something which was not the subject of a question but which was known to them, which they ought to have considered it as material. As for a representation, it is something directly said in answer to a specific question.

The distinction between non-disclosure and misrepresentation can be found in the *Zurich General Accident* case⁶. Avoidance for non-disclosure will be restricted to facts of which the proposer was aware and which they ought to have realised the insurer would regard as material. Whereas the misrepresentation of a material fact will afford grounds for avoidance of the construction insurance contract no matter the proposer was aware that it was correct or not.

In common law, the potential parties are under an obligation not to misrepresent material facts which affect the insurer’s decision to accept the risk or not. In principle this is a reciprocal obligation, however it is obviously more in the burden of the insured than the insurer. It can be realised in section 20(1) of the Marine Insurance Act 1906 which deals only with the obligation of the proposer. Furthermore, section 18(1) of the Marine Insurance Act 1906 required the assured to disclose to the insurer every material circumstance which is known to the assured, before the contract is concluded. Section 18(1) allows the insurers to avoid the contract if the insured fails to make disclosure concerning every circumstance in the ordinary course of business.

TEST OF MATERIALITY

Concerning the test of materiality, section 18(2) and section 20(2) of the Marine Insurance Act 1906 state that every circumstance which is material and would influence the judgment of a prudent insurer in fixing the premium, or determining any risk has to be disclosed with no misrepresentation. The theory in section 20(2) of the Marine Insurance Act 1906 had been interpreted more clearly in practice in the landmark case of *Pan Atlantic Insurance Co Ltd v Pine Top Insurance Co Ltd*⁷. The House of Lords held that “*a material circumstance is one that would have an effect on the mind of the prudent insurer in assessing the risk and it is not necessary that it would have a decisive effect on the insurer’s acceptance of the risk or on the amount of premium charged. Before an insurer may avoid a contract for misrepresentation of a material circumstance it has to show that it was induced by the misrepresentation to enter into the policy on the relevant terms.*” Pan Atlantic shows practically that the insurer owes the insured a duty of good faith.

In *Cuthbertson v Friends’ Provident Life Office*⁸ concerning about critical illness cover, Lord Eassie observed that for a fact to be material, it has to be considered

⁴ HIH Casualty & General Ins Ltd v Chase Manhattan Bank [2003] UKHL 6, [2003] Lloyds Rep. I. R. 230

⁵ J Birds and N J Hird, *Birds’ Modern Insurance Law* (8 th ed 2011) Sweet and Maxwell (p.114)

⁶ *Zurich General Accident and Liability Insurance Co v Leven* 1940 SC 406, 415, by Lord President Normand

⁷ *Pan Atlantic Insurance Co Ltd v Pine Top Insurance Co Ltd* [1995] AC 501, 518, by Lord Mustill

⁸ [2006] CSOH 74; 2006 SLT 567

material *cadit quaestio*⁹ in the view of a reasonable underwriter. In practical terms, the insurer must also show that either “*the proposer appreciated that the fact in question would have had that significance*”, or, assuming that the proposer did not have that appreciation, or “*A reasonable person making the proposal and possessed with the factual knowledge possessed by the actual proposer would think that fact to be material to the insurer*”. This shows practically that the insurer owes the insured a duty of good faith.

In current practice in the construction industry in the United Kingdom, the person who is seeking insurance named as the proposer may normally complete a proposal form demanded by his broker. Although the proposer may simply answer specific questions appeared in the proposal form, his duty to disclose all material circumstances known, or deemed to be known, to them has not been removed¹⁰.

Section 17 of the Marine Insurance Act 1906 allows the Insurers the remedy of avoidance of the policy if the Insured breaches their duty of utmost good faith. Insurers are not allowed to seek damages for the breach relating to non-disclosure. They cannot deny liability for specific claim. They can only avoid the policy or to affirm it, waiving the breach and treating the policy as continuing.

INDUCEMENT

In addition to the materiality test, insurer will only be entitled to avoid a policy if they can show that they were induced by the non-disclosure or misrepresentation by the insured, to enter the contract. In *St Paul v McConnell Dowell*¹¹, four insurers of a construction project had avoided the contractor’s policy for all risks cover because the insurers were mal-informed that the Marshall Islands Parliament Buildings were to be built on piled foundations, but the design had changed to spread foundation. The proposer omitted disclosure of the changes to the insurers. There was a major subsidence of the buildings. The Court of Appeal ruled that the insurers were entitled to avoid the policy for reason of non-disclosure and misrepresentation even though the court accepted that the misrepresentation is an “*error in presentation*” and considered it to be a mistake “*in good faith*”. The court considered a few implications concerning the piled foundations. Firstly, the contractor had consulted and accepted professional advice; secondly, the ground conditions require more expensively deep piled foundations. The court decided that if the facts were disclosed, any prudent insurer would have a much higher estimate on risk and may come to a different decision on acceptance of the risk. It can be argued that the insurers had been induced by the non-disclosure to enter into the contract¹².

The three underwriters argued that if the foundation design was disclosed, they would have been acted in a different manner. However, the Court of Appeal decided that there was consistent evidence from the three insurers, with expert evidence, but inadequate evidence to displace a presumption that the fourth insurer’s underwriter was induced in the same way as the other three underwriters by the non-disclosure or misrepresentation of the piled foundation. This is how the theory of the duty of utmost good faith works in practice in a construction context.

⁹ the fact is sufficient to settle the matter

¹⁰ Section 18 of Marine Insurance Act 1906

¹¹ *St Paul Fire and Marine Co (UK) Ltd v McConnell Dowell Constructors Ltd* [1995] 2 Lloyd’s Rep 116

¹² “Insurance Law for the Construction Industry” Edited by Robert Hogarth, Oxford University Press (2008)

In practice, it can be argued that the inducement requirement has little effect on the “*decisive influence*” test as most insurers are prudent. If a fact is material it is not easy to envisage in what circumstances the insurer would not be induced by the insured’s failure to disclose the facts unless the insurer has acted imprudently for commercial purposes. A distinctive example demonstrating the insurers had not been induced by the failure to disclose material facts is the case of *Norwich Union Insurance Ltd. v Meisels*¹³. The court was convinced that the insurer had not been induced by the failure to disclose his circumstances because the insurer had deliberately omitted a question concerning insolvencies. Under this circumstance, the insurer could not argue that the insured had failed to disclose the information if the question was remained in the proposal form.

Whilst the insurer may have a claim in the case of a breach of utmost good faith in non-disclosure, the insurer also owes the insured a duty of good faith. In actual fact, they owe a mutual obligation to treat each other fairly. In practice, the insurer’s duty of good faith exists at all stages of the claims process. The insurer should act in a timely and considerate manner. They should not threaten the insured by their financial power.

MISREPRESENTATION

Section 20 of the Marine Insurance Act 1906 requires a duty to ensure that all material representations made are true. In principle, representation can be oral or in writing, may be as to a matter of fact, or to a matter of expectation or belief. A matter of fact deemed to be true if it is “*substantially correct*”, and what a matter of expectation or belief deemed to be true if it is made “*in good faith*” that is “*honesty*”. It can be argued that there must be some basis to confirm a representation of expectation or belief to be considered that it is made in good faith¹⁴. While sounding good in theory, but in practice, it is very difficult to distinguish between a representation as to fact as to representation as to expectation or belief. This distinction is crucial as each case is different; hence the standard for determining it to be a misrepresentation is also dissimilar.

INFLUENCE

It is not uncommon in the construction industry to employ a broker for the purpose of insurance contracts. A broker is considered to be the insured’s agent as identified by Purchas LJ in *Roberts v Plaisted*¹⁵. If the proposer discloses all material circumstances to his broker, he will still be liable if his broker fails to disclose them to the insurers. If the broker altered the data in the proposal form during the transference from the information given by the insured, the insured is still liable for the inaccuracy of the data. In practice, the breach of utmost good faith in this context can be seen in *Mark Whitlam v Andrew Hazel*¹⁶, the Court of Appeal ruled that the insurers were entitled to avoid the policy because the answers provided by the broker as the insureds’ agent in three questions concerning the insured’s occupation, were considered “*inaccurate and misleading*”.

For the insured, there are some exceptions to duty of disclosure. It can be argued that the insured does not need to disclose facts which reduce risk, or facts the insurers

¹³ [2006] EWHC 2811; [2007] 1 Lloyd’s Rep IR 69 (QBD)

¹⁴ *Economides v Commercial Assurance Co Plc* [1998] QB 587 (QBD)

¹⁵ [1989] 2 Lloyd’s Rep 341 (CA)

¹⁶ *Mark Whitlam v Andrew Hazel for Lloyds Syndicate 260 trading as K6M Motor Policies at Lloyds*

should know or presumed to know, or facts which are of common knowledge and also facts that the insurer has waived disclosure.

REMEDIES

As discussed earlier, the only remedy in practice for misrepresentation under the Marine Insurance Act 1906 is avoidance. An insurer can avoid the contract no matter the misrepresentation was entirely innocent, fraudulent or negligent. In practice, there are also some other implications.

Firstly, an insurer may reject any claim that has been made, and recover any claims payments already made.

Secondly, the policyholder may demand the return of the premium paid. An exception to this in terms of fraudulent misrepresentation is stated in section 84(3)(a) of the Marine Insurance Act 1906: “*Where the policy is void, or is avoided by the insurer as from the commencement of the risk, the premium is returnable, provided that there has been no fraud or illegality on the part of the assured*”.

Sections 17, 18 and 19 of the Marine Insurance Act 1906 indicate that the contract can be avoided by the other party if the utmost good faith has not been observed by either party. This remedy is draconian to the insured as they are deprived from any cover no matter they made an innocent mistake or a wilful concealment. In practice, the Courts had made damages available as illustrated in cases of *Banque Keyser v Skandia*¹⁷ and *The Good Luck*¹⁸.

In practice, a breach of the duty of good faith does not automatically give a right to damages. Steyn J, in *Banque Keyser v Skandia*¹⁹ suggested that once it is accepted that the principle of the utmost good faith imposes meaningful reciprocal duties, owed to the insurers and vice versa, it seems anomalous that there should be no claim for damages for breach of those duties in a case where that is the only remedy. However, the Court of Appeal had a different opinion; damages were rejected because they have not been mentioned in the Marine Insurance Act 1906. It can be argued that the Courts decided that non-disclosure does not give rise to liability in damages, because deceit or fraud requires a positive misrepresentation whereas non-disclosure is not.

Birds²⁰ commented that in *Fraser v Thames Television*²¹, the court has been prepared to create new torts. His arguments against a new tort were:

Firstly, the duty of disclosure arises from the common law courts of Lord Mansfield, and not equity as suggested by the Court of Appeal.

Secondly, while the court suggested the effect on the actual underwriter in question was irrelevant, *Pan Atlantic Insurance Co Ltd v Pine Top Insurance Co*²² means this point no longer stands.

Thirdly, the absence of a reference to damages in section 17 should not be decisive as the 1906 Act was a codification of common law. In other circumstances the courts have been content to accept implied meanings of the Act. Finally, the fact that fault is

¹⁷ *Banque Keyser v Skandia* 1987, 1 Lloyd’s Rep 69

¹⁸ *Bank of Nova Scotia v Hellenic Mutual War Risks Association (Bermuda) (“The Good Luck”)* 1989, 2 Lloyd’s Rep 238

¹⁹ *Banque Keyser v Skandia* 1987, 1 Lloyd’s Rep 69

²⁰ J Birds and N J Hird, *Birds’ Modern Insurance Law* (8 th ed 2011) Sweet and Maxwell

²¹ *Fraser v Thames Television* [1984] QB 44; [1983] 2 All ER 101

²² [1995] 1 AC 501

not needed for a breach should also not be decisive this means a party in breach of contract, can be liable without fault or blameworthiness.

It can be argued that the wording of “*if utmost good faith is not observed by either party, the contract may be avoided by the other party*” in section 17 should be repealed²³. The law should allow the court to decide appropriate remedies. If the insurer acts in bad faith, damages should be available to the insured.

CONCLUSIONS

In conclusion, the duty of utmost good faith (*uberrimae fidei*), indeed, plays an important role in construction insurance contracts. What does the duty of utmost good faith (*uberrimae fidei*) in insurance contract mean for the construction industry? An insurer has the right in law to avoid the contract of insurance in its entirety if the insured was guilty of fraud, non-disclosure or misrepresentation before the contract was entered into. It seems to be unjust because even though the insured may be honest, he could still be in breach of duty. The insurer may also have a claim in the case of a breach of utmost good faith during the contract. It proceeds on the basis that the insurer owes the insured a duty of good faith. In the last decade, the English courts are turning their eyes towards the mutuality of the duty of good faith owed by the insurers to the insured. There is a new practical focus on inducement to balance the risk on the insured and insurer, where the mutuality of the duty of good faith is shifting towards the obligations on the insurers.

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²³ Banque Financiere de la Cite SA v Westgate Insurance Co Ltd [1991] 2 AC 249 (HL)

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CONSTRUCTION MEDIATION IN SCOTLAND: A COMPARISON OF THE VIEWS AND EXPERIENCES OF LAWYERS AND END-USERS

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Recent research in different parts of the UK has pointed to growing acceptance of the mediation process from legal professionals with promises of headline grabbing, potential costs savings for hard pressed construction industry users. Nonetheless in many jurisdictions take up is low despite positive evidence relating to use and there is scant empirical knowledge about construction lawyers' role in the referral of cases to mediation and sophisticated evidence relative to lawyer and client interaction in the expediting use of the process. This paper draws upon recent work (both interview and questionnaire based) that the authors have conducted over the past 24 months with construction lawyers and end-users relative to their experiences of mediation in the Scottish construction field – a multiplicity of viewpoints not found in other comparable studies. The findings reveal a small yet significant measure of generally successful mediation activity and growing support for the process among both lawyers and end users. Nevertheless, the barriers to mediation's acceptance remain well-grounded, both throughout legal and client circles and various solutions to overcoming such obstacles are examined in the paper. Evidence gleaned in Scotland has significance beyond its borders given the commonality of issues pertaining to mediation growth across all developing jurisdictions and the presence of a dominant adjudication regime in Scotland which can be seen as a significant inhibiting factor in the use of mediation in many different countries.

Keywords: Construction Lawyers, end-users, mediation, Scotland.

INTRODUCTION

There has been much debate and discussion on the role that lawyers should play in the mediation process (Reich, 2002; Clark, 2012). It is widely recognised that the increasing involvement of lawyers can affect the way in which mediation is conducted, the lawyer-client power balance and the perception of the process itself (Wissler, 2003). It is also widely documented that the practice of mediation is affected by the way lawyers perceive and utilise it, such that they are commonly referred to as gatekeepers to the process (Welsh, 2004). Indeed, a growing body of research demonstrates that lawyers often control which disputes are mediated, the choice of mediator, and the prioritisation of interests within the process itself (see generally Clark, 2012). If we accept that lawyers' perceptions & values influence the ability of mediation to deliver potential benefits, then it follows that lawyers' interests need to be taken into account for mediation to be more widely adopted as a favoured

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means of dispute resolution; notwithstanding lawyers' interests can often diverge from those of their clients (Sela, 2009; Clark 2012). In terms of these interests, there is a significant amount of scholarship focusing on the ways in which lawyers reframe and edit disputes into a legal form that they best understand with the matter then entering a familiar, legal-centric process which ultimately produces outcomes limited by law (Felstiner and Sarat, 1980-81). Mediation represents a challenge to this dominant model and may be viewed with suspicion as a result.

Against this backdrop, the purpose of this paper is to compare and contrast data arising from the two groups of research subjects in respect of their views on, and experiences of the mediation process and explore some of the reasons why such differences exist. While most research in the mediation field has tended to focus on the views and experience of lawyers, the findings presented here are useful in helping us understand the different ways in which mediation and indeed dispute resolution more generally is perceived and encountered by both end-users and their lawyers.

Specifically this paper reflects upon research undertaken by the authors over recent years analysing the views and experiences of both lawyers and end-users (contractors and sub-contractors) relative to construction mediation in Scotland (Agapiou and Clark, 2011; Agapiou and Clark, 2012; Agapiou and Clark, 2013). Although research into construction mediation can be found in many other jurisdictions such as England and Wales (Gould, 1999; Gould *et al.*, 2009), the USA, South Africa, and Australia (for a review of international evidence see Brooker and Wilkinson, 2010), the aim of our recent work was to fill a gap in the existing literature and shed significant new light on the use of, and attitudes towards construction mediation in Scotland.

METHODS

The research strategy combined both quantitative and qualitative research methods. The analysis articulated here draws on questionnaire survey and interview research carried out between 2010 and 2012. The method of data collection & analysis comprised two phases, involving initially construction lawyers and then construction contractors and sub-contractors:

The first phase involved the distribution of a questionnaire survey of 165 Scottish construction lawyers with a response rate of c. 30% (50 respondents), followed by a qualitative approach to produce 'thicker' descriptions (Geertz, 1973) of salient issues relative to construction lawyers' interaction with construction mediation, drawing upon semi-structured, face-to-face interviews of participants. The 11 interviewees were from various positions within the legal profession including advocates, solicitors and solicitor-advocates lasting on average around an hour.

In the second phase, a questionnaire survey was deployed to elicit the opinion of end-users and potential end-users relative to mediation based upon a sample of main and sub-contracting firms in Scotland. Using a membership list of contractors and subcontractors provided by the Scottish Building Federation (SBF), comprising mainly small and medium sized construction firms, we collected responses from 63 firms, representing a survey response rate of around 18%. The findings of the SBF questionnaire survey were subsequently discussed in semi-structured interviews with a panel of 9 industry experts.

In both cases, interview participants were recruited from those: (i) with prior experience of mediation in the construction context; and (ii) respondents who had provided detailed comments on mediation in the quantitative phase of enquiry. The

interviewees were also geographically dispersed within the Central Belt. The qualitative phase of enquiry involved an interview with each participant each lasting approximately one hour.

Whilst we are aware that the samples were small and inviting respondents to self-select for interview has its methodological weaknesses, we pursued this approach as it was the most effective way to obtain access to participants with experience of mediation in the construction context in Scotland.

All the interviews conducted in this research were recorded using a digital voice recorder and transcribed. Permission was sought from the participants to record the interviews. The audio files of all interviews were transcribed for the purposes of analysis. The statistical analysis of the quantitative survey data was undertaken using the SPSS software package. We used descriptive statistics to identify the existence of any patterns in the responses provided and to present a profile of the sample population.

The next section presents some of the key findings from the data analysis from the questionnaire and the participant interviews focusing on the views and experiences of lawyers and end users with respect to mediation.

FINDINGS AND ANALYSIS

Knowledge of Mediation

All lawyers who responded to our survey professed awareness of mediation, compared to 80% of the end-users. Given the wealth of publicity and awareness raising in respect of mediation experienced in Scotland over recent years, the lawyer unanimity in terms of knowledge holds few surprises, although the research did not glean what kind of understanding lawyers held about the process. The fact that one in five end-users was still unaware of mediation may reflect a more limited appreciation of the process in the public generally. Additionally, we might surmise that a far greater percentage of those that did not respond to the survey may be largely unaware of the process.

Equally, it is clear from the research that education and training provision, including CPD and on-going professional learning, has a significant role to play in expediting knowledge levels. Here there is a clear divergence between such exposure for lawyers and end-users. In our survey some 82% of lawyers had received training or education in mediation. This represents a significant increase from the 60% recorded in research into Scottish commercial lawyers' experiences of mediation undertaken around five years prior to this survey (Clark and Dawson, 2007). One of the starkest findings from the 2007 survey was that less than 4% of the commercial lawyers in the 2006 survey reported exposure to mediation in their university studies. That figure rose to 20% in the current study, suggesting an increased embedding of mediation in Scottish traditional lawyer education. It is also clear from the lawyer research that CPD and on-going professional training and education in mediation for legal professionals has risen sharply in recent years.

By contrast, clients generally lacked any training or education in mediation, with only 12% reporting any such exposure. Clearly respondents from the world of contractors and sub-contractors emanate from a whole range of professional and non-professional backgrounds which would at times militate against educational exposure to mediation in any initial training. A recurring theme in interviews with end-users, however, pointed to the dearth of ongoing professional mediation training provided in mediation

by professional bodies in the field such as RICS, Institute of Civil Engineers and Corporation of Architects. We shall return to the issue of education and training for end-users at the end of the paper.

Mediation Use

Lawyers were much more likely than clients to have instituted policies on mediation use. Some 66% of lawyers surveyed had a firm policy or practice of encouraging use of mediation, as opposed to only 19% of clients. This schism is to be expected perhaps, given that lawyers are repeat players in dispute resolution as opposed to their clients, many of whom will have had much more limited exposure to formal disputing practices generally and may not formulate policies in respect of their occurrences.

The professed policy of many lawyers to encourage the use of mediation chimes with reports that many large law firms in Scotland have changed the name of their litigation departments to 'conflict resolution' hubs to reflect a more holistic approach to dispute resolution (Clark, 2009). Nonetheless, it is difficult to determine how much store to put on such shifts in nomenclature or reported policies in favour of mediation use by lawyers, *per se*. Certainly our interviews with end users found few reporting that lawyers were often in favour of mediation in the construction sector. Equally such a sentiment was at times expressed by lawyer respondents to our survey themselves smarting at the lack of receptivity towards the process from their legal colleagues. We explore these matters further below.

In the lawyers' survey some 58% of respondents had represented a client in mediation on at least one occasion. For end-users who responded, the rate of use of mediation was 30%. The lawyer survey tracked 178 cases and revealed a settlement rate of 74% with a further 9% partially settling at mediation. The end-user survey uncovered only 37 cases with a lower settlement rate of 65% but with a further 14% partially settling. The disparity in the results in terms of volume may reflect the fact that our end-user based research was limited to SBF members and may also stem from the more limited response rate to that survey. Equally, there may clearly be double counting in much of the lawyer reported cases which will have inflated the number reported.

Nonetheless, there is a marked similarity in the types of cases commonly reported by lawyers and end-users as being mediated such as change to scope of work, payment, damages, professional negligence and delay. There were also similar reported settlement rates, particularly when partially settled cases are included. Importantly, there were also generally shared views in respect of high reported rates of satisfaction with mediation in terms of such factors as speed, cost, mediator performance and quality of outcomes.

End users and lawyers also espoused generally similar reasons for mediating, such as saving costs and time, seeking continuation of business relationships, and to a lesser extent procuring creative agreements. Although the data from clients was generally too limited to make any concrete assertions in this respect, it is clear from the lawyer survey that although the overall numbers of construction litigators that have mediated may remain low, many become repeat players. Almost all lawyer respondents that had mediated had done so more than once. In this sense, there was also a statistically significant correlation between rate of lawyer usage and levels of satisfaction suggesting that either lawyers became more satisfied the more experienced they became in the process, or that the more content lawyers sought out repeat experiences.

Attitudes to Mediation

It is perhaps in relation to attitudes towards mediation that most divergence between lawyers and their clients are to be found. Here we summarise some of the main issues uncovered. First, on the matter of judicial prompting of mediation, although the extent that the process should become entwined with formal courts and formal civil justice mechanisms has long been a controversial issue (see Clark, 2012; Genn, 2009); end-users were generally supportive of such measures. For instance, some 76% of end-users surveyed agreed that judges should refer more cases to mediation. The same proportion (76%) also agreed that rendering mediation a mandatory first step in litigation procedures was an attractive proposition.

Lawyers trod a little more cautiously on this territory. Nonetheless, 62% of lawyers surveyed were in favour of increased judicial promotion and a slim majority - 54% - supported compelling recourse to mediation. Given that previous research into Scottish commercial lawyers found a mere 27% of lawyers supporting mandatory mediation (Clark and Dawson, 2007), the tide may be turning within legal circles on this issue - at least for those who have become converts to the process.

When and how lawyers ought to be involved in mediation are emotive and divisive issues. While 74% of lawyer respondents suggested that legal practitioners made the best mediators, this view was not shared by clients. Only 4% of clients agreed with this proposition. By contrast, 88% of clients stated that those with industry experience as construction professionals were superior in the mediation role. Such matters tie into the longstanding debate regarding the identity of the rightful inheritors of the mediator's crown. While there is a significant and longstanding debate surrounding whether lawyers are the most appropriate professionals to act as mediators (Clark 2012), the extent that subject matter expertise in the area of dispute is an essential tool in the mediator's kit bag is also a moot issue (Burns, 2012). True facilitative mediators would argue that subject expertise is irrelevant and that core mediation skills, attributes and experience are the most salient requirements. Nonetheless, it is hardly surprising that construction professionals, used as they are to adjudicators with significant subject matter expertise, should demand the same from their mediators. Such mediators would be able to bring industry norms and technical know-how into the mix which may be seen as valuable selling points.

One matter that affects the extent that mediation is adopted is the appeal of other options for disposing disputes that lie on the table. In this sense, it can be contended that one of the key roadblocks to mediation development in the construction sector in the UK is the dominant position of statutory adjudication as a default dispute resolution process in most construction contracts. Since its championing by the Latham Report in 1994 (Latham, 1994) adjudication has gained industry acceptance as the usual manner by which a binding (albeit temporary) resolution to disputes for which negotiations have proved incapable of settling can be gained. Our survey suggests that construction lawyers in particular have lined up to support the process in their droves. While the vast majority of lawyer respondents were disparaging about litigation and arbitration, some 84% agreed with the statement that "*adjudication is generally well adapted to the needs of the construction industry*". Furthermore, in interviews, the majority of lawyers were very positive about adjudication and generally viewed the process as the dominant and obvious next step to resolving disputes for which negotiations had failed to produce a settlement. Interviewees referred to such positive features of adjudication as getting a quick and binding

decision, the relatively low costs involved and the clarity and certainty of the process. We might observe here that adjudication represents a familiar type of process for lawyers. Its premise is adversarial, based on a familiar model of written pleadings and results in a decision rendered by a third party adjudicator. As such it represents well-trodden terrain for lawyers and a fits hand in glove with their general *modus operandi*.

In contrast to the generally positive appraisal provided by lawyers, consonant with anecdotal evidence of growing disquiet around the process, end-users were much more disparaging of adjudication. While joining hands with lawyers in their generally negative view of arbitration and litigation, a mere 25% of end-users agreed that adjudication was generally fit for the needs of the construction industry. In follow up interviews, a wide range of reasons for dissatisfaction was voiced. Such complaints included, poor standards of adjudicators, the high costs of the process, limitations of the paper-based approach of adjudication and the ability of one side to highjack the other with a claim.

Despite these negative views, many end-user interviewees suggested, however, that the heavy presence of adjudication in the construction industry and its cultural embedding in the industry had the effect to squeeze out any potential for mediation to develop further in the field. In terms of this dominance, it should be recalled that lawyers may be crucial in developing cultural norms in dispute resolution. By dint of their oft powerful position relative to their clients in respect of dispute resolution decisions, lawyers may legitimise new processes by way of how they explain and evaluate such mechanisms to their clients - what has been termed "*law talk*" (Felstinar and Sarat, 1980-81). While lawyer dominance is certainly true in respect of disempowered, 'one-shotter' clients (Johnstone, 1972) it can be questioned whether this holds true in respect of more sophisticated repeat player clients, particularly in an era where lawyers have lost ground in terms of social status, and the financial squeeze on legal business may have rendered external lawyers more subservient to the demands of their clients.

The fact that the adjudication process may be one which comports better with the interests of lawyers rather than their clients, begs the question as to the relative role of lawyers and their clients in decisions over which dispute resolution pathways to take. On this question, survey evidence from end-users reveals that one of the most common reasons (40%) as to why they had declined an offer from an opponent to mediate was that their lawyer had advised against it. Similarly, some 42% of end users viewed that lawyers acted as barriers to mediation's growth on the basis of their ignorance of the process and 43% blamed lawyers' negative perceptions of the process for their resistance. Such views are consistent with substantial evidence generally of lawyer resistance and cultural barriers towards mediation within legal circles globally and across different dispute areas (Peters, 2010; Clark 2012).

Such viewpoints were given further credence in the qualitative research where many end user interviewees elaborated on the ways in which lawyers discouraged mediation and pushed other more traditional alternatives. Sentiments expressed included: "*[l]awyers I've spoken to about mediation do tend to roll their eyes a little bit.... There seems to be a bit of cynicism there. I guess it might be the thought that their clients are giving up some [or] ceding control of the project or the outcome a little bit...* ";

"[it's] for the lawyer to say, 'well have you thought about mediation? Here's how it works, and it may just suit your particular dispute.' You don't get that kind of advice,

in my experience I think the minute there's a dispute ... a subcontractor's first tendency is to go and speak to their lawyer, and then their lawyer starts writing letters, and then before you know it, it's adjudication or it's court."

Adding succour to the notion that lawyer resistance is a significant factor in stifling mediation in Scottish construction mediation circles were the views of lawyers themselves. First, interviews with lawyers found them espousing that they were typically in control of decisions relative to dispute disposal in construction matters even ultimately in respect of larger clients. The common sentiment expressed, also found in end-user interviews, was that once the matter escalated to lawyers, as experts hired by clients in need of their assistance, they called the shots. If legal professionals do indeed harbour an inherent preference for the familiar shores of adjudication, their gatekeeping effect may produce a difficult climate for those interested in expediting mediation use.

Lawyer disinterest may be predicated on a whole raft of reasons. One such reason may be cultural dissonance. Unlike adjudication, mediation may seem a rather alien process to the lawyer with its emphasis on mutual interests, information sharing, harmony and client empowerment (Clark, 2012). The idea of mediation may thus render the process unappealing for lawyers particularly when yoked to a general ignorance of what mediating entails, concerns over losing control of the matter at hand as well as financial considerations that might lead lawyers to more potentially lucrative modes of dispute resolution (Clark, 2012).

Lawyer respondents did not generally lay the blame for the limited uptake of construction mediation at the feet of the legal profession. In response to the statement that a barrier to mediation's development was its negative perception amongst lawyers, 26 percent of lawyers surveyed agreed albeit that some of those interviewed reflected on the difficulties of persuading their legal colleagues to mediate. Lawyer respondents were in fact more likely to view that negative perceptions of construction industry professionals were a barrier to development (38 percent). Although end-users were much more likely than lawyers to blame legal professionals for poor uptake of mediation (e.g. caused by lawyers' ignorance 43%; caused by lawyers' negativity towards the process, 42%) they did not shirk from laying the blame at the door of their fellow construction professionals (caused by lack of awareness in the construction industry, 63%; caused by negativity towards the process, 50%). In this sense it could be argued that the well renowned machismo inherent within the construction industry may militate against the adoption of more conciliatory methods of dispute resolution such as mediation (Brooker and Wilkinson, 2012).

While both lawyer and client respondents generally eschewed any notion that participation within mediation would be damaging to their reputation in the field (a mere 16% of clients and 8% of lawyers agreed with this statement) the interviewees for both groups revealed much more textured views on this matter. Many of those interviewed – both lawyers and end-users – pointed to the adversarial climate in construction law. Moreover, some end-users expressed the view that lawyers may be reluctant to propose mediation because their own clients would not like it. Certainly there has been significant debate surrounding the term 'mediation' itself. While mediation in practice may often amount to an arena of intense, tough negotiation, the current nomenclature may produce negative connotations such as weakness and compromise which would jar in 'hard-nosed' environments such as construction. Ross (2007) made the point that mediation in Scotland requires to be sold in a much more

‘selfish’ way – pointing to individualistic gains that could be gleaned from the process – rather than the emphasis on harmony and compromise often prevalent at present. Certainly we view that such an approach may yield positive results in the context of Scottish construction.

CONCLUSION

While there is evidence of a growing base of construction mediation in Scotland and seemingly real success in terms of the activity that has taken place, the overall level of use remains low. Coupled with growing dissatisfaction amongst the client base with adjudication and recent research in other jurisdictions pointing to significant financial benefits from mediating construction disputes (Gould *et al*, 2009) the case for developing further use of the process is strong.

In terms of expediting mediation, a two-pronged attack is required. Although our evidence suggests that practical exposure is the best way to drive future commitment to mediation use, education has a key role to play too. It seems that lawyers remain largely in control of decisions to mediate, even perhaps in respect of larger sophisticated players in the construction field. Quite rightly then educational efforts have often been targeted at the legal profession through increased exposure in university study and post qualifying level training. There is a small and growing cadre of lawyers that have become champions for the mediation process in Scotland (Clark, 2009) and we would expect this to continue to grow steadily.

What is lacking, however, is sufficient awareness raising and education for the client base. In this sense the benefit of privacy in mediation may also be its worst enemy. Lack of dissemination of success stories relative to mediation is undoubtedly an inhibiting factor throughout the construction industry. To assist parties in crossing the Rubicon and dipping their toes into the waters of mediation, there needs to be greater education and training. There is a role here for industry bodies such as the Royal Institute of Chartered Surveyors, Scottish Building Federation and Chartered Institute of Arbitrators (Scottish Branch) through their training and CPD provisions to help propagate the mediation message to their members by educational measures focusing on the sharing of positive experiences gleaned in the process. In this sense, the most compelling cases for mediation are not to be made by mediators or other advocates of the process but by those who have themselves sampled its wares, are keen to go back for more and able to speak the language of other potential users in articulating its benefits. The research interviews we conducted with end users in particular revealed very powerful messages in this regard which may resonate well with industry peers.

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CONSTRUCTION MEDIATION IN SCOTLAND: AN INVESTIGATION INTO ATTITUDES AND EXPERIENCES OF MEDIATION PRACTITIONERS

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Recent research on Construction Mediation in Scotland has focused exclusively on Construction Lawyers' and Contractors' interaction with the process, without reference to the views of Mediators themselves. This paper seeks to address the knowledge gap, by exploring the attitudes and experiences of Mediators relative to the process, based on research with practitioners in Scotland. Based on a modest sample, the survey results indicate a lack of awareness of the process within the construction industry, mediations were generally successful and success depended in large measure to the skills of the mediator and willingness by the parties to compromise. Conversely, the results indicate that mediations failed because of ignorance, intransigence and over-confidence of the parties. Barriers to greater use of mediation in construction disputes were identified as the lack of skilled, experienced mediators, the continued popularity of adjudication, and both lawyer and party resistance. Notwithstanding the English experience, Scottish mediators gave little support for mandating disputants to mediate before proceeding with court action. A surprising number were willing to give an evaluation of the dispute rather than merely facilitating a settlement. The research concludes that, in Scotland, mediation had not yet become the indispensable tool for those seeking to resolve construction disputes due to lack of support from disputing parties, their advisors and the judiciary.

Keywords: construction mediators, mediation, Scotland.

INTRODUCTION

The construction process is extremely complex, even for a small project. It involves the construction of a unique, high value, capital project in the open air. It requires input from various designers, such as architects, engineers and quantity surveyors, and a myriad of trades-people coordinated by a main contractor, who is effectively a manager of the process due to the universal practice of sub-contracting all trades. This complex process creates a huge number of interfaces which inevitably creates friction, which in turn causes disputes. The friction is exacerbated by a 'macho' culture within the construction industry which is still male dominated and aggressive (Brooker and Wilkinson, 2010).

Most construction disputes are about money, i.e. the contractor believes he is entitled to more money than the employer is willing to pay. In a perfect world a construction project would commence with an employer who knew exactly what he wanted, a

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design team that translated these requirements into precise drawings, specifications, schedules and bills of quantities, all of which were issued to competent, adequately resourced builders who submitted realistic tenders leading to the appointment of the lowest tenderer in the traditional procurement method. Thereafter, there would be no changes and the builder would simply construct the works in accordance with the contract documents and the final account would be the same as the tender price. No such project has ever been, or will ever be, accomplished. The one certainty in construction is change and it is change which causes conflict.

Traditionally, Arbitration was considered a popular alternative to litigation and the industry recognized it initially to be an inexpensive, efficient, prompt, private and informal 'dispute resolution' process within which decisions were made by experienced industry professionals. The process was claimed to be quicker and cheaper than litigation, confidential and the arbitrator's award was final and binding on the parties with virtually no grounds of appeal to the courts. In reality, arbitration was slow and expensive with written pleadings, long periods of adjournment before a closed record was produced, legal debates, and proof hearings which lasted for weeks.

Following recommendations in the Latham Report (1994), the Housing Grants, Construction and Regeneration Act 1996 provided for statutory adjudication of all disputes at any time for construction disputes within the definition of the Act. Adjudication has proved to be very popular with the construction industry as it provides a quick and relatively cheap resolution to construction disputes. It is considered to be 'rough justice', however, due to the tight time constraints (Macaulay 1999). Other criticisms of adjudication are increasing cost due to lawyer involvement leading to challenges to the adjudicators' decisions on the grounds of lack of jurisdiction or breaches of natural justice. Against this backdrop, research points to construction mediation gaining increasing recognition as a simple, voluntary, without prejudice, cost-effective solution in which in which a neutral third-party actively assists parties in working towards a negotiated agreement, with the parties in ultimate control of the decision to settle and the terms of resolution (Agapiou and Clark, 2011, 2012).

Although extensive research has been carried out on Scottish construction lawyers' interaction with mediation (Agapiou and Clark, 2011, 2012), no single study exists which adequately captures the attitudes and experiences of mediators themselves, their predilection for the process, their views on its benefits, and the optimal regulatory and statutory environment required for mediation's further promulgation as the most effective means of Dispute Resolution within the Construction Arena. The principal aim of this paper was, therefore, to survey and report upon the attitudes and experiences of Scottish construction mediators.

MODELS OF MEDIATION

Mediation has been described as,

'the art of changing people's position with the explicit aim of acceptance of a package put together by both sides, with the mediator as the listener, suggestion-giver, the formulator of final agreements to which both sides have contributed' (Alper and Nichols, 1981).

The key principles of mediation are its voluntary nature, flexibility, impartiality and confidentiality. In the world of conflict resolution it is widely held that there are three theoretical models of mediation: Mainstream; Transformative; and Narrative. Whilst

it may be argued that all disputants are transformed to some extent in every mediated case, it is the Mainstream model that is generally used in the Construction Field

Hibbert and Newman (1999) list specific disadvantages of mediation: disclosure of parties' possible trial positions; equitable settlements depend on full discovery which results in delay and costs; its non-binding nature; use of delaying tactics; quick resolutions are prone to error and unfairness; uncertainty as to privilege of disclosures; and inequality of bargaining position and representation. One criticism of mediation is that it is too focused on making a deal by urging parties to compromise. In striving to reach a settlement the rights and wrongs of a dispute may be overlooked just to do a deal. There may be no legal basis or foundation for the settlement at all. Abel (1982) believes that informal justice, such as mediation, increases capacity of those already advantaged.

Clark (2012) maintains that, 'Mediation has often been painted as providing second class justice for the disenfranchised in society'. A central tenet of mediation is that the mediator is neutral and impartial. Hippensteele (2009) asserts that one cannot assume the neutrality of a mediator. As Grillo (1990) states, 'mediators, like all other human beings, have biases, values, and points of view'. Fiss (1983) dismisses the mediation process as mere 'settlement.' He sees mediation as the civil analogue to plea-bargaining. Fiss believes that consent to settlement is often coerced and is made by someone who lacks the authority to settle. A further criticism of mediation is that it lacks transparency. The strictures of confidentiality inhibit the accumulation of knowledge about the practice of mediation.

The facilitative approach, or interest-based approach, is generally thought to be the purest form of mediation. The mediator is interposed between the parties to explore their positions, to provide a means of communication, to enhance their common interests, and to produce an ambience conducive to the parties reaching their own solution to their dispute. The mediator would not express an opinion nor propose a settlement. The evaluative approach, or rights-based approach, focuses on the respective rights of the parties in dispute. The mediator attempts to evaluate the strengths and weaknesses of each party's case and indicates a view on a settlement. Hibbert and Newman (1999) suggest that, 'Construction disputes are suitable for mediation by the evaluative approach; mediation by the facilitative approach is less attractive'.

RESEARCH METHODS

The research presented herein is part of a larger MSc Dissertation Submission that explored the views and attitudes of Scots Construction Mediators, employing quantitative and qualitative methods (Trushell, 2013). Given space constraints only details of quantitative phase of enquiry are presented here. This paper explores the attitudes and experiences of Mediators relative to the process, based on questionnaire survey of practitioners in Scotland. The questionnaire design was guided to large extent by previous quantitative research in this field (Agapiou and Clark 2011). It was important to follow a similar methodology in order to provide commonality across the studies for ease of comparison. The Participants were selected on the basis of mediators known personally to the primary author. Every construction mediator identified and other contacts were invited to contribute additional names until the sample size grew to 11 in a snowball effect. Although this was statistically a small sample, it represented a large proportion of the practising construction mediators in Scotland at that time. The entire research design of this research was constrained by

the small population of practising Scottish construction mediators (thought to be circa. 20 in 2013). The questionnaire survey was designed to capture data related to the biography; training and experience of participants, and their opinions on how mediation could be promoted to the wider construction industry in Scotland. The attitudinal survey covering 17 items was prepared in a table format using a five-point Likert scale (see Table A1). The survey was carried out in 2013.

FINDINGS AND ANALYSIS

The data on Mediator Profiles, Mediator Training and Mediator Experience are presented in this section followed by the analysis of interviews carried out with the sample respondents relating to the benefits of mediation, the process of mediation and the promotion of mediation. The results of the attitudinal survey drawn from the same respondents follow thereafter.

Mediator Profiles

Figure 1: Primary Professions

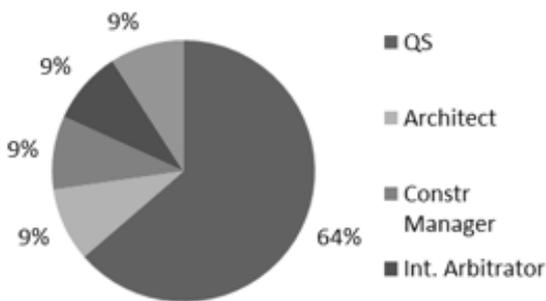


Figure 2: Mediators' Age

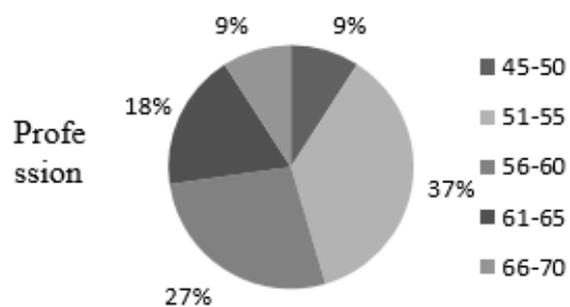


Figure 3: Years in Primary Profession

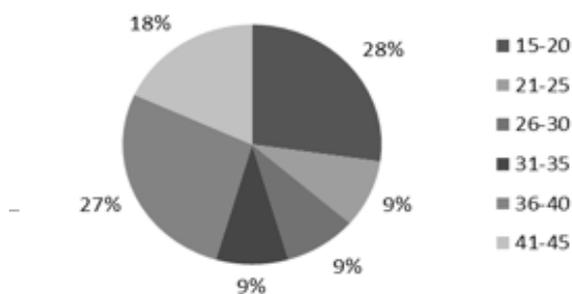
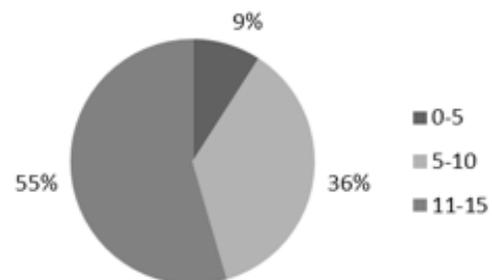


Figure 4: Years as a Mediator



The youngest was 47 years old and the oldest was 68, with an average age of 57.3 years. Some 91% were aged over 50 and 27% were over 60 years old. Construction mediation is clearly not a young person's profession. The range of primary professions of the mediators was narrow. Some 64% were quantity surveyors and there were one each of architect, construction manager and international arbitrator. Only one described himself as a professional mediator, although he had previously been a senior advocate.

The minimum period spent in their primary profession had been 15 years and the maximum was 45 years with an average of 30.7 years. Just over a third, 37%, ranged between 15 and 25 years and a further 45% had served over 36 years in their primary profession. The mediators were, therefore, highly experienced in their respective

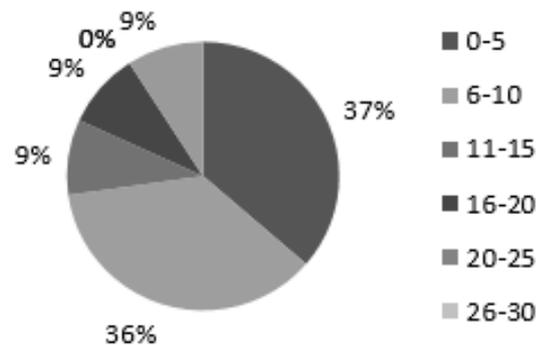
professions. The number of years practising as a mediator ranged from a minimum of two years to a maximum of 15 years with an average of 10.7 years. Just under half, 45%, had practised for less than 10 years whilst 55% had practised between 11 and 15 years. The mediators were, therefore, relatively experienced given the youthful age of the construction mediation profession itself.

Mediator Training

All but one of the mediators had undergone some formal training in mediation. Almost half had been trained by Core Solutions of Edinburgh and the others by The Royal Institution of Chartered Surveyors (RICS), Centre for Effective Dispute Resolution (CEDR), or the British Academy of Experts (BAE). Eight of the 11 mediators, 73%, were accredited by Core Solutions, The Royal Institution of Chartered Surveyors, or The Chartered Institute of Arbitrators. Eight mediators were members of a recognized mediator panel, such as The Royal Institution of Chartered Surveyors, The Royal Incorporation of Architects in Scotland, or The Professional Institute of Mediators.

Mediator Experience

Figure 5: Number of Mediations



The number of mediations carried out by each mediator ranged from a minimum of one to a maximum of over 50. The average number was 7.2 per mediator, excluding the highest number which was regarded as an outlier. Just over a third, 37%, of mediators had carried out fewer than five mediations and a further third, 36%, had completed between six and 10 mediations. Another 18% had done between 11 and 20 mediations. Almost three quarters, 73%, had carried out fewer than 10, but one mediator had done over 50. The number of truly experienced Scottish construction mediators is, therefore, very small which is not surprising, given the small number of mediations carried out. The one full-time, professional mediator carried out most mediations as would be expected. The subject matter of disputes reflected the general topics of construction disputes, such as building defects, fees, extensions of time, payment, valuation of variations and final accounts. The amounts in dispute ranged from £75 (which failed to settle) to multi-million pounds. There was, however, a cluster around £10,000 to £200,000 with only a few above £1 million, although individual values were not disclosed. Settlement rates were generally high, around 80%, but one respondent noted a recent trend against the expectation of settlement.

Attitudes to Mediation

The individual responses to the attitudinal survey were aggregated together and expressed as a percentage. The 'Strongly Agree' and 'Somewhat Agree' responses were consolidated into 'Agree', as were the 'Strongly Disagree' and 'Somewhat

Disagree' responses into 'Disagree', to produce clear cut answers. The number of 'Don't Know' answers was extremely low with only four out of the 17 questions eliciting such a response. An overwhelming 91% of respondents disagreed that mediation was detrimental to the development of the law. Some 82% strongly disagreed with the statement. Only 18% of respondents agreed that mediation is inappropriate where there is a power imbalance between the parties. Some 82% disagreed, of which 55% strongly disagreed. Almost two-thirds, 64%, of respondents agreed that judges should refer cases to mediation. Members of the Scottish judiciary appear to support the 36% of respondents who disagreed with the proposition. A small majority of 55% of respondents disagreed that making mediation a mandatory first step in dispute resolution would be a positive development, with 36% strongly disagreeing. It was perhaps surprising that less than half, 45%, of mediators agreed with the proposition. There was only muted support for mandatory mediation. In interviews it was clear that the majority of mediators again emphasized the consensual nature of mediation and believed that mandating parties would be counter-productive. There was widespread recognition that parties forced to mediate could not be forced to settle. Active encouragement to mediate before court action was supported in preference to making it absolutely mandatory.

Another way to expedite the help institutionally embed the process is by contractual inclusion. Only 64% of respondents agreed, 36% strongly, that construction contracts should contain a mediation clause, whilst only 9% strongly disagreed and a further 27% somewhat agreed with the statement, contrary to what might have been expected. While the majority of mediators answered in the affirmative, there were some emphatic negative responses in the interviews. There would seem to be some support for a tiered dispute resolution structure starting with executive negotiation, moving through mediation to adjudication or arbitration or litigation. There was also recognition, however, that mediation was a consensual process and parties should have an option to use it or not. In terms of views of formal civil justice processes, only 27% of respondents somewhat agreed that litigation is generally well adapted to the needs and practices of the construction community. Some 73% disagreed, including 45% who strongly disagreed. Whilst litigation was not a favoured dispute resolution process, arbitration fared much better with 82% agreeing that the process is well adapted to the needs and practices of the construction community. No respondent strongly disagreed with the statement and 18% somewhat disagreed. Given the small number of construction arbitrations currently taking place in Scotland this result was surprising and certainly it is not reflected in the views of construction lawyers and contractors on this issue².

It was, however, no surprise that 82% of respondents agreed that adjudication is well adapted to the needs and practices of the construction community, including 45% who strongly agreed. This perhaps reflects the fact that all but one of the mediators also practised as an adjudicator. Almost two-thirds, 64%, of respondents disagreed that default to adjudication in many construction disputes renders mediation obsolete. Over one-third, 36%, however, agreed with the statement. It should be noted that the Housing Grants, Construction and Regeneration Act 1996 does not make recourse to adjudication mandatory. It merely confers a statutory right on either party to a construction contract to take any dispute to adjudication at any time. On one view then, there is, therefore, no reason to believe that adjudication renders mediation

² Albeit that such data was collected prior to the roll out of the new statutory arbitration regimes under the Arbitration (Scotland) Act

obsolete. It may simply be that some types of disputes are more readily resolved by adjudication than by mediation and vice versa. Indeed, it is noted that there was a 30% reduction in the number of adjudications carried out in the United Kingdom in the year to May 2011 with only a tiny recovery of +3% in 2012 (Trushell *et al*, 2012). Nonetheless research into the views of both construction lawyers and end-users suggested that the default presence of adjudication and its cultural embedding in the industry may militate against further mediation use (Agapiou and Clark, 2012)

In relation to other potential barriers to mediation's growth, a third of respondents, 36%, believed that lawyers will lose money if mediation grows, but more than half, 55%, disagreed and 9% didn't know. A convincing 82% of respondents disagreed that suggesting mediation to an opponent is a sign of weakness, including 55% who strongly disagreed. A mere 18% agreed with the statement.

A small majority of respondents, 55%, agreed that a barrier to mediation's development is its negative perception among (a) clients and (b) lawyers. Further analysis, however, revealed different levels of agreement between the two factors. The negative perception among clients was split equally between strongly agree and somewhat agree in the responses. In contrast, only 9% of respondents strongly agreed with the negative perception among lawyers, whereas 45% only somewhat agreed. Mediators, therefore, appear to believe more strongly that clients' negative perceptions of mediation are the bigger barrier than lawyers' perceptions. Almost three-quarters, 73%, of respondents agreed that mediation training should be compulsory for lawyers, although a quarter, 27%, disagreed. In contrast, two thirds, 64%, thought it should be compulsory for construction professionals, including 27% who strongly agreed. There also seemed to be recognition, however, that mediator training was both time-consuming and expensive, and that the required pool for mediators was necessarily limited in Scotland.

Respondents generally thought that there were already enough mediation training providers, and so the professions should restrict themselves to providing mediation awareness training to encourage its wider use. Mediators may believe that lawyers exert a greater influence than construction professionals in advising clients to use mediation and so need to know more about the process. A substantial majority of respondents, 64%, agreed there is a lack of awareness regarding mediation amongst the legal fraternity, with 27% strongly agreeing and 36% somewhat agreeing. An overwhelming 82% agreed there is a lack of awareness of mediation amongst construction professionals of which 36% strongly agreed and 45% somewhat agreed. A mere 9% somewhat disagreed and a further 9% surprisingly didn't know. The implications for mediation training needs amongst both lawyers and especially construction professionals are clear.

Comparison with Lawyers' and Contractors' Attitudes

The attitudes and experiences of Scottish construction lawyers and contractors had been previously surveyed (Agapiou and Clark 2011, 2012 and 2013). Of the 17 questions answered by mediators five were not common with those answered by lawyers and contractors. Seven questions produced similar answers and the remaining seven questions were analysed to identify differences between the respondents. Whilst 80% of mediators and lawyers disagreed that mediation is inappropriate where there is an imbalance of power between the parties, 60% of contractors agreed with this statement. As contractors are likely to be the more dominant party in a mediation it is difficult to reconcile this answer with what happens in practice although it may be

redolent of a lack of sophisticated appreciation of the mediation process. Whilst 82% of mediators agree that arbitration is generally well adapted to the needs and practices of the construction community, 80% of lawyers and 56% of contractors disagreed. The diametrically opposite view of mediators and lawyers is perverse but it may be reflected of the fact that the bulk of the construction mediators, also working as adjudicators would see opportunities to move in arbitration too in the aftermath of the changes heralded by the Arbitration (Scotland) Act. Whilst over 80% of mediators and lawyers agreed that adjudication is generally well adapted to the needs and practices of the construction community, almost 60% of contractors disagreed. This may reflect the fact that in main contractor/sub-contractor disputes taken to adjudication some 70% of referring sub-contractors win at the expense of the main contractor respondents (Trushell *et al* 2012). Whilst about 65% of mediators and lawyers disagreed that default to adjudication in many construction disputes renders mediation obsolete, 42% of contractors agreed. Whilst about 65% of mediators and lawyers disagreed that mediation suffers from a lack of coercive power, 52% of contractors agreed. Whilst 54% of mediators and 42% of contractors agreed that a barrier to mediation's development is its negative perception among lawyers, 62% of lawyers disagreed, perhaps unsurprisingly. In five out of the seven questions addressed above, it is contractors who are out of step with the mediators and lawyers. The admitted lack of awareness and experience of mediation by contractors appears to be confirmed.

CONCLUSION

The research found that Scottish construction mediators believe that mediation is a successful dispute resolution process because it is quick, cheap, flexible, creative, confidential, non-confrontational and applicable to almost all disputes. A successful outcome depends on the skills of a good mediator, thorough preparation by all participants, the presence of key decision-makers, the parties' willingness to compromise, and the mediator's judicious application of pressure to settle. Mediations fail because of ignorance, over-confidence and intransigence of the parties, uncompromising expert advice, cynical commercial reasons, and fraught emotions. There are few experienced construction mediators in Scotland, and the continued popularity of statutory adjudication is a significant barrier. Mediators believe that clients' negative perceptions of mediation are a bigger barrier than lawyers' perceptions. Whilst accepting that a facilitative model was the purest form of mediation, about a third of the mediators were prepared to offer an evaluation of the dispute, possibly due to a substantial proportion being Quantity Surveyors with sound technical knowledge. All agreed, however, that the agreement of the parties was vital before an evaluation could take place. There was little support for mandating parties to mediate before proceeding to court action. The mediators wanted judicial encouragement for mediation backed by some legislative support, mediation clauses incorporated into construction contracts, and government adoption of mediation as the default process in its own contracts. Brooker and Wilkinson (2010) showed that mediation of construction disputes can flourish only with the active encouragement of government and its judiciary.

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Table A1: Attitudes

	Strongly Agree	Somewhat agree	Agree	Somewhat disagree	Strongly disagree	Disagree	Don't Know
Mediation is detrimental to the law	1 9%	0 0%	1 9%	1 9%	9 82%	10 91%	0 0%
Mediation is inappropriate where there is a power imbalance between the parties	1 9%	1 9%	2 18%	3 27%	6 55%	9 82%	0 0%
Judges should refer cases to mediation	2 18%	5 45%	7 64%	2 18%	2 18%	4 36%	0 0%
Making mediation a mandatory first step would be a positive development	2 18%	3 27%	5 45%	2 18%	4 36%	6 55%	0 0%
Litigation is generally well adapted to the needs and practices of the construction community	0 0%	3 27%	3 27%	3 27%	5 45%	8 73%	0 0%
Arbitration is generally well adapted to the needs and practices of the construction community	2 18%	7 64%	9 82%	2 18%	0 0%	2 18%	0 0%
Adjudication is generally well adapted to the needs and practices of the construction community	5 45%	4 36%	9 82%	1 9%	1 9%	2 18%	0 0%
Default to adjudication in many construction disputes renders mediation obsolete	1 9%	3 27%	4 36%	4 36%	3 27%	7 64%	0 0%
Mediation suffers from a lack of coercive power	2 18%	2 18%	4 36%	3 27%	4 36%	7 64%	0 0%
Lawyers will lose money if mediation grows	1 9%	3 27%	4 36%	4 36%	2 18%	6 55%	1 9%
Suggesting mediation to an opponent is a sign of weakness	1 9%	1 9%	2 18%	3 27%	6 55%	9 82%	0 0%
Construction contracts should contain a mediation clause	4 36%	3 27%	7 64%	3 27%	1 9%	4 36%	0 0%
A barrier to mediation's development is its negative perception among clients	3 27%	3 27%	6 55%	4 36%	0 0%	4 36%	1 9%
A barrier to mediation's development is its negative perception among lawyers	1 9%	5 45%	6 55%	4 36%	1 9%	5 45%	0 0%
Mediation training should be compulsory for lawyers	2 18%	6 55%	8 73%	2 18%	1 9%	3 27%	0 0%
Mediation training should be compulsory for construction professionals	3 27%	4 36%	7 64%	2 18%	2 18%	4 36%	0 0%
There is a lack of awareness regarding mediation amongst the legal fraternity	3 27%	4 36%	7 64%	3 27%	0 0%	3 27%	1 9%

THE APPLICATION OF PLANNING LAW FOR ENVIRONMENTAL PROTECTION AND IMPROVEMENT IN NIGERIA

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The problem of environmental protection in Nigeria when the provisions of planning laws are not complied with in the construction and management of buildings in Nigeria was examined in this research. The papers also examines different state planning laws as well as judicial authorities while advocating the creation of new towns, effective zoning, as well as the provision for enhancing sanitary conditions of the environment. The researchers adopted the doctrinal and non-doctrinal research methods. Materials were gathered from primary and secondary sources. Thus published text (both local and foreign), Journals, law reports (foreign and indigenous) and laws dealing with the subject matter where rely upon. Materials from the town planning offices in Nigeria were used. Officials of the town planning offices, construction engineers as well as lawyers were personally contacted and interviewed when carrying out this research. The objective of this paper is to examine the provisions of planning laws that relates to the construction and management of buildings and to make planning laws an issue of concern to bring about its application in the construction and management of buildings for environmental protection and improvement in Nigerian. The paper explains that the protection and improvement of the environment is important to the present as well as the future generations. Thus, while constructing houses within the environment for development purposes, the provisions of planning laws must be strictly complied with, in order to maintain a balance between the development and protection of the environment. The paper explains further that the need for development has led to the construction of structures without clearly defined patterns. This has led to the development of slums which are the reflection of lack of master plan for such an area or the ineffectiveness of relevant authority in enforcing the existing planning laws. Thus this paper concludes that a proper and effective enforcement of planning laws remains the key to environmental protection and improvement in Nigeria.

Keywords: enforcement, improvement, planning, protection.

INTRODUCTION

The environment has been created for the benefit and sustenance of mankind when committed to proper and beneficial use. But the way and manner in which man subjects the environment to certain activities tends to destroy man himself or the dislocation of the ecosystem which helps to make life meaningful and conducive to mankind. In order to protect and improve the environment there must be a proper effective enforcement of planning laws in the construction of houses and their management. This is because the international construction industry has taken an increasingly leading role throughout the years towards the effective implementation of

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sustainable construction practice due to its direct involvement in projects with high environmental impact².

The environment is very important to mankind to the extent that everything done on earth has to deal with the environment. This is why care must be taken to ensure that the resources within the environment are optimally utilized. However, there must be a balance between the development of these resources and the attainment of balanced environment. But we must encourage the application and enforcement of planning laws when houses are being constructed for environmental protection and improvement.

Basically, town planning law concerns the management of physical development and its distribution. Primarily, they are codes for physical land development. However, their environmental protection and improvement implications or capabilities should not be undermined, and cannot be overemphasized.

It is obvious that one of the problems with environmental protection and improvement in Nigeria is that of urban and regional planning. Planning laws could be used to ensure a healthy environment, by making provision for decongesting congested places and that houses are constructed and managed according to the provisions of planning laws. Planning laws could also be utilized to prevent the development of slums and ensure the creation of space for free flow of air and effective ventilation. The above will help promote and ensure a safe environment which will help to protect and improve the environment and also prevent litigation in the area of construction management.

Based on the foregoing, this paper will examine the need for the protection and improvement of the environment and how planning law can be applied in the construction and management of houses for the protection and improvement of the environment.

THE NEED FOR THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT

Generally, people all over the world rely on their environment for their survival. They are directly affected by the way others around them make use of the environment, as well as the type and manner of implementation of governmental policies. The destruction of the environment occurs during attempts to achieve development objectives. Thus, it was stated by Tandy that:

*The destruction of the environment most often occurs during attempts to achieve developmental objectives such as the provision of housing facilities, building of roads and bridges, and other physical infrastructures.*³

Therefore, there is need to protect the environment against destruction. The realization of the above fact has urged many countries around the world to commit themselves, under the umbrella of the United Nations Conference on Human Settlement (Habitat II) 1996, to:

Promoting optional use of productive land in urban and rural areas and protecting fragile ecosystems and environmentally vulnerable areas from the negative impacts of

² Ricardo E B (2013) "social licensing in the construction industry: community and government interests". IBA international construction projects committee, vol 8 issue 1, 23.

³ Tandy, C (1988) "Handbook of Urban Landscape". London: Architectural Pres, 2.

*human settlements, inter alia, through development and supporting the implementation of improved land management practices that deal comprehensively with potentially competing land requirements for agriculture, industry, transport, urban development, green space, protected areas and other vital needs.*⁴

The point here is that to ensure the protection and improvement of the environment in this regard, we must begin with the recognition of the challenges facing cities and towns. However, the most serious problems confronting cities and towns and their inhabitants include the problem of constructing houses without complying with planning laws. This has seriously affected the protection and improvement of the environment. Thus, there is great need for the enforcement of planning laws in the construction and management of houses for the protection and improvement of the environment.

The Application of Planning Law In The Construction And Management of Houses For the Protection and Improvement of the Environment

Planning is anything that relates to the character of the use of land. C.S. Ola defines town planning as:

*The art and science of controlling the use of land and the character and arrangement of buildings, so as to achieve economy, and secure convenience and beauty...it ensures safety of the citizens by the provision of pedestrian ways and easy access to and from dwelling - house. Planning prevents the deterioration of areas into slums and minimises public expenditure on slums ... Good planning ensures easy access to places of work, without the hazards of traffic congestion. It locates the right centres for school, playgrounds, markets and shopping centre's.*⁵

Thus, it was stated that planning facilitates economic developments, promotes a healthy and safe environment, and necessarily involves the formulation of policies and laws to control and regulate private rights to, or the indiscriminate use of land and the environment at large.⁶ According to Oludayo:

*Planning 'looks beyond today and projects into the future. It examines what is, in terms of activity patterns, space requirements; it gathers other relevant socio-economic indicators and makes use of all those to determine future space requirement of each activity ... it also ensure judicious use of resources to ensure conservation, preservation and the natural process of rejuvenation.*⁷

The application of planning laws in the construction and management of houses can help to protect and improve the environment when new towns are planned cities started on previously undeveloped land with dwellings and provide economic opportunity within its borders. They are usually large enough to contain a full

⁴ The Istanbul Declaration of the United Nations Conference on Human Settlements (Habitat II) (Istanbul, 3rd- 4th June, 1996), available at: <http://www.daccessdds-ny.un.org/doc/UNDOC/GEN/G96/025/00/PDF/G9602500.pdf?>

⁵ Ola, C S (1984) "Town and Country Planning and Environmental Law in Nigeria". 2ed, Ibadan: university Press, 4 – 5.

⁵Smith, I O (2004) "Power to Make Planning Laws in a Federation: The Nigerian Experience", 24 Journals of Private and Property Law, Lagos: University of Lagos press 15.

⁶ Oludayo, A (2004) "Environmental Law and Practice in Nigeria" Lagos: University of Lagos Press, 477. See Alden I and Morgan R (1974) "Regional Planning: A Comprehensive View" London: Leonard Hills Books.

complement of community facilities for its residents. New town has been defined by Eldredge⁸ as a complete small city with dwellings, jobs, and a full complement of community facilities, including a higher culture, with a fixed area and population. In a report by the United States Advisory Commission on Inter-governmental Relations (ACIR) it was concluded that not everything that is called a “new town” is actually one. The (ACIR) defined new town to mean:

*[A]n Independent, relatively self-contained, planned community of a size large enough to support a range of housing types and provide economic opportunity within its borders for the employment of its residents. It is large enough to support a balanced range of public facilities and social and cultural opportunities...within reasonable limits. The proportion of the total area to be used for the industrial, commercial, residential, public facilities, and open space, are provided for. New towns are started on previously undeveloped land and are built by staged development over a period of time.*⁹

Moreover, it was stated by Mehmert, an expert in Urban Planning that:

*The increasing influx of rural persons typically uneducated and unskilled, has led to severe over-crowding in slums and squatter villages in the major cities and towns of the less developed countries generating unmanageable pressure on health and education facilities, housing and other services.*¹⁰

The concept of “New Town” was formally adopted by the British through the passage of the New Towns Act 1946, and later on by Russia, Germany, India and Hong Kong.¹¹ Although, the concept of “New Towns” has not been very well embraced in Nigeria, however, there have been plans by the government to improve the environment by the construction of new towns in such places as Lagos¹² and the nine states that made up the Niger Delta areas of Nigeria.¹³

More over planning laws can be applied for this purpose by making provision for zoning. The Black’s Law Dictionary,¹⁴ defined zoning to be “[a] legislative division of a region, especially a municipality, into separate districts with different regulations within the districts for land uses, building size, and the like”. Thus zoning involves land allocation, the arrangement of public facilities, and the coordination of private activities on allocated land.

Zoning is regulated and its regulation governs how land may be used and the size, type and number of structures that may be built on the land. Thus, specific locations are given for different types of residence, industries, businesses, leisure places etc.¹⁵In

⁸ Eldredge, H W (1976) “The New Town Concept”. In: Eldredge H W (Ed) *Towing Megalopolis*, Vol. 2, New York: Boubleday and Co Inc., 2.

⁹ Cited in Onokerharaye, A G and Omuta, G E (1994) “City Structure and Planning for Africa”. Benin City: The Benin Social Science Series for Africa, 160.

¹⁰ Mehmert O (1978) “Economic Planning and Social Justice In developing Countries”. London: Oxford University Press, 72.

¹¹ Onokerharaye, A G and Omuta G E (1994) “City Structure and Planning for Africa”. Benin City: The Benin Social Science Series for Africa , 158.

¹² <http://allafrica.com/stories/201003020286.html>

¹³ <http://allafrica.com/stories/2010031022.html>

¹⁴8th Edition, at p. 1649

¹⁵ Listokin D and Burchell, R W (2007) “City Planning”. Microsoft Student [DVD].

the case of *Ohio v. Amber Reality Company*,¹⁶ the legality of zoning was challenged and the US Supreme Court gave a rationale for the practice when a company found it could not utilize its land for the purpose for which it was bought as it ran contrary to the zoning regulations in that area where the land was situated. The company sued on the ground that this violated the 14th Amendment protection against taking property without due process. The majority of the court rejected this argument and the court ruled that, zoning was both reasonable and indispensable in view of the complexities of urban life and land uses.

Moreover, in the case of *Penn Control Transportation Co v. New York City*,¹⁷ the US Supreme Court recognized zoning laws as having the potential to promote “*health, safety morals and general welfare*” by “*prohibiting particular contemplated use of lands*”.

The Town and Country Planning Law of Bendel State, 1976¹⁸ made adequate provision for the implementation of the zoning concept. Section 3 of the above law provides that:

A planning scheme may be made under this law with respect to any land, whether there are or are not buildings thereon...and of preserving buildings or other objects of architectural, historic or artistic interest and places of natural interest or beauty and generally of protecting existing amenities whether in urban or rural portions of the area.

The Town Planning Law of Lagos State¹⁹ stipulated in Clause 3 of its First Schedule that development plans must include “*zones for various uses... master plans shall include definition of the main planning zones and the main types of developments and uses that are permissible...*” The above provisions have within the potential to create a better environment.

Zoning preserves the neighbourhood by eliminating non-conforming or conflicting uses. This standard is readily upheld by the courts. Thus, in the case of *Ademola v. Rutili and Ors*,²⁰ the defendant attempted to build a school on land zoned to be an open space. The development was successfully restrained by the plaintiff on the ground that it contravened the approved Victoria Island Scheme. In the English case of *Re Carshalton Urban District Council's Application*²¹ the land in question was subject to restriction, which forbade the erection of building of any kind except such as is normally erected in public parks and open spaces. The objectors were entitled to the benefit of the restrictions. However, the Council sought to modify the restrictions to enable them erect twenty-six bungalows for elderly people among facilities. Upon application to the court, the court refused the application and held that use as a public open space in accordance with the stipulations of 1932 was both possible and reasonable and that the proposed development would injure the objectors.

¹⁶ 272 US 365 (1926)

¹⁷ 438 US, 104, 125 (1978).

¹⁸ Cap. 165, Laws of Bendel State, 1976 (applicable to Delta and Edo State in Nigeria. Delta and Edo states were formally together and known as Bendel state before they were separated to two states in 1991.

¹⁹ Cap. 181, Laws of Lagos State, 2005.

²⁰ Unreported Suit No. LD/784/84 of 21/09/85.

²¹ (1965) 16 P& C.R., 68.

Furthermore planning law is applied to protect the environment through the setting of minimum safety environmental standards for buildings, to ensure a sanitary housing condition. Thus, planning mechanisms has been employed even in more developed jurisdictions like the United Kingdom to create and maintain a healthy environment in the construction and management of houses. For example, in the case of *MacDonald v. Glasgow Corporation*,²² A land which has been waste ground was used for dumping rubbish. No planning permission was obtained. The land was later sold and the new owner continued to use it for the same purpose. A suit was brought against the owner. It was held by the court that he had no right to continue to dump rubbish on the land without planning permission; as such a practice has the capacity to endanger the health of occupants of adjacent houses. Similarly, in the case of *Ealing Corporation v. Ryan*,²³ it was found that the three floors of the house in question were occupied by different families and it was inferred that the bathroom and lavatory accommodation was also shared by the occupants. These were against planning stipulation for health reasons. The planning authority filed a suit against the occupants and the suit was held in the authority's favour. Thus, it can be stated that planning law has been applied to maintain environmental sanity and has also helped to prevent the outbreak of disease which is common with the slum areas. This is a good case to be taken into consideration in the construction and management of houses.

The slum areas are the endemic affliction of our urban environment. They are characterized by over-crowdedness, poor housing and the absence of such facilities as toilet, hygienic kitchen system, bathroom and store absence of good and functional drainage and waste disposal systems, unregulated buildings and air space, etc.²⁴ In the case of *Agunregne v. Adeyemi*,²⁵ the defendant built her house so close to the plaintiffs house that the flow of air and light into the plaintiff's house was obstructed. This causes the plaintiff's house to be uninhabitable during dry season because of heat and darkness. The plaintiff filed a case against the defendant urging the court to order the pulling down of the defendant's house to abate the nuisance. The court adjured the parties to seek extra-judicial redress and it was stated by Ajose-Adeogun J. that:

The plaintiff has the right to seek further redress in respect of future interference with the use or enjoyment of her house (this is if the defendant does nothing to abate the nuisance).

Furthermore, Section 17(1) of the Building Adoptive Bye-Laws provides that no drain shall be laid so that it passes through or under any building,²⁶ and that no person shall let or occupy any new building until the drainage thereof including disposal of surface water shall have been completed to the satisfaction of the health officer²⁷. The Bye-Laws also prohibit any person from letting or occupying any building until suitable latrine accommodation approved by the health officer, has been provided.²⁸

²² (1960) 11 P&C.R., 318.

²³ (1966) 17 P&C.R.,15

²⁴ Taylor, R W (1986) "Urban Development Policies in Nigeria: Planning, Housing and Land Policy". In: a revision of a paper presented at World Congress on Land Policy, held in London, on July 7th – 11th, under the auspices of London Institute of Land Policy.

²⁵ (1977) 10 CCHCJ, 2 447.

²⁶ Operational in Edo State and Delta State.

²⁷ S. 17(3)

²⁸ S. 18(1)

CONCLUSION

This paper has attempted to show how planning laws can be applied in the construction and management of houses to improve the environment. It has also revealed that the protection and improvement of the environment is important both to the present as well as the future generation. The paper has also shown that the need for development has left most cities in Nigeria without enforcing planning rules and that the situation has led to the creation of slums and other unpleasant environment.

Moreover, it was revealed that in Nigeria, most major cities and towns have grown beyond their delineated boundaries. This situation has led to the need for towns to be created, as the creation of new towns can help to disperse crowded cities and leads to the creation of a healthier environment. In fact the construction of new towns enables the improvement of the environment. Consequently, the provisions of planning laws must be strictly complied with in the construction of the houses that makes up new towns in order to keep the environment in healthy condition safe for habitation.

This paper also disclosed that slums and other unpleasant environment is a reflection of the lack of a master plan for such an area or the ineffectiveness of the relevant authority in enforcing the existing planning laws. The paper further reveals that planning laws could also be used to prevent the development of slums and ensure the creating of space for free flow of air affecting ventilation. Thus a proper and effective enforcement of the provisions of planning laws remains the key to environmental protection and improvement in Nigeria.

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INTERACTIVE LEARNING IN UK CONSTRUCTION PRACTICE: EXAMINING THE ROLE OF BIM PROCESS STANDARDS

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From a construction innovation systems perspective, firms acquire knowledge from suppliers, clients, universities and institutional environment. Building information modelling (BIM) involves these firms using new process standards. To understand the implications on interactive learning using BIM process standards, a case study is conducted with the UK operations of a multinational construction firm. Data is drawn from: a) two workshops involving the firm and a wider industry group, b) observations of practice in the BIM core team and in three ongoing projects, c) 12 semi-structured interviews; and d) secondary publications. The firm uses a set of BIM process standards (IFC, PAS 1192, Uniclass, COBie) in its construction activities. It is also involved in a pilot to implement the COBie standard, supported by technical and management standards for BIM, such as Uniclass and PAS1192. Analyses suggest that such BIM process standards unconsciously shapes the firm's internal and external interactive learning processes. Internally standards allow engineers to learn from each through visualising 3D information and talking around designs with operatives to address problems during construction. Externally, the firm participates in trial and pilot projects involving other construction firms, government agencies, universities and suppliers to learn about the standard and access knowledge to solve its specific design problems. Through its BIM manager, the firm provides feedback to standards developers and information technology suppliers. The research contributes by articulating how BIM process standards unconsciously change interactive learning processes in construction practice. Further research could investigate these findings in the wider UK construction innovation system.

Keywords: Building Information Modelling, innovation systems, interactive learning, management of innovation, standards.

INTRODUCTION

The innovation systems literature underlines the importance of interactive learning to innovation and technological change (Freeman 2002, Lundvall 1998). In construction practice, construction firms interact with and learn from both internal and external sources such as clients, material suppliers, universities and professional bodies (Gann and Salter 2000). Across the United Kingdom (UK), large construction firms are considering to use new process standards aimed at providing structured ways of managing construction information.

Standards are viewed different by scholars. While some view them as institutions, routines, technical infrastructure or common codes for communication, those with interest in social practices argue that they are common, repeatable best practices which streamline social interaction (Hawkins *et al.* 1995). Studies distinguish between

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product and process standards. While product standards focus on the physical attributes of end products particularly their modularity, compatibility and interoperability (Barlow 1999, Eastman 1996), process standards are associated with the method and organisation of production activities. In preconstruction practice for instance, process standards might refer to the structured ways of interaction between professionals involved in the creation, storage, exchange and exchange of construction information.

Building Information Modelling (BIM) involves the use of set of process standards to provide a common way of creating, storing, accessing, exchange and communicating built asset information (Bsi 2010). By using BIM, there is a view that firms can improve productivity, reduce cost and reduce uncertainty (Nisbet 2012). However, BIM standards are less understood in some sections of the industry especially among civil engineers (Maradza 2014). In an attempt to improve BIM uptake, the UK government recently mandated BIM on all public projects by 2016 (Cabinetoffice 2011). Findings from a few UK government sponsored trial projects indicate that BIM can achieve the desired benefits (Cabinetoffice 2012).

Below are examples of some of the BIM process standards used in the UK.

25. Industry Foundation Classes (IFC) British Standard ISO 16739
26. Library objects: BS 854 (1-4)
27. BS1192: 2007, Publicly Available Specification (PAS) 1192 (1-4) including Construction Building Information Exchange (COBie)
28. International framework for dictionaries of digital objects ISO 12006 -3:2007 and Digital information delivery manuals: ISO 29481:2010
Object library standards - Uniclass2 and BIM execution plan

Lundvall and Johnson (1994) have argued that common codes of communication enhance interactive learning through managing diversity and complexities in interactions. Interactive learning is a process by which a firm attains new competences through networking and drawing competences from within and outside its borders (Lundvall and Johnson 1994). As construction firms increasingly implement BIM (Nbs 2013), how they interact and learn in systemic innovation contexts is of importance to scholars and practitioners interested in managing innovation processes. The research investigates interactions between professionals using BIM process standards in a large multinational UK construction firm. The purpose is to understand the relationship between BIM process standards and interactive learning in construction practice.

THEORETICAL BACKGROUND

Systems of innovation

The innovation systems literature evolves from a socio-economic perspective of technological change (Lundvall 2013). It departs from the neo classical economic model which views as static the innovation process by arguing that the process of innovation is qualitatively different, dynamic, involving complex social interactions between the firm and other organisations (Freeman 1995, Lundvall and Johnson 1994). Lundvall has argued that interactive learning, user producer interactions and innovation are at the heart of economic advancement (Lundvall 1992). Learning is viewed as an interactive process between individuals at the foundational or micro level and is socially embedded. Understanding it is futile without considering the institutional and cultural context (Lundvall 1998). The perspective posits that knowledge is a fundamental resource while learning is the most important process for

innovation (Lundvall 2010). In contrast to other approaches which view innovation as exogenous, the concept argues that innovation is evolutionary and is shaped by many factors over time (Fagerberg *et al.*, 2005).

Whilst innovation systems concept was aimed at understanding variations in national economic activities, scholars soon began to explore its relevance in examining local and regional variations in economic activity. Scholars have proposed concepts of national, regional, sectoral and technological innovation systems, however where boundaries are set depends on circumstances (Carlsson and Stankiewicz 1991). In construction innovation studies the concept has been used by Miozzo and Dewick (2004) to analyse variations in construction industries in five European countries.

Despite its wide use, the innovation systems approach has been criticised for what Edquist called "*conceptual diffuseness*" (Edquist in Fagerberg *et al.*, 2005: p.186). He singles out inconsistent definitions of the term "*institution*" and lack of clarity on the boundaries of the system. Another critique concerns the function of an innovation system. Lundvall (2010) explains that the function of an innovation system is to produce, diffuse and exploit economically useful knowledge. However, Edquist (1997) questions whether there can be an agreed function of an innovation system. Other scholars have criticised the concept for addressing the national context, yet globalisation has dissipated the nation state (Carlsson 2006). Lundvall concurred, adding that the "*all countries have become small*" (Lundvall 2010: p.02). Moreover systems are dynamic, complex and rapidly changing to the extent that developing a consistent methodology for studying them is difficult if not impossible (Carlsson *et al.* 2002). In addition, little emphasis is placed in understanding the concept at the micro level. Lundvall (2010) refers to this as the micro foundations of the innovation system.

In spite of the criticism, the concept provides a useful analytical framework for examining the dynamics inherent in the innovation process. By integrating the role of social interactions, the institutional environment and the cultural context, the concept provides a useful way of building an in-depth understanding of the innovation process.

Interactive learning

Learning is the process of acquiring knowledge (Nonaka and Takeuchi 1995). Arrow (1962) has argued that learning is not only spurred by R&D but also through social interactions between people. He adds that learning takes place through problem solving and involves drawing from previous experiences. Innovation systems scholars have argued that it is through interactive learning that firms can explore and exploit knowledge. Studies mention three types of learning which are: learning by doing (Arrow 1962); learning by using (Rosenberg 1982) and learning interacting (Lundvall 1985). Whilst learning by doing and learning by using refer to experiential competence building, interactive learning is viewed as involving the exploitation of communication networks to source and accumulate tacit and codified knowledge (Lundvall and Johnson 1994).

Learning processes are collective, cumulative, dynamic, context dependant and shaped by the institutional environment. Gregersen and Johnson argues that, "*different kinds of knowledge diversity are the basis of interactive learning, and they depend on communication between people and groups of people with different knowledge endowments*" (Gregersen and Johnson 1997: p.486). As a result Johnson in Lundvall (2010) suggested that learning categorisation should resemble the intensity of human interactions. He proposes four kinds of interactive learning and they are: imprinting, rote learning, learning by feedback and searching.

Interactive learning occurs internally and externally to the firm. Scholars suggest that internal learning occurs through interactions between employees in problem solving activities, training, job rotation and communication between individuals and departments. Externally learning occurs through feedback users and producers, and between organisations (Lundvall 1985). Although the innovation systems concept is useful in examining the process of innovation, it is largely informed by studies in industrial firms (Freeman 1982). According to Davies and Brady (2000), learning processes in construction firms are different from those witnessed in industrial firms. They argue that firms utilise temporary project teams which disband upon completion and interactions are short term. This affects learning from projects; between projects and firms, and between firms and other organisations (Winch 2010).

Construction innovation systems and interactive learning

The concept of innovation systems is yet to gain traction among construction innovation scholars. The concept has so far been limited to a few studies which sought to examine the performance of a European construction industry (Miozzo and Dewick 2004). This research views the primary goal of a construction innovation system as facilitating interactive learning processes in order to produce knowledge required to advance the development of new or improved services for the built environment. The boundary of the innovation system is set around the actors identified in the analytical framework proposed in Figure 1 below. The ability to simultaneously create and source knowledge between projects and from the firm's institutional environment is seen as the vital cog that drives innovation in construction (Winch 2010).

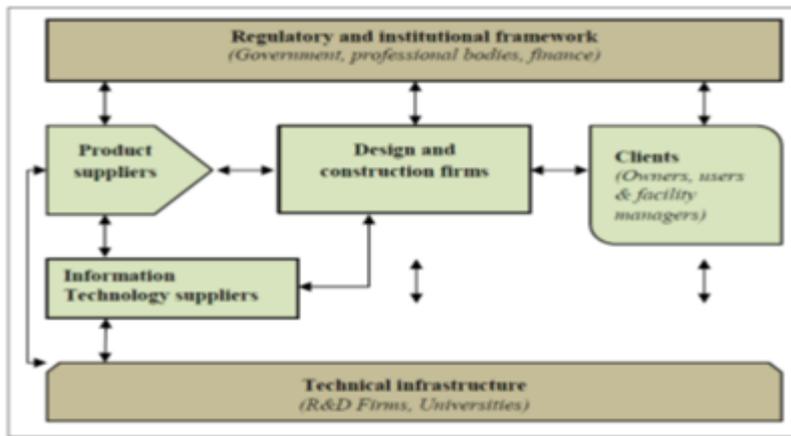
In construction firms, interactive learning is characterised by face to face discussions between individual professionals, recruitment of new employees and transfer of staff to other projects (Dodgson *et al.*, 2008). Salter and Gann (2003) have explained that learning occurs through face to face meetings, training, job shadowing and IT technologies, however they also note the influential role of the context and the firm's environment (Salter and Gann 2003). Scholars acknowledge the dynamics and complexities surrounding learning from external sources. They suggest that learning tends to occur through participation in joint ventures, industry conferences and engagement in R&D activities (Gann and Salter 2000, Miozzo and Dewick 2004). Blayse and Manley (2004) have identified clients, technical standards and the firm employees as potential sources of learning. Gann and Salter (2000) have proposed an analytical model to illustrate knowledge flows (See Figure 1 below).

Standards

Views on standards vary with some scholars suggesting that they are useful for diffusing technologies, managing market entry for new products and compatibility between different technologies (Freeman 1995). Nelson and Nelson (2002) have suggested that standards provide a social infrastructure for technology transfer. Others have suggested that standards support production economies but they can limit innovation (David 1985). Studies distinguish between product and non-product standards (process standards) (Hawkins *et al.* 1995). Product standards are concerned with the physical attributes of products, particularly their quality, modularity, compatibility and interoperability (Barlow 1999, Eastman 1996). Barlow and Ozaki (2005) explains that necessitated product and process innovation in Japanese construction. Process standards are associated with the method and organisation of production activities.

In construction the debate on process standards has focused on *"the introduction of processes that facilitate the production of a variety of models using the same machinery and material inputs"* (Barlow and Ozaki 2005: p.15). Whyte and Lobo (2010) have discussed the role of standards as digital infrastructures for delivering construction projects. They suggest that standards facilitate collaboration between teams involved in construction practice. Other scholars have examined the role of standard processes on large infrastructure projects and have noted that they influence interactions between professionals (Brady and Davies 2010). Thus there is a simmering debate on the relationship between process standards and innovation.

Figure 1: Framework for understanding knowledge flows in construction adapted from Gann and Salter (2000)



RESEARCH METHODS

This interpretive study uses a case study design to provide an in-depth account of the complexities surrounding the use of BIM process standards in a single large international construction firm headquartered in France. The firm's UK division has a turnover of £1.2 billion in 2012. The UK division has been involved in the design and construction of award winning land mark projects. The firm is selected because of its size (above £1 billion turnover), experience in supporting standards development, participation in government BIM trial projects and it was ready to provide access to the researchers. In the UK, the firm has 5 divisions and the civil engineering division is the largest by turnover. Although BIM is being deployed across the firm, due to time, access limitations and with advice from senior management in the firm, the civil engineering division was selected for a detailed study. The civil engineering division also resembled best practice in terms of how the firm is deploying BIM. The aim is to provide a holistic account of BIM process standards use. The study focused on a variety of issues including how BIM users interacted and exchanged knowledge. The account offered is that of those involved in day to day practice. Therefore the data collected is that of the multiple meanings and mental constructions made by practitioners as they interact and use the BIM process standards. By examining interactions between professionals involved, the study seeks to explore the issues that arise in project based environments and how they shape interactive learning processes.

The case study design is selected because it is useful in studying the *"particularity and complexity of a single case, coming to understanding its activity within important circumstances"* (Stake 1995: p.xi). It provides a holistic account of human experiences (Creswell 2003). Baxter and Jack (2008: p.544) also argued that case studies *"... ensure that the issue is explored through ... a variety of lenses which*

allows for multiple facets of the phenomenon to be revealed and understood". The case study design is common in studies of this nature (Gann and Salter 2000, Miozzo and Dewick 2004). The selected design is not without challenges, for instance it only captures the views of a limited group of individuals hence generalisation is to an individual's context (Stake 1978). Despite this challenge, this method enabled rich data to be collected which appreciates the contextual issues surrounding interactions at multiple levels of analysis. In the process the research captures specific issues in localised contexts. Wider generalisations are therefore not the priority here, instead the focus is on theoretical generalisation.

Empirical evidence was collected from participants in their natural settings. In order to capture their lived experiences around BIM process standards, a decision was taken to only interview the firm's professional pool involved in everyday BIM use. Data was collected over a period of 7 months and it involved interviews, observations and secondary documents collected from three ongoing projects and the BIM core team. The ongoing projects were selected with the advice from the firm's BIM manager. Data collection was done in: a) three hour long workshops involving the case study firm, IT suppliers and a wider industry group on three occasions, b) more than 15 observations of practice which lasted more than 80 minutes in the BIM core team and in three ongoing projects, c) 12 semi-structured interviews, each interview lasted on average 70 minutes; and d) secondary publications from the firm.

Participants were selected on the basis of their role, their availability, and through the snow balling strategy. Through examining the everyday use of BIM, it was possible to understand how users interacted. Discussions focused on what the standard meant to the participant, the effect on their work practices and whether the standards encouraged or hindered their information sharing activities or shaped their interaction patterns. The analytical model presented in Fig 1 was used to guide the discussions and probe interviewees that they cite specific examples of their interactions with the actors identified in the model. The discussions focused on how they solved problems and whether the firm had provided them training. Interviews were conducted with design engineers, site engineers, site operatives, BIM managers and consultants. A particular disadvantage of the research strategy is that it only captures the views of a limited group of individuals, at one specific time period. Despite this, it offers a rich data of the social interactions.

The interviews were recorded and transcribed by the researcher to engage deeply with the data. Although the interviews focused at the firm level, they encouraged participants to cite specific examples from their daily experiences. Data was analysed through an iterative process of identifying emergent themes, coding and continuous reviewing of the data to identify aggregate themes and central meanings. The model presented in Fig 1 was used to analyse data. Although this study is inductive, concepts established in literature were used to develop an analytical framework for data coding. To improve the research's validity, method triangulation and interview participants were accorded an opportunity to review and revise the transcriptions and subsequent publications (Silverman 2009). Data analyses suggested that BIM process standards have influence internal and external interactive learning processes.

FINDINGS

The case study firm

The construction firm employees just over 6,000 employees in the UK and its global work force exceeds 60, 000. At the time of data collection, the firm was involved in

more than 300 projects in the UK. The civil engineering division of the firm employs approximately 3 500 people in the UK. Most of these people are based on projects located across the UK. The firm acquired the division in 2008. The UK firm's turnover was just over £1.2 billion in 2012. The civil engineering division is currently involved in one of the largest rail projects in the UK. The division is involved in the airports, education, nuclear, rail, health and roads sectors.

The civil engineering division has a long history of working with IT suppliers which dates back to the 1970s. It has championed the use of IT technologies in design and construction activities. It has also been involved through its BIM managers in BIM standards development in the UK and globally since the early 1980s. One of the widely used Xtech technology (not real name) was developed by the firm's former employees, with its support. The BIM manager was involved in trial projects which led to the development of the PAS 1192 standard. The civils division has been involved in the government sponsored COBie and PAS 1192 trial project which involve collaborating with 11 competitors, 3 standards developers and 4 IT developers. The firm remains in full support of the Xtech technology and occasionally acts as a hotbed for trialling improvements in the technology. As the manager noted:

"... we have quite a big influence over XTech because we're quite a big user of them and they're, they are beginning to say the right sort of things" Interview C01

IT suppliers are increasingly relied upon to support construction activities. The firm's BIM manager is involved in a number of standards initiatives. BIM standards are fully implemented in the BIM core team but not on projects. In practice, BIM standards are embedded in digital technologies such as Xtech. As a result user interaction with the standard is invisible. A number of digital technologies are available in the market some of them are not embedded with the national standards. Implementation in the firm faces significant challenges because project managers have autonomy over the choice of what technology to use.

Interactive learning process within the firm's innovation system

BIM process standards allow engineers to integrate information to create a single 3D digital object. The 3D object provides a single source of information required to perform different activities. Through 3D simulations presented to construction teams, problems can be addressed collectively through talking around the 3D model. Data shows the use of a common 3D model allows professionals to share knowledge about the design and its delivery. Engineers were able to communicate effectively with operatives performing different tasks at once. Skilled operatives shown a 3D model over lunch could appreciate their tasks. Teams could comment on one 3D model and advise engineers on the practicalities of delivery than before. The 3D model could be shared with subcontractors. Engineers were able to learn from operatives who are at the fore front of delivery. They described how Xtech has improved their communication activities. They can now access project information from a single source and circulate a variety of information with ease. Despite the benefits, some participants were unclear of their interaction with the standard nor its importance to their activities. Some were not even aware of BIM standards.

External interactive learning processes

Externally, the firm participates in trial and pilot projects involving other construction firms, government agencies, universities and suppliers. The firm engages with and provides feedback to researchers from universities. Through its BIM manager, the firm provides feedback to standards developers and information technology suppliers.

This helps shape the standard to the extent that specific issues could be addressed in the next version of the standard and also the technology. However, participants complained that clients were inconsistent, resistant to embrace BIM process standards and they tended to use their own process standards. This meant that the firm's employees had to forget and learn anew each time they had to interact with a different client. This limited the firm's ability to exploit user and producer relations.

DISCUSSION

In the theoretical background, the context specificity, the dynamic nature and role of the environment on interactive learning activities was noted. Types of interactive learning suggested by some scholars were identified as imprinting, rote, learning by feedback and searching (Lundvall 2010). Findings from the research suggests that process standards supported interactive learning. Both internal and external interactions were supported by the use of standards. Experiential learning occurred through 3D modelling which required in-depth knowledge of the digital technologies in which the standards are embedded. While internal searching and feedback occurred through interactions between engineers and operatives, workshops, seminars and training sessions were also seen as important. Lundvall and Johnson (1994) suggests that common codes of communication provide access to a wide variety of information. In the construction firm, the use of Xtech provided a common information facility which could be used by users irrespective of their geographic location. This allowed engineers to access a wide variety of information.

Literature suggests that face to face interactions are important for internal learning activities (Salter and Gann 2003). However, the use of BIM process standards suggest interactions are focusing more on the common 3D object. The BIM manager acts as a champion (Nam and Tatum 1997) and assists in collecting and disseminating knowledge from external sources into the firm. Literature suggests that external interactive learning occurs through feedback between users and producers. In the construction firm, findings suggest that the BIM manager facilitates interactive learning through his involvement in national bodies and taking leading role in BIM standards initiatives. Despite this, implementation in the firm is the result of extensive and complex negotiations. The invisible effects of embedded standards, together with the technical requirements might be contributing to implementation challenges.

Scholars suggest that interactive learning occurs through collectives (Gregersen and Johnson 1997). The construction firm participated in BIM trial projects. It was possible for the firm to simultaneously access knowledge from its competitors. Participation provided a collective voice to influence the direction of the technology and standard. However, findings reveal a deeper problem which stems from a limited understanding of standards. Even though the firm through the BIM manager contributes to BIM standards, implementation in projects is slow due to resistance from project managers. This could also explain the lack of consistency in the implementation approach considered by the whole firm. As a result, it may be impossible for the standard to be fully exploited to support interactive learning.

CONCLUSION

The research investigated the interactions between professionals involved in construction practice. It sought to understand the relationship between BIM process standards and interactive learning. Interactive learning in construction firms involves exploiting communication and social networks to develop knowledge essential for the

firm. BIM process standards are used to structure information sharing activities. Through their use, participants were able to make use of a single source of information. Construction firms interact with a diverse source involving clients, suppliers, universities, regulatory authorities and other firms. Empirical evidence suggests that BIM process standards is enhance interactive learning process because they facilitate internal and external interactions with sources of knowledge. The use of common 3D objects supports talking between professionals. Participation in trial project improves the firm's chances on engaging with a diverse source. BIM process standards support user and producer interactions, however they are not as yet understood. BIM process standards are increasingly influencing and shaping the construction process. Such change in the process of construction could be beneficial to achieving efficiencies in construction and improve quality. However this was not specifically examined in this research and could form part of future research. Further research could examine the wider implications on innovation in construction.

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AN APPRAISAL OF THE PROTOCOL THAT WAS PUBLISHED BY THE CONSTRUCTION INDUSTRY COUNCIL (CIC) TO FACILITATE THE USE OF BUILDING INFORMATION MODELLING (BIM) ON PROJECTS

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The UK Government has mandated using Building Information Modelling (BIM) Level 2 by 2016; however a deficiency in standard frameworks to manage BIM implementation and overcome its associated legal risks could make this planned scheme struggle. Therefore, in February 2013, the Construction Industry Council (CIC) released the first edition of its BIM protocol which provides a legal framework intended to promote the use of BIM level 2 on construction projects. This paper carries out a critical appraisal of the CIC protocol to find out whether it will facilitate BIM use, and therefore, accelerate the uptake of BIM adoption across the industry. An overview of the CIC protocol content is provided, along with a review of its benefits and difficulties of use. Additionally, this paper undertakes an evaluation of the protocol performance regarding its ability to overcome the legal issues facing BIM implementation. The assessment was carried out through conducting interviews and circulating questionnaires among construction professionals. It has been found that the CIC protocol is somewhat successful in managing BIM contracts, and the protocol seems to provide an average performance in overcoming the legal issues associated with BIM implementation. This suggests that the CIC protocol will be fairly useful for accelerating BIM uptake.

Keywords: building information modelling (BIM), BIM level 2, BIM protocol, contracts, intellectual property (IP).

INTRODUCTION

In February 2013, the Construction Industry Council (CIC) issued the first edition of its BIM protocol. This is a legal document that has been designed to stimulate the collaboration between project parties in order to facilitate the use of BIM on projects (RICS, 2013). The protocol has been formulated to support Level 2 BIM projects, in line with the Government's requirements to use at least Level 2 BIM on all public projects by 2016 (Out-Law, 2013a).

This paper analyses the CIC protocol and discusses the issues connected with its use, including an evaluation of its benefits against the legal barriers facing the adoption of BIM. Carrying out this critical appraisal is essential for overcoming the legal and contractual challenges, because finding out how successful the use of this framework is will decide how successful the implementation of the BIM strategy will be. Lowe

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and Muncey (2009, p. 1) suggest that construction professionals ignoring standard frameworks forms the greatest challenge to undertaking BIM in the United States. Therefore, an assessment is provided in this study for the CIC protocol to consider how successful it is in facilitating BIM use in the UK.

THE RESEARCH METHODS USED

Both primary and secondary research was carried out as part of this study. The primary research data was obtained by conducting several interviews and circulating a questionnaire online between 32 professionals representing different sectors in the UK construction industry. The questionnaire was designed and structured to measure the attitude of the UK construction professionals towards the release of the CIC protocol and the benefits that would be obtained from using such a protocol, whereas the interviews were undertaken to review some critical points about this protocol and to discuss the possible effects of its publication on projects involving BIM processes. The lack of professionals who fully understand the CIC protocol was the reason why the questionnaire was designed to rely on data quality not quantity.

The data required for the secondary research was collected from existing sources of information. This included books, construction journals, online sources, and reports to extract thorough and detailed information on the benefits and difficulties that may be associated with the use of the CIC protocol, despite the fact that not much of sources are available on this basis, because the protocol has not been officially used on projects so that its benefits and problems of use can be discovered in more detail.

LITERATURE STUDY

This section firstly provides background information on BIM and the main legal issues surrounding its implementation across the UK construction industry, along with a brief review of the CIC BIM protocol. Secondly, the possible benefits obtained from using the protocol are identified and critically analysed. Finally, the protocol is examined for areas of possible legal gaps and disputes.

Background information

Building Information Modelling, is defined according to the US National Building Information Modelling Standard (NBIMS-US) as "*a digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about forming a real and reliable basis for decisions during life-cycle, for earliest conception to demolition*" (Fallon & Palmer, 2007, p. 2). Klein (2012, p. 2) has defined BIM as a tool which can be used to improve the efficiency of delivering a project and providing superior management of its constructed facility. According to Alan Barrow, president of the Institute of Civil Engineering Surveyors (ICES), BIM is a method of information management which enables everybody that engages in any project's different phases such as, planning, designing, constructing, operating, maintaining and demolishing to collaborate successfully and work in harmony (President's Column, 2013, p. 5).

In 2011, the UK Government published a report entitled "*Government Construction Strategy*". This report described the aim to reduce construction costs by up to 20%. Several objectives were set in pursuit of this aim. The main objective was to adopt at least Level 2 BIM (including all project documents, information assets and data exchange procedures) for all public projects by 2016 (Cabinet Office, 2011). The Government's BIM adoption plan was enshrined in a strategy report for the

Government Construction Client Group written by a joint Department for Business, Innovation and Skills and industry working party (BIM Working Party, 2011 cited in Klein 2012, p. 2). Contract and legal issues were identified in this report as potential inertia factors that could hamper the adoption of BIM (Udom, 2012b). Thus, the report recommended developing standard protocols and service schedules to set out requirements for project delivery, and to also facilitate the response of the supply chain to BIM strategy (Department for Business, Innovation and Skills, 2011, p. 20).

The development of a protocol which manages BIM processes and contractual responsibilities requires examining the legal and contractual barriers facing the adoption of BIM. Udom (2012a) notes that issues related to Intellectual Property (IP) rights, data corruption and model management are considered the main issues surrounding BIM implementation. In addition, Lewis (2012, p. 47) has written that, while BIM at Level 2 addresses concerns to design input, restrictions on liability and model ownership, a comprehensive and workable contractual framework is needed to manage data exchange and assign the roles that indicate who does what and when. Glover (2013, p. 13) suggests that the BIM protocol must form the contractual framework to manage BIM implementation, clearly indicating the obligations of project parties, needs to be incorporated into project contracts such as the NEC and the JCT Public Sector Supplement.

An overview of the CIC protocol

The CIC protocol, which was published in 2013, is a fairly succinct document consisting of only eight clauses. These clauses provide users with the terminology, obligations and roles required for establishing a collaborative environment in which project information is properly shared to implement BIM processes. The protocol's declared objective is to "enable the production of Building Information Models at defined stages of a project" Rock (2013). The protocol defines the role of information management and assigns it to the information manager who is responsible for controlling and managing data exchange processes on projects. It also includes a provision giving it priority over other project documents in case of any inconsistencies.

Two appendices are attached to the CIC protocol. Appendix 1 is the Model Production and Delivery Table (MPDT). This table assigns responsibility for models provision and also discerns the levels of detail required at each project stage to build effective BIM models. Appendix 2 is the Information Requirements (IR) document, which defines how BIM models should be created.

The benefits intended to be obtained from using the CIC protocol

Releasing this protocol, and the suite of BIM documentation and standards, has helped the Government to move forward with its strategy. According to Office Insight, (2013), *"The widespread adoption of Building Information Modelling (BIM) in architecture, design and construction has moved closer with the publication by the Construction Industry Council (CIC)"*. Chris Hallam, an infrastructure law specialist, also explained that, *"the CIC's new Protocol is a great step forward for widespread BIM adoption in the UK and is to be welcomed"* (cited in Office Insight, 2013). Khalid Ramzan, who is another infrastructure law specialist, added in regards to the publication of this protocol *"it is a clear step forward and should accelerate the up-take of BIM across the UK construction industry, particularly on public sector projects."* (Out-Law, 2013b). Additionally, David Philp, the Government's head of BIM implementation, said in the BIM Show Live conference that the publication of

the CIC protocol has changed the Government's focus from setting up processes by which BIM adoption is enabled to steering an actual implementation of BIM across the industry ("*BIM Makes Real Progress as Focus shifts to implementation*", 2013). Although Malone (2013) cautions that "*standardisation of information protocols will prove challenging, and aligning project team behaviours even more so*".

The protocol is considered to be an essential document, as it provides the legal framework which could facilitate and encourage the use of BIM on projects (Construction Industry Council, 2013, p. 7). The protocol has been formulated to make it easier for construction organisations to adopt BIM processes through facilitating collaborative working methods in project teams, and functioning within common standard forms of contracts (Out-Law, 2013c; RICS, 2013). It has been designed to fit into existing construction contracts such as NEC3 and JCT using a simple amendment (Out-Law, 2013b; Shilvock, 2013). It contains the text of a template which enables simple amending of contract provisions, and it also includes terms which could easily adapt the NEC3 contract conditions (BIM Task Group, 2013; NEC, 2013, p. 4).

Moreover, the protocol provides support for the production of deliverables for data drops at certain project stages (Dla Piper, 2013, p. 3). Specific obligations, liabilities and constraints connected with the use of BIM models are stated in this framework (The Construction Index, 2013), and the protocol also deals with parties' liabilities in relation to data sharing, copying, using or modifying. Additionally, it makes changes to the protection of the Intellectual Property (IP) generated on projects, and also to the licensing of third party material (Out-Law, 2013c). IP rights are protected under the protocol through granting short-term licenses for the employer and other members of the team, allowing the use of the IP created only for the permitted purposes. This licensing provides project team members with access to the produced models. However, the licenses granted would not be final or continuous, or subject to change, unless the right sub-licensing is obtained (Ho, 2013).

The legal issues and difficulties associated with the protocol use

Part 1 of the "*BIM Legal Roundtable Discussion*" (2012), entitled "*Overview of the BIM Protocol and the Role of the Information Manager*" highlighted the following poor points in the CIC protocol:

- **Reliance on Data:** BIM models might become corrupted as they pass between project team members. This corruption, which could have a great impact on conflicts between parties, is unlikely to be detected by the protocol users.
- **Intellectual Property (IP) Rights:** No fundamental changes are provided for IP licensing under the protocol. Licensing is left to project parties to deal with it in the main contract. However, short-term licenses are granted under the protocol to ensure an adequate use of the IP created.

Although the protocol makes it easier for organisations to acquire the rights to use material (electronic data) in particular circumstances, it makes it harder for firms to preserve absolute control of their IP rights (BIM Journal, 2013). Despite the large inducement created under the protocol for companies to share IP on projects, no absolute protection is provided for IP creators, because once the employment of a project team member is terminated, the protection provided for their IP is ended. This allows other members, who might be rivals, to access, adjust and use their IP for project purposes with no need to make payment, which would cause problems for developers and operators across the industry (Out-Law, 2013c).

Moreover, the protocol's design does not seem to satisfy all the needs. According to Out-Law (2013a), locking the use of the protocol into BIM Level 2 will not fulfil the needs of those intending to use more sophisticated levels of BIM, and therefore the protocol use will be limited, although this locking is intentional and essential to adhere to the BIM strategy requirements. Further, the protocol was designed to mainly rely upon the input of the details provided by BIM skilled experts. Therefore, projects' employers should thoroughly review the protocol to make sure that its use will successfully deliver their projects' intended results (Hallam and Ramzan, 2013).

STUDY RESULTS AND DISSCUSSION

This section presents the results obtained from doing the interviews and circulating the questionnaire to emphasise professionals' views regarding the protocol's ability to promote BIM implementation across the construction industry.

Interview results

The eight interviewees, who were working in different sectors of the construction industry, highlighted the following points about the CIC protocol:

- The protocol seems to be well written. However, appendix 1 (the MPDT) is too simple and does not fully meet the purpose for which it was drafted.
- Regarding the role of information management, the person who performs this role should fully understand the whole process of BIM, as the information manager should not be the 'postman' who only sends and receives information. He/she should be the person who coordinates the process of building the BIM models.
- Overall, the protocol seems to promote the uptake of BIM through giving a standard form to start with.
- It does not relieve issues associated with Intellectual Property rights very efficiently.
- It needs to be used extensively in complex projects, so that judgements can be made on its use and benefits.
- Publishing this protocol seems to be a step in the right direction. However, the protocol is not one size fits all.
- Publishing this protocol will promote BIM implementation, as it seems to meet the requirements of the Government's strategy.
- Drafting and publishing this protocol is a step forward in BIM implementation. It certainly promotes BIM adoption, as it provides something to point at.
- This protocol deals with data exchange, which is the core of BIM process.
- A step forward with BIM uptake could be made through drafting and publishing documents like the CIC protocol, as people need a standard to guide them. They need something concise to let them know what to do, how and when.

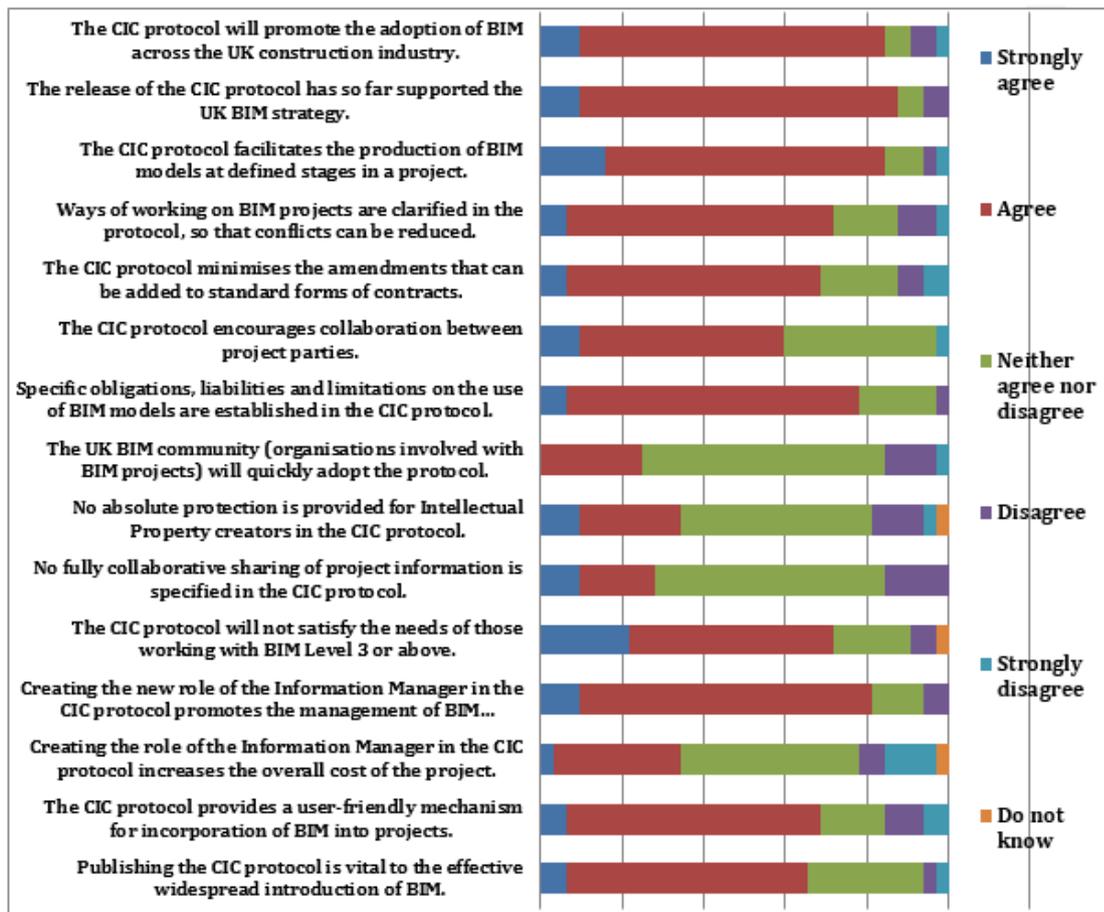
Questionnaire results

The results shown below were collected from 32 professionals who were from various sectors in the construction industry including lawyers, contractors, managers, engineers and architects. These respondents took part in this survey to critically appraise the CIC protocol and discuss its ability to manage BIM projects, with the aim of identifying its potential benefits of use and challenges.

The protocol's overall performance

As shown in figure 1, most respondents agreed that the CIC protocol will support BIM uptake and facilitate its implementation on projects. It provides a user-friendly document that facilitates the production of BIM models and encourages collaboration between parties by setting specific obligations, liabilities and limitations in relation to creating and using these models. However, the respondents mentioned that the design of the protocol would only work with BIM Level 2 projects, and will not meet the needs of those looking to engage in more advanced levels of BIM. Equally, they were unsure whether it provides absolute protection of the Intellectual Property created on BIM projects, or whether it gives sufficient support for the collaborative working methods necessary for the sharing of information required on these projects.

Figure 1: The overall performance summary of the CIC protocol based on respondents to the survey



Effective contractual framework

Over half the respondents agreed that the protocol will succeed in providing an effective contractual framework to manage BIM projects. This indicates the potential the protocol has to successfully support Level 2 BIM projects and, in doing so, aid the Government's strategy.

Terminology

Most professionals ranked the ease with which the protocol terminology can be understood as moderate. This is an encouraging point, as the easier it is to understand the protocol terms, the more likely it will be accepted and used across the industry.

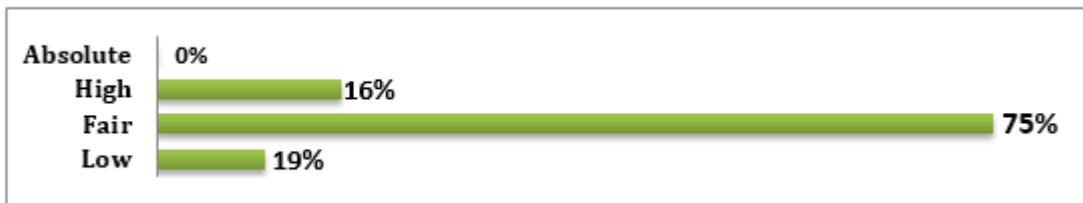
Effectiveness in addressing legal issues

The protocol aims to overcome the legal issues connected with BIM implementation. These include concerns such as model ownership, liability for data accuracy and Intellectual Property rights. The protocol's effectiveness in addressing the legal issues surrounding BIM implementation was considered by over three quarters the respondents as being average.

Protection of intellectual property (IP)

Most respondents expect fair protection to be provided for IP creators under the CIC protocol (See figure 2). The protocol secures IP rights through granting short-term licenses for the employer and other members of the project team, allowing the use of the IP created only for the permitted purposes.

Figure 2: Protection provided by the protocol for Intellectual Property



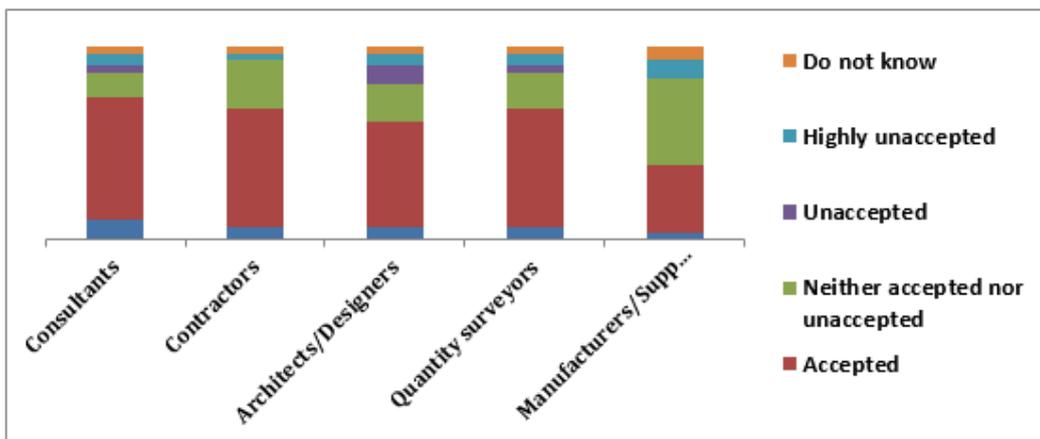
Support provided for sharing project information

The majority of respondents expect average support to be provided by the protocol for data exchange. This is an assessment of the effort made regarding the liabilities, obligations, and constraints set in the protocol to manage data sharing, copying, use and modification.

Acceptance across the construction industry

Respondents felt that various groups within the industry such as consultants, architects, quantity surveyors and contractors would accept the protocol (See figure 3). They think it will be successful in dealing with BIM issues, providing fair protection for IP creators, giving some support for data exchange and providing users with a framework which can be easily understood and successfully used for managing contracts involving BIM processes.

Figure 3: Acceptance of the CIC protocol across the construction industry



In addition to the above mentioned results, respondents indicated the following considerations about the CIC protocol:

The protocol's benefits of use

- Generally, the protocol is considered as a fairly simple document which provides the procedures required to manage data exchange on BIM projects.
- Legally, it is a universal framework which can be incorporated into common contracts with simple amendments. It also provides a step towards more sophisticated protocols.
- It is a standard document with a managerial concept.
- Technically, it suits the requirements for BIM Level 2, as it overcomes most of the issues associated with this level.
- The protocol guides the design team to the way in which it meets the employer's requirements and fits the project's needs.

The protocol's legal gaps and problems for use

- Designing the protocol to depend on the underlying contract to set the parties' main obligations might be considered as a legal gap.
- The parties' obligations, which are set in the protocol to manage the role of information management, might be considered excessively weak.
- Technically, the way with which the protocol deals with Intellectual Property issues does not seem to be fully comprehensive.
- The protocol is not appropriate for all BIM projects, as it was designed to be only used with Level 2 BIM projects, and also because it does not look to support truly collaborative working methods.
- Legally, the protocol cannot be easily controlled, because it is too process-driven. Additionally, the technical information required to fill the protocol's appendices should be adequately addressed and thoroughly defined before use, otherwise, these appendices will be useless.

CONCLUSION

The CIC protocol has been analysed using the data obtained from reviewing literature, conducting an online survey and undertaking personal interviews. The literature study has indicated that a step forward has been made with BIM implementation since this protocol was released. This publication has provided a document which can be incorporated into standard contract forms with simple amendments, and can also clarify the roles, liabilities and obligations required to establish a collaborative platform in which BIM processes can be implemented. Other benefits, extracted from the online survey results, indicate that this protocol can facilitate the production of BIM models through encouraging the adoption of collaborative modes of working, and clarifying the work sequences required to be established at each project stage. The survey has also concluded that reasonable protection will be provided by the protocol for the Intellectual Property created. It also concludes that the protocol will be somewhat successful in managing BIM contracts. Additionally, the ease of the protocol's terminology was considered to be moderate, and the protocol's support provided for data exchange, and the performance given to overcome the legal issues surrounding the implementation of BIM Level 2 were both considered to be average. The result of the interviews indicates that using the protocol will accelerate the uptake of BIM adoption across the industry, considering all the benefits that can be gained from its use.

On the other hand, some problems and legal issues are considered to be associated with the CIC protocol use. The literature study indicated that if a failure has occurred

in the data exchanged between parties, it will not necessarily be observed by protocol users. Additionally, problems of Intellectual Property (IP) infringement might arise from using the protocol, as the IP of a team member may be accessed by others in the team even after this member's agreement is terminated. The survey results have also highlighted some legal gaps and problems associated with the protocol use. These include the weakness of the protocol's obligations in regard to dealing with the role of information management, the simplicity of the protocol's model delivery table, which might not fully fulfil the aim for which this table was designed, and also the protocol's inappropriateness in dealing with contracts involving advanced levels of BIM (beyond Level 2), which might limit its use.

To sum up, despite the problems that might be associated with its use, the CIC protocol has the potential to be fairly successful in dealing with BIM implementation issues (For example: IP rights, collaboration among parties and data exchange). Additionally, releasing the protocol seems to be facilitating BIM uptake, as a step forward with BIM adoption has been taking place since this legal framework was issued.

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A PROPOSED BIM BUSINESS VALUE MODEL

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The business value of IT investments has long engaged researchers in fields of information systems (IS) and information technology (IT). Only in recent years has the business value of IT investments received attention in a construction industry context. Particularly, research on the business value of Building Information Modeling (BIM) has emerged in research during the last decade. However, much of the studies do not account for how organizational and business factors influence the value creation process. The research also tends to emphasize what the economic effects of BIM are rather than exploring how these values are created and under what organizational conditions. Hence, the aim is to explore how business value of BIM can be developed in an organizational and business process context. Building on models of IT business value creation from the IT/IS research field, together with findings from interviews on the perceived economic outcomes of BIM, a tentative BIM Business Value Model is proposed that accounts for organizational and business process factors. The model is then used to analyse and suggest what organizational and business related activities that need further attention from research in order to enable BIM business value creation. The findings indicate that among these activities are managing stakeholder requirements, incentives for BIM use, joint inter-organizational activities with partners and delivery of key information to operations and maintenance. A prerequisite for value creation with BIM is however to be able to manage organizational change if BIM is to have a potential impact on performance.

Keywords: business strategy, information technology, information systems, value management.

INTRODUCTION

Technological advancement enables refined solutions and new approaches towards more efficient ways of doing things. Building Information Modelling (BIM) is considered as more than just a technical tool (Eastman 2008). BIM also supports multi-disciplinary, collaborative and integrated approaches (Hartmann *et al.* 2012) and contributes to the development of business processes and work practices (Eastman 2008). The implementation of BIM in construction is however rather slow and the expected positive effects of BIM are not yet being met (Gustavsson *et al.* 2012).

Much of the research on BIM has been from rational, process and technological oriented perspectives, such as modelling, classification and standardisation (Grilo and Jardim-Goncalves 2010, Hallberg and Tarandi 2011), optimizing planning and scheduling for more efficient processes (Gilligan and Kunz 2007). There is less research from organizational and economical perspectives problematizing BIM in its organizational and business context (Adriaanse and Voordijk 2005, Gustavsson *et al.* 2012). Previous research indicates improved project performance by the use of BIM

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by making the building process more efficient, however does not provide a complete and comprehensive list of benefits and associated costs (Becerik-Gerber and Rice 2010).

The potential value of BIM has gained increasing interest in research (Barlish and Sullivan 2012, Kam *et al.* 2013). However, most of the research has focused on identifying what the economic benefits are (Barlish and Sullivan 2012, Gilligan and Kunz 2007, Kam *et al.* 2013), as opposed to how business value can be developed and under what organizational conditions. One example of current research that accounts for organizational prerequisites in value creation through BIM indicates that the economic effects of using BIM are perceived to be negative on short-term basis (i.e. additional costs) when there is insufficient emphasis on the organizational context in which value creation takes place (Vass and Gustavsson forthcoming).

In the area of information technologies (IT) and information systems (IS), IT business value has engaged research for a long time. IT business value has been studied in variety of industries (e.g. manufacturing, banking) and with various research approaches (Barua *et al.* 1995, Hitt and Brynjolfsson 1996, Keen 1981, Venkatraman 1994). Research on IT business value has focused on a more strategic perspective when evaluating the effects that IT has upon business processes in organizations and organisational performance (Davenport 2013, Grover and Kohli 2012, Kohli and Devaraj 2004, Melville *et al.* 2004). In the IT business value model, Melville *et al.* (2004) emphasizes that, in order for IT to have a positive impact on the business processes and organizational performance of a firm, organizational change has to occur on the operational level of the organisation alongside the implementation of IT. Until then, initiatives from industry level and macro level are not likely to have a positive effect on organizational performance (Melville *et al.* 2004, Winch 2010). Departing from the literature on IT/IS research, this paper will draw upon the conclusions from the IT business value model in Melville *et al.* 2004 and combine with the findings from an interview study of the perceived business value of BIM (Vass and Gustavsson forthcoming) in order to propose a tentative BIM business value model that includes organizational and business factors. The purpose is to increase the understanding of how BIM business value can be developed and thereby contribute to the much-needed discussion on BIM and the effects of using BIM within the organizational and business context. The rationale behind applying the IT business value model to the construction industry and BIM is because the IT business value models recognizes the need for organizational change alongside the introduction of IT and how organisational change induced by IT reforms the business processes of the organization, and hence, has a long-term effect on organizational performance.

METHOD

The research approach is exploratory and qualitative. The basis is literature reviews (within IT/IS and Construction management) combined with a recent interview study based on nine in-depth semi-structured interviews. The literature reviews were done based on IT business value development in industry in general and in construction in particular. The respondents were selected by purposive sampling and they represent client/owner, contractor and consultant. The respondents were selected on the basis of long engagement in the Swedish construction BIM-community (for example BIM Alliance Sweden), their experience of working with BIM and their current position. The rationale behind purposive sampling is that the research aim of discovering the consequences of using BIM for doing business remains unclear and ambiguous, which

makes early BIM-adopters and experienced BIM users of more interest to the survey (Bryman 2012). All interviews lasted 1,5 hours and were documented and analysed. The analysis was based on interpretation until a meaningful and sense-making pattern was found. Representative extracts were selected to construct the narratives. The analysis continued with a comparison with the IT business model.

RESEARCH ON BUSINESS VALUE IN IT/IS

Research on IT business value originates from computer and information systems research in the early 1990s (Bakos and Kemerer 1992, Barua *et al.* 1995). IT business value can be defined as “*the organizational performance impacts of IT, including productivity enhancement, profitability improvement, cost reduction, competitive advantage, inventory reduction, and other measures of performance*” (Melville *et al.* 2004). Much research point to positive outcomes from IT on organizational performance (albeit there are also research concluding the opposite) (Venkatraman 1994). The bulk of research on IT business value in the IS/IT field includes inter-organizational and business processes as key enablers of value creation. There are systematic attempts to leverage IT, both on technical levels and on business process levels, e.g. organizational change (Venkatraman 1994). Research shows that value creation through IT requires extensive and long-term investments organisational change, an input that often is neglected in productivity estimations (Brynjolfsson 2011).

A MODEL OF IT BUSINESS VALUE

The “*IT Business Value Model*” (Figure 1) by Melville *et al.* (2004) is based on the resource-based view of the firm (that aligns the rationale of economics with management research) and integrates the research on IT and organizational performance into a single framework. In the model, it is assumed that IT impacts organizational performance via microeconomics, industrial organizational theory and via socio-political perspective. The IT value creating process is multi-layered process contingent upon three primary impacts: the focal firm, the competitive environment and the macro environment.

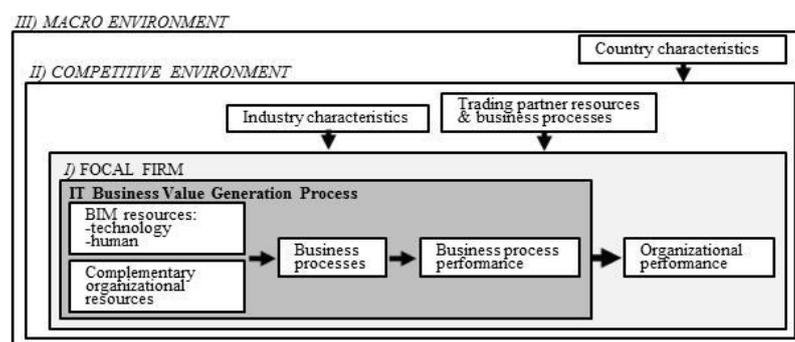


Figure 1. *IT Business Value Model (Melville et al. 2004)*

The focal firm represents the organizations’ IT resources and complementary organizational resources (organizational change). These generate value when deployed in the organizations’ business processes. IT resources alone seldom create IT business value, but need to be accompanied by organisational change, i.e. complementary organizational resources, such as changes in organizational structures, culture and work place practices. The complementary resources are often neglected or unaccounted for in most productivity measures. Business processes are those activities that the organization performs to transform its resources into outputs, e.g. customer service and sales. The competitive environment is the environment in which the focal

firm operates. The competitive environment is comprised of the industry characteristics, for example regulations, competitiveness and trading partners. Finally, the focal firms' ability to generate business value is affected by the macro environment in which it operates, such as governmental regulations of IT infrastructure, government promotions or country specific factors (Melville *et al.* 2004).

RESEARCH ON THE BUSINESS VALUE OF BIM

BIM offers an effective IT-tool for information storage and transfer (Becerik-Gerber and Rice 2010) but there is still a lack of knowledge of the economic effects and outcomes of BIM. BIM is thought to represent all the information needed for the building life cycle (Eastman 2008) with the following benefits reported in research: improved business performance, lower costs, increased profitability and increased safety (Barlish and Sullivan 2012, Gilligan and Kunz 2007). According to Kam *et al.* (2013), applying BIM in business also has positive effects on collaboration, coordination of multiple disciplines, sustainable design as well as competency and reputation. Kam *et al.* (2013) has formulated the VDC Scorecard in an attempt to evaluate the maturity of BIM in practice. According to Kam *et al.* (2013), the findings indicate that the BIM performance depends on early stakeholder involvement and the use of quantifiable objectives, among other things. However, there is research that accounts for negative perceptions of the business value of BIM as well and highlights the difficulties in quantifying these (Vass and Gustavsson forthcoming).

TOWARDS A MODEL OF BIM BUSINESS VALUE

In this section, findings from the interviews that contribute to the developing of a corresponding BIM business value model are presented. The results from the interviews are presented on three levels: the focal firm, the competitive environment and the macro environment (in accordance with the IT business value model).

The focal firm

The interviews indicate that the use of BIM currently seems to be dependent upon BIM-enthusiastic individuals rather than coordinated and collaborative efforts of the organization. However, some of the respondents did expect that the construction project managers' role would extend to also become information managers, or coordinator of building information models, whereas others expected BIM to become the responsibility of another individual, such as a third party consultant. Most respondents did agree on that more collaboration among the project participants is needed in order to change the organizational structures, routines and attitudes relating to BIM. For example, one respondent stated that:

“Technical innovations come and go, but the work processes basically stay the same and those are the ones that need to change” (Respondent H).

Yet, one of the biggest challenges has been to successfully implement change and the respondents' efforts have had varying results. For example, some of the respondents explained that they currently could not tell whether the effects of BIM stem from merely using the model, or if they are a result of BIM forcing them to change their work processes. Most respondents also emphasized how BIM projects that typically depend on having a BIM enthusiastic project manager on-board hinder organizational change as the vital knowledge and routines of the project become too much tied to certain individuals and too much experience based. As one respondent explained:

"Most of the BIM use is taking place in the project where a BIM driven project manager sees to that BIM is being used, but in the rest of the organization we do not have any established routines or guidelines for how to implement BIM" (Respondent G)

Another respondent experienced that what is needed for changing the organizational routines and processes alongside using BIM in the organization is a business case for BIM. Other respondents, however, were of the view that organizational change with BIM is merely a talk in the industry and not so much work in progress as it ought to be. One respondent expressed how the construction industry is actually not far behind other industries when it comes to the general use of IT, but that the industry has troubles managing paradigm shifts from new technologies and from changes because it is so fragmented. The respondents also argue that there are not enough incentives today to actually use BIM and to change the existing work processes. And there are no clear incentives for project managers, who are responsible for project time, cost and quality (i.e. project goal), to work with BIM and add risk and thereby jeopardize the project fulfilment:

"It is a challenge to convince project managers to use BIM when the traditional work ways are sufficient and when they already make money" (Respondent E)

One respondent expressed the view that merely introducing incentives is not enough - all the project partners must synchronize their efforts to change their business models and business processes accordingly to the incentives. Another respondent explained that altering and crafting your organizations work processes to meet the demands and needs of the clients enables organizations to make more money, and consequently further drive the use of BIM forward. However, most respondents did share the understanding of the construction industry procurement process as driven by price pressure and a lowest bid mentality, thus impairing the use of BIM. A few respondents also discuss how it is currently a problem that BIM is not yet fully a legal document and does not yet have full legal status that stretches above the status of, for example, paper drawings.

The respondents currently did not see any direct positive economic benefits from BIM, and the vast majority of the respondents associated BIM with costs, such as a costly software tool in need of frequent updates and additional education. However, the respondents did speak of BIM in terms of desired future positive economic benefits, such as more efficient and optimized processes, internal benchmarking, fewer errors and reworks and improved project performance. Project performance was often emphasized in terms of satisfied clients and satisfied end-users, but the most prominent desired effects of BIM on organizational performance was that of an improved flow of information to the operations and maintenance phase for the entire life cycle.

In conclusion, BIM resources and complementary resources (organizational change) are merely a means to an end, and are insufficient for business value creation unless they are applied in some value creating activities. As one respondent explained: *"The business effects of BIM do not originate from the model itself, but from the business processes built around the model"* (Respondent E).

The competitive environment

There respondents provided examples of factors that are unique to the construction industry and that can have a positive or negative impact on their ability to create BIM

business value. The strongly project-based environment with temporary relationships among a multitude of stakeholders, matched together by a lowest-bid procurement process, is considered an industry specific factor that has impact on the focal firm. For example:

"The fragmented construction process leads to loss of information between each project phase and overhead costs for each project actor" (Respondent H).

"The project-based industry and fragmentation may sometimes result in errors, rework, duplication of data, and having to reconstruct the model" (Respondent C)

Another example is the persistent and strongly rooted traditional approaches. To actually use BIM, there has to be clear and reliable arguments for the positive benefits. Otherwise there is no reason for changing something that already works 'good enough'. Moreover, industry associations, e.g. BIM Alliance Sweden, are considered as an example of a positive factor for value creation through BIM. The respondent also brought up the need for more a simple and comprehensible framework for BIM. Some respondents put emphasis on the role of software suppliers and stated that BIM is considered an extra cost due to costly software updates that they can't fully make use of.

Most respondents indicated that they perceived value creation with BIM to be dependent on inter-organizational collaboration and sharing of knowledge and routines. It was explained that project actors are now forced to work together with BIM and start communicating with each other:

"It is a two-way street. You need to understand not only your own firm's business processes, but also the clients" (Respondent D).

The macro environment

The macro environment is also influencing the BIM business value generation process, such as government regulations, industry standards, software developments, national building codes, government subsidies, public procurement forms, funds allocated to education and research, laws and regulations and culture. A few respondents especially emphasized the difficulties of BIM not having legal status:

"There have only been modest efforts towards giving the building information model legal status" (Respondent A)

Different country specific characteristics also steer the direction of BIM. For example, based on the respondents understanding of Sweden's developments in IT, the respondents explain that Sweden has had a good IT maturity and strong engineering and telecom industry and good IT infrastructure. A few respondents also explain how they perceive that the entrepreneurs in Sweden have been at the forefront of BIM implementation.

The BIM Business Value Model

To conclude the interview findings, the construction industry is not yet fully making use of BIM on the three levels of the IT business value model (see Figure 1). Based on the interviews, the components that make up the IT business value model, e.g. organizational change, seem to be lacking or be insufficient in the construction industry. The respondents do show insights and an awareness into what organizational conditions are needed for value creation through BIM, but these are expressed as expectations and beliefs of the future and not as efforts carried out today. What this

means for the proposed BIM business value model (see Figure 2), is that the model is built upon these deficiencies (as identified in the interviews) and on what is currently lacking in the industry's ways of working with BIM, rather than on positive examples from the industry. Thus, the BIM business value model can serve as a map and guidance for what organizational conditions that are missing and need to exist for business value creation.

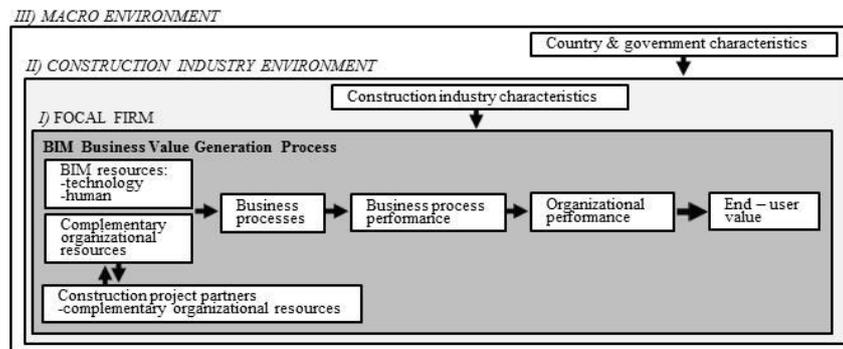


Figure 2. A proposed tentative BIM Business Value Model

For example, on the operational level (focal firm), successful BIM use seems to be dependent on certain key individuals according to the interviews. Organisational change is thus tied to a few BIM knowledgeable individuals rather than the organization as a whole. What this means for the BIM business value model, is that the project participants outside of the organization, e.g. suppliers and consultants, contribute with BIM knowledge that is fully understood and made use of perhaps only by the certain BIM knowledgeable key individuals in the organization, and that the knowledge exchange between the organization and its partners is tied rather loosely to the organization as a whole. In the BIM business value model therefore the role of the construction project partners is more emphasized than in the IT business value model. What can be understood from the interviews is then that the daily work practices, routines, culture etc on the operational level is the level from where organizational change needs to originate from, and then work its way up the organization. BIM initiatives from the construction industry environment (e.g. different BIM associations) and from the macro environment (e.g. government BIM imposes), are then more likely to have an effect on the operational level.

The current procurement forms with price pressure and the incentives forms within the construction industry environment seem to hamper organizational change rather than enable it. This has implications for the BIM business value model as not only the organization and its immediate project partners are important for co-creating business value, but also actors in the competitive - and macro environment, such as the legal and juridical environment surrounding the construction industry. Organizational change in the BIM business value model is thus suggested to expand over organizational boundaries and mutual and synchronized efforts are needed in order to change the organizational structures, routines and attitudes.

In terms of organizational performance, the interviews interestingly indicated that the respondents currently do not see any direct positive economic benefits from BIM, and the vast majority of the respondents associated BIM with costs. However, the respondents did speak in terms of desired benefits of BIM in the future, such as end-user value and improved facilities management. Consequently, in the BIM business

value model, the business value for the end-user is an integral part of what is considered organizational performance.

To summarize the BIM business value model, the model requires careful consideration and attention to the construction industry environment. What is proposed in the BIM business value model is what organizational prerequisites are important, yet missing in the construction industry. For example, close attention has to be paid to transforming the BIM knowledgeable individuals' tacit knowledge into knowledge for the entire organization. The BIM business value model suggests mainly two important proposals on what organizational prerequisites are necessary for value creation with BIM. Firstly, organizational change has to occur within the operational level (focal firm), meaning that the BIM knowledge that is currently tied to individuals rather than to the organizations has to become internalized into the knowledge base of the organizations as a whole. Secondly organizational change has to occur on operational level in the focal firm before organizational change can have an effect on the industry environment and on the macro environment. These conditions are currently lacking in the Swedish context and are the organizational prerequisites for BIM business value creation that are highlighted the BIM business value model.

CONCLUSIONS AND DISCUSSION

The proposed BIM business value model can be viewed as a snapshot of how far the Swedish construction industry currently has come in its use of BIM for value creation. Much of what was discussed in the interviews suggests that the use of BIM in the industry is currently not mature enough today to be analysed in a business value context. There seem to be too many technical and implementation issues persistent in the industry that requires immediate attention from the respondents. However, applying a BIM business value model to the construction industry is still valuable as it enables a deeper exploration of where in the organization that the conditions for business value creation are good and where they are weak. It is therefore considered important to propose a tentative model that can form the basis for the industry's continued development. The rationale behind the proposed BIM business value model is to highlight what is currently lacking in the industries ways of working with BIM and what needs more attention in research.

The purpose of developing a tentative BIM business value model based on the IT and IS fields, was to explore what organizational factors and business factors that seem to be prerequisites for BIM business value creation. The organizational and business enabling factors turned out to be a complex and problematic issue for the respondents. The respondents' organizations simply don't speak of BIM in terms of business value. However, much of what was discussed as problem areas in the interviews relate to the problems in IT/IS research that later laid the foundation for the development of the IT business value model. By applying the IT business value model to the BIM context, the problem areas for value creation with BIM can be understood in the light of a model that has been developed in IT/IS research over three decades and that has been thoroughly built upon in several years of research within a variety of research fields and through a variety of research approaches.

The quest for developing a tentative BIM business value model has shed light on the special circumstances of the construction industry that creates difficulties for business value. The question is whether the construction industry should take on influences from other industries, as it is so different and unique, or if doing so enables BIM

business value creation to move forward. By applying the BIM business value model as a lens for observing value creation in the construction industry, it could be argued that much of the organisational and business factors necessary for BIM value creation can be unravelled. By illustrating what organisational and business process prerequisites that are lacking, an awareness and insight on what might be the missing link in BIM value creation can start to form. The tentative BIM business value model thus serves a guide for future research on BIM business value creation by pointing out areas of research that need more exploration. Suggestions for future research include more empirical research and support on how the BIM business value model can be expanded.

Limitations of the study relate to the qualitative material that the proposed model is based upon. The sample contains only nine respondents, who are also part of the same BIM community, which raises the question of whether the results can be generalized to the industry as a whole. Yet, each of the respondents represent BIM experts within their respective fields, and as they represent several actors and thus enable triangulation (Denzin 2006). The original model from the IT/IS field that was used to modify and suggest a tentative BIM business value model, also raises limits the study. The theoretical pillars used to construct the IT business value model (e.g. the resource-based view of the firm) suffers from limitations, and these put limits to both the IT business value model as well as the proposed BIM business value model. Despite these limitations, the findings give a current view on the industries progress in using BIM for value creation.

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PERCEPTIONS OF THE VALUE AND VIABILITY OF IMPLEMENTING LEAN CONSTRUCTION WITH BUSINESS INFORMATION MODELLING

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Whilst research has been conducted on the theoretical links between lean construction and building information modelling, very little has focused on the areas of perceived value and on the perceived viability from utilising the methods together. Furthermore there has been little research to date on whether building information modelling implementation is regarded as potentially leading to an increase in the use of lean construction. To address these gaps in the literature data were collected from semi-structured interviews with site-based and office-based practitioners with knowledge and experience of lean construction and building information modelling. Analysis of the data identified three broad themes: 1) the drivers of lean construction and building information modelling; 2) the connections between lean construction and building information modelling; 3) barriers to implementation. In terms of the specific connections between the two methods the issues highlighted were a) the importance of educating the team b) the importance of early involvement of project participants and, finally c) the importance of managing change. Overall a strong potentially symbiotic relationship between building information modelling and lean construction was identified, as both share the same philosophy in terms of collaborative working and enhanced communication. The use of the two methods then was perceived as having the potential to add value in both financial and non-financial terms. However, not all interviewees believed that the increased use of building information modelling, if it materialises, would necessarily drive greater implementation levels of lean construction. Though there were some marked differences between the opinions of site-base versus office-based professionals, with the site-based practitioners being much more sceptical as to the value and viability of using lean construction and building information modelling together than their office-based colleagues.

Keywords: information management, information technology, information systems, modelling.

INTRODUCTION

It has been suggested that lean construction and building information modelling are two methods for improving performance of both individual construction projects and the construction industry in general. They form part of the wider move towards smart construction in an integrated and collaborative environment, which has been identified in the UK Government Construction Strategy 2025 as necessary to enhance performance at the project and industry levels. Furthermore, the UK government have highlighted the importance of successfully implementing these changes in order to

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enable the construction industry to achieve a competitive advantage over other nation's industries. Yet whilst there has been much research on different aspects of lean construction and building information modelling as individual entities there has been relatively little focus on utilising the two methods together. Hence the study focus on exploring in depth with a small group of industry practitioners their attitudes and experiences relating to the value and viability of implementing lean construction and building information modelling in tandem.

Lean construction and building information modelling are both responses to the challenge of achieving performance improvement in the construction environment, although, arguably, they have slightly differing emphases. Building information modelling involves the use of technology as a central tool to improve project delivery (Adriannese *et al*, 2012), whereas lean construction relates more to a change in management style and philosophy in order to achieve improvement. However, there are similarities between the two methods in that both require high levels of collaboration and an integrated project delivery in order to deliver maximum benefit from their utilisation (Cho and Ballard 2011; Ilzor and Kelly 2012). In terms of the outcomes from using lean construction and building information modelling it is suggested that both methods are able to contribute to increased efficiency, reduced costs, improved client satisfaction and ultimately increased profits.

As stated earlier there has been a small amount of work focused on utilising lean construction and building information modelling together, though much of this is conceptual in nature. Breit *et al* (2008) argue that building information modelling can actually be used to support lean construction methods. With the accurate planning tools available within building information modelling facilitating the use of methods associated with lean construction, such as pull-scheduling and Last Planner System®. Davis (2007) highlight that the manufacturing industry have used virtual simulation techniques - akin to building information modelling - to implement lean production, but that this potentially fruitful integration of methods has rarely been recognised nor made in construction. Sacks *et al* (2010) identified a number of areas of common interest between building information modelling functionality and lean principles, and, hence, suggested 55 distinct interactions between building information modelling and lean construction. Furthermore Khanzode *et al* (2006) provided a framework that links virtual design and construction with a lean delivery process. This framework has been further developed i.e. through CIRIA's 2013 "*Guide to Implementation of Lean Construction Principles with Building Information Modelling*". In addition, The University of Salford have developed a maturity model for the implementation of building information modelling, which was based on eleven criteria points. The model was designed to provide a framework to assist with the implementation of lean construction and building information modelling and to assess a project's level of implementation of the two methods. Finally, given that building information modelling enables greater use of lessons learned taken from one project to the next, as the information is already recorded in a digital format, this can facilitate continuous improvement - a key lean principle. For this and the other reasons outlined above increasing use of building information modelling could potentially be a catalyst for lean construction.

As the implementation of building information modelling can result in waste reduction - one of the key principles of lean construction - it is suggested that building information modelling will naturally result in increased lean processes (Dave *et al* 2013). In this respect Arayici *et al* (2010) found some evidence that when building

information modelling technology was implemented lean process improvements were achieved. Here the role of building information modelling in facilitating easier implementation of lean principles is maximised through encouraging early integration of the project participants, as building information modelling requires such early input from the project team to develop the models (Ilzor and Kelly 2012). Specifically building information modelling implementation can contribute directly to achieving lean goals through such functions as clash detection and improved information exchange (Dave *et al* 2013). Additionally building information modelling could help users visualise the project and gain a better understanding of the project, improving information exchange and assisting collaborative planning - which is a key lean construction tool (Dave *et al* 2013).

In terms of practical applications of lean construction and building information modelling, one of the most notable examples is the Sutter Health Castro Valley project in California, where lean construction and building information modelling were implemented (Sacks *et al* 2010). This was a \$320 million state-of-the-art medical centre where the two methods were used together to deliver an accelerated schedule of 30% compared to the expected timeframe and to meet aggressive budget cuts (ibid). Other notable UK projects that have utilised lean construction and building information modelling include Terminal 5 Heathrow airport and road projects by the Highways Agency. These projects, demonstrate the benefits that can be achieved when lean construction and building information modelling are successfully implemented together and how building information modelling facilitates the implementation of lean construction and vice versa (Dave *et al* 2013).

Whilst the UK government are pushing the implementation of building information modelling within the UK construction industry, the implementation of lean principles is not being as overtly promoted in a similar fashion. Nevertheless, if the widespread adoption of building information modelling that is being mandated is actually realised, this could potentially result in greater implementation of lean principles and lean construction. As building information modelling becomes the norm and is implemented to greater levels of maturity it has, arguably, the potential to facilitate the greater adoption of lean methods that have shown to be successful on individual projects (Dave *et al* 2013). Yet, countering this potential is the fact that despite the, albeit limited, focus on the unifying concepts of the two methods and some notable published successful case studies - as outlined above - it has been noted that it is still quite rare for lean construction and building information modelling to be used together effectively (Gerber *et al* 2010).

One reason for this rarity could be the cultural change required to extract maximum value from the two methods and a resistance to the change that adopting them together would require in relation to knowledge, skills, attitudes and behaviours (Brewer and Gajendran 2012). Beck (2011) argues that to change people's core beliefs you have to demonstrate the value of change to help make change the logical choice. Yet whilst some research has been conducted on how building information modelling supports lean, very little has demonstrated the value of using lean construction with building information modelling. One study was undertaken by Gerber *et al* (2010) who analysed three projects that used building information modelling with lean construction, however no comparisons were made between the projects and the research generally focused on the techniques used and some of the specific advantages of using the two methods, rather than on the overall value of using the them together. Hence the research aimed to explore the viability and the value of using lean

construction and building information modelling together. Understanding the value is particularly important as a lack of recognition amongst those working in the construction industry as to the benefits that can be realised has previously been cited as a reason for not using methods such lean construction and building information modelling by a number of authors (Davis 2007; Mossman 2009; Knutt 2010).

RESEARCH METHOD

To achieve the aim stated above, qualitative data were collected from industry practitioners with knowledge and experience of lean construction and building information modelling, through in-depth and semi-structured interviews with seven practitioners. This research approach was chosen as it is appropriate to gain understanding of individual perceptions of a particular topic (Silverman, 2010). In this case the topic is the viability and value of implementing lean construction and building information modelling together. The sampling framework comprised of industry practitioners that were split between office-based staff, such as consultants, with an expertise in building information modelling and lean construction and site-based participants working for main contractors. The reason for ensuring representation from these two broad groups was that as a pilot to the study the researchers had analysed the case of a project that had used building information modelling, in order to gain a deeper appreciation of the practical issues associated with utilising both building information modelling and lean construction to a specific construction scenario. The case involved the design and build of a new school, with a total value of £7.5m, in the UK. The design involved a multi-disciplinary team which included an architect and engineers who all worked with Autodesk Revit building information modelling software. It was the main contractor's first building information modelling-enabled construction and was promoted as the first fully integrated building information modelling project involving designers, main contractor and supply chain partners. During the course of analysing the case it became transparent to the researchers that there were specific difficulties in integrating building information modelling on site - hence the decision to include both groups in the schedule of interviews. The small sample of interviewees reflected the difficulties in finding people with the requisite knowledge and experience of the two methods and the resources required in undertaking the data collection. The sample was obtained through the researchers utilising their own networks of contacts with industry professionals and, whilst small in number, was deemed as satisfactory given the exploratory nature of the research.

Table 1: Practitioners knowledge, experience and work-base

Interviewee	Years Experience	Base	Building Information Modelling Knowledge/Experience	Lean Construction Knowledge/Experience
1	8	Office	4	5
2	30	Office	5	3
3	7	Office	3	4
4	33	Site	2	1
5	16	Office	5	4
6	14	Site	4	1
7	10	Site	4	1

Key: knowledge/experience 1 -lowest 5-highest

The specific knowledge and experience and whether site or office-based of those interviewed is shown in table 1 above. Participants rated their own knowledge and experience on a scale of 1 - 5. The questions were structured into three areas: how lean construction is implemented? How business information modelling is implemented? How can the two methods be implemented together? What is the value of undertaking such integrated implementation?

Thematic analysis was used to identify themes through coding (Braun and Clark 2006). In this manner themes were drawn amongst all the respondents and areas of commonality and differences were identified. This coding hierarchy helped further develop potential themes within the data and facilitated the analysis of the frequency and coverage of each initial code. This demonstrated not only how many times each code was mentioned but also in how much detail participants discussed each code therefore suggesting the importance they placed on that topic.

FINDINGS AND DISCUSSION

The high-level themes that emerged were as follows: 1) the drivers of lean construction and building information modelling 2) connections between lean construction and building information modelling 3) barriers to implementation. Within the theme of "*connections between lean construction and building information modelling*" 3 second-level themes were identified: a) Educating the team b) The importance of early involvement c) Managing change. The next section discusses of these themes in turn and finishes with observations on different perspectives between the site and office-based interviewees.

The drivers of lean construction and building information modelling

The first driver identified by some interviewees was the need to remain competitive within the industry, with failure to do so resulting in missed opportunities and ultimately business failure - especially with the UK Government building information modelling mandate coming into effect in 2016. Rather than government pressure mandating building information modelling, in the case of lean construction interviewees suggested that the current market conditions is forcing increased use of lean principles as people try to implement more efficient methods of working to be able to meet the increasingly reduced programmes and budgets. The interviewees suggested that people were increasingly turning to lean methods to be able to operate successfully and deliver client demands.

So, the increased use of lean due to market demands and the increased use of building information modelling due to government pressure should theoretically result in the increased combined use of both methods. However, one interviewee suggested that whilst the use of lean construction and building information modelling will increase they believed that rather than using the methods in their entirety certain aspects of each will be utilised for each individual project, partly due to the barriers to full implementation (see later section). Such approaches could prevent the maximum benefits of utilising the two methods together being realised and in the worst case scenario could result in their being adopted as part of a tick-box exercise rather than as a way of adding meaningful value to a construction project.

Connections between lean construction and building information modelling

All of the interviewees made the connection between the two methods, with the greatest focus of connectivity revolving around both methods being able to improve efficiency and collaboration. Building information modelling is perceived as driving

collaboration and it was recognised that lean construction work best when in a collaborative environment, so it was proposed that a greater use of building information modelling will create an environment that facilitates greater use of lean principles. Furthermore, the interviewees saw an emphasis of building information modelling on improving efficiency - a key lean principle; and the ability to more easily facilitate continuous improvement, due to the improved information management and reporting available within building information modelling - another key lean principle. Therefore, this would suggest that as the use of building information modelling increases the use of lean principles will be able to increase and there exists great potential in the future to implement lean construction and building information modelling together.

However this theoretical development of building information modelling followed by lean construction was met with mixed reactions. Three out of the 7 interviewees opined that increasing use of building information modelling won't necessarily lead to increased use of lean construction. This could be attributed to the understanding of lean construction principles as some participants may focus only on lean construction tools and techniques, such as pre-fabrication or collaborative planning and feel that building information modelling use will not have an impact on these activities. Countering this it could be argued that building information modelling could even help increase the use of these methods as well. It was also suggested by some that the use of lean construction with building information modelling will very much depend on the nature of the project, with a belief amongst some that it would only be suitable for larger project. As stated by Interviewee 4: "*lean construction and building information modelling should go hand-in-hand on large projects as there are benefits of both and they both, as far as I'm concerned, tie in to try and achieve the same goal*"

Educating the team

Throughout all of the interviews it was clear that great importance was attached to not only using lean construction and/or building information modelling but also using them effectively and the corresponding difficulties in doing this. From the interviewees' responses this required having the right people and processes in place to effectively implement new methods. This highlights the importance of training the team to ensure maximum benefit; although this is something that the construction industry is notoriously bad at doing. Furthermore, this training of personnel should not just relate to the site team but also to the sub-contractors, as it is they who carry out the work and therefore it is vitally important that they are proficient in the methods used. This was raised particularly in relation to building information modelling where it is very important to have sub-contractor involvement. It was perceived that currently, other than the heavy design-oriented sub-contractors like M&E and steelworks, very few sub-contractors are building information modelling-proficient and this deficiency can only harm the effective implementation of building information modelling and lean construction. Therefore, the interviewees suggested that we need to educate the supply chain and take them on the journey towards full building information modelling implementation with the main contractor, in order to ensure maximum benefit. While some of the site-based interviewees argued that this would only go so far, the office-based participants suggested that this could go all the way through to the sub-contractors and then everyone should at least have an understanding of the fundamentals of building information modelling. This would facilitate a more integrated project and enable lean construction. This need to educate project participants doesn't just relate to the supply chain but also to clients. The

interviewees suggested that it is important for clients to fully understand the impact and potential of building information modelling and lean construction to be able to make a more informed decision on whether to require or support implement of the two methods.

The importance of early involvement

The importance of implementing building information modelling and lean construction from the start of a project was highlighted, with some interviewees suggesting that there is a tendency to bring lean in later in a project to try and fire-fight and get the project back on track. This point was reflected in the comments of Interviewee 2: *"To get anything to be successful it's got to be from day one and has to have the full involvement from everybody."* Interview 6

Managing change

The interviewees highlighted the importance of managing change effectively to facilitate a harmonious environment in which to implement methods. This ensures that the people tasked with implementing the methods will drive implementation. However, the participants suggested that this no easy task, as there can be resistance to change within the industry as people oppose new ideas and new methods. In the words of Interviewee 2: *"It's hard to change as no one likes a change but you have to change to move forward."* For projects and the construction industry as a whole to benefit from lean construction and building information modelling this resistance needs to be overcome through effective change management and by ensuring the people are adequately trained and appropriate processes are in place.

Barriers to implementation

The majority of the issues that were raised as barriers to implementation were consistent with those identified in the prior literature - as highlighted by Bernstein and Pittman (2005) and Yan and Damian (2008). Cultural issues within the construction industry were raised as a major barrier. Other key barriers that were raised were poor understanding of lean construction and building information modelling and a feeling that lean construction and building information modelling may not be suitable to a particular project context. Despite the fact that UK Government reports and existing literature on the topics suggest that lean construction and building information modelling are suitable for the majority of projects there was a widespread perception the methods would not be appropriate for anything other than large projects; with the belief that clients would be unwilling to pay for their use on the smaller jobs. The poor understanding of the two methods can be mitigated through education and training - as discussed above. This comes back to the need to educate clients to allow them to make the most informed choice on what they choose to implement. It was also suggested that some types of contract may not be as suitable for the implementation of lean construction and building information modelling. Interviewees believed that the more collaborative forms of contract would be more suitable, with the opinion being that only when the more collaborative contracts are common place will there be a suitable environment to implement lean construction and building information modelling.

The final barrier was the perceived high cost of implementing building information modelling or lean construction. This was particularly the case in relation to building information modelling. The interviewees suggested that the initial start-up costs of licenses, software and training can provide a significant barrier to implementation building information modelling. Particularly for SMEs as they may struggle to absorb these set-up costs. However it was recognised that these initial costs can be more than

recovered through future savings: *"There is always a learning curve with building information modelling but then after a while you will start using it all the time and it will become second nature and you will get fewer issues and more benefits"* (Interviewee 1).

Differing views of site-based and office-based professionals

The majority of the issues and potential barriers with lean construction and building information modelling were raised by the participants that were site-based rather than those office-based. One interpretation is the office-based practitioners view these two methods through rose tinted spectacles. As such they see the positives yet fail to recognise the potential issues and potentially negative impact of implementation. Furthermore, it could be argued that the site-based individuals have a better understanding of the true impact of implementing these methods on a construction project as they see how different methods impact on site. However, another interpretation is that the differences are indicative of the general resistance to change that exists amongst site-based practitioners and the need for effective change management in order to break down such resistance and to create a suitable environment for the effective implementation of lean construction and building information modelling.

CONCLUSIONS

The interviews highlighted the benefits of using lean construction and building information modelling, both individually but more usefully in combination. However whilst the interviewees highlighted the need to implement lean construction and building information modelling as government pressure and market conditions are dictating it, they did suggest that there are significant barriers to effective implementation of both methods. The interviews revealed the need to have the right processes and the right people in place for lean construction and building information modelling to be implemented effectively and the importance of managing the change effectively to ensure the methods are championed rather than resisted. Furthermore, the need to educate the supply chain and clients to provide a suitable environment in which lean construction and building information modelling can be utilised is necessary. All of the participants did make the correlation between lean construction and building information modelling. However only 4 of the interviewees suggested that they see building information modelling as a catalyst to increased use of lean construction. It could be argued that currently not enough practical research has been completed to push this correlation to the forefront of people's thinking and some of the more negative viewpoints towards the use of lean construction results in people resisting its implementation. As was mentioned in the interviews only when people fully realise the benefits will they be receptive towards these new methods of working.

In terms of value the interviewees noted the ability of lean construction and building information modelling to reduce programme durations, make projects more efficient and, therefore, achieve cost savings. Furthermore, for the cost savings to be realised the barriers to effective implementation have to be overcome to provide a suitable environment within which the potential cost savings can be realised. If this environment is created then the two methods could potentially be implemented together effectively and help deliver cost savings. Furthermore, as the government mandate dictates the use of building information modelling on public projects this has the potential to lead to increased use of building information modelling within the industry and potentially increased use of lean construction. Then over time, as the

methods become common practice, it will reduce the barriers and help increase the potential benefits.

While lean construction and building information modelling have the potential to be beneficial for construction projects individually and the wider industry, currently there is not always a suitable environment for participants to extract maximum benefit from implementing the methods. This has resulted in them often being implemented as an add-on or extra rather than an intrinsic part of the project from the start. It is important that the industry realises the importance of implementing them in an environment that is conducive to which the potential benefits will be realised. Furthermore, this tendency to implement lean construction and building information modelling as an extra has resulted in some construction professionals not fully understanding the potential benefits and instead viewing them as more of an inconvenience and an unnecessary cost. This has resulted in a resistance to change that needs to be overcome to achieve effective use of lean construction and building information modelling. While there are other barriers to successfully utilising the two methods through time and increased use these should be overcome.

However the cultural issues that affect the industry and restrict a collaborative environment could prove more difficult to mitigate for. Yet if these issues are not overcome the UK construction industry risks falling behind other nations that could utilise them more effectively in the future. This could have a detrimental effect not only on our construction skills exports but also on the national market as more contracts may go to more efficient foreign contractors. To help overcome the issues discussed it would be beneficial for an in-depth case study to be completed on a project that implements building information modelling to at least Level 2 and expressly uses lean construction methods, such as LPS® and lean principles. The key would be that the methods are utilised from project inception, rather than using building information modelling for the design-related activities and lean construction later on in the construction phase.

Such research would uncover some of the practical implications of implementing lean construction with building information modelling and therefore provide the demonstrable evidence to industry professionals and clients as to the benefits of combining lean construction and building information modelling. This is particularly important in relation to clients as it is likely that many clients will only proceed with something that they can clearly see the benefits for. Furthermore, many of the innovations within the industry, of which lean construction and building information modelling are just two examples, need to be client-led, as well as being supported by companies in the supply chain. The involvement of the clients is seen to be necessary by contractors, as they suggest that lean construction and building information modelling need to be client-driven to ensure that the methods are desired on the project and so will then get the full backing from the project team.

In practice it is difficult for trends to be accurately evaluated. Whilst implementation of building information modelling in particular has been quite fast moving it is still in its infancy. Therefore it would be beneficial to complete an evaluation of the extent to which building information modelling can act as a catalyst for lean construction through longitudinal studies over a period of years. It would be particularly useful if this were to be done after 2016 once the UK Government building information modelling mandate had come into effect as building information modelling should be

becoming more common practice at this stage. Hence it would also highlight the effect this mandate has on the use of lean construction.

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THE WIDER IMPLEMENTATION ISSUES OF BIM WITHIN A MULTIFACETED PROPERTY AND REAL ESTATE CONSULTANCY

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The purported benefits of Building Information Modelling (BIM) have resulted in its widespread advocacy across the industry. However, the realities of its implementation are often misunderstood and overlooked. BIM is a complex and unbounded technology, therefore trying to apply it to a project without consideration of the associated organisational changes is likely to end in failure or lower than predicted returns. Factors such as professional development and technical support, the technology learning curve, positive and negative feelings towards the technology, and strategy effectiveness can all help and hinder implementation. This paper draws on a set of interviews with members of a BIM implementation board within a large multifaceted construction company. The purpose of the interviews was to establish the 'as-is' position of the organisation in terms of BIM use, focussing on current practices and cases studies of previous and on-going projects and their utilisation of both BIM processes and sustainable design activities. However, thematic analysis highlighted significant barriers to the successful implementation of BIM within the organisation: lack of top-level support, misunderstanding across the organisation over BIM capabilities, regional differences in implementation support, and a predominant focus on the bottom-line preventing effective resource allocation. It is therefore argued that the organisational context and conditions of technology, process, and actor interaction are a necessary precursor to successful BIM implementation and should be taken into account when assessing performance on a BIM-enabled project, in order to comprehensively inform and support change management initiatives.

Keywords: BIM, implementation barriers, performance measurement.

INTRODUCTION

The realities of BIM implementation are often misunderstood and overlooked; BIM is a complex and unbounded technology, therefore trying to apply it to a project without consideration of the associated organisational changes is likely to end in either failure or higher costs.

A number of studies identify the challenges and risks associated with BIM implementation and execution that are helpful to understand elements of project success and how to improve ROI. These include: data interoperability issues, issues of computable design data, under-developed practical strategies to exchange and integrate information, implementation issues, incomprehensive strategies for

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implementation, exploitation of BIM hyperbole that only considers the quantitative aspects of BIM benefits, learning curve of software, and difficulties associated with changing normal protocol to bring stakeholders in earlier (Azhar, 2011). These difficulties are indicative of a failure to consider the context and extent of 'ICT Diffusion', defined by Peansup and Walker (2006) as 'the process by which an ICT application is adopted and implemented by an organisation until its expected users accept and transfer knowledge of how to use these ICT applications throughout the organisation'. The level of success is in-part dependent on the effectiveness of the organisation's strategic implementation plan, which must consider issues of critical management support, technical support, a supportive workplace environment and users' individual characteristics (Peansupap and Walker, 2006). An effective entrepreneurial leadership role that requires a high level of technical competence is essential to overcome many of the challenges and risks associated with the diffusion of an innovation such as BIM within a construction company, the delegation of which is dependent on the availability of resources and adequate power (Nam and Tatum, 1997). In reality champions of innovations compete with existing operational activities for resources which means the implementation of technologies is achieved through 'learning on the job' (Barrett and Sexton, 2006) when much of the literature regarding the successful implementation of BIM advocates a number of antecedent requirements at an organisational level.

Drawing on a set of interviews this paper explains the 'as-is' position of a multifaceted construction company currently implementing BIM. The data identifies issues inherent to the organisation that are intensified by the implementation of BIM. Analysis of the interview data exposes the existing issues within Company A and supports a more systemic sociotechnical approach to implementation that the literature propose. The paper is structured as follows: the rationale for the research approach is first explained, the findings are divided into thematic subheadings of Insufficient top-level support, Misunderstanding across the organisation over BIM capabilities, Resource allocation, and Regional differences in implementation support, and finally conclusions are put forward.

RESEARCH APPROACH

A semi-structured interview protocol was developed based on the reviewed literature, commonly occurring themes throughout BIM team meetings, and the consultancy's analysis of Company A's as-is position prior the implementation of their services. Nine interviews varying in length from 40-90 minutes were conducted with BIM Team members including regional directors, discipline directors, CAD Managers, the BIM Team coordinator, and the IT Change Manager. The interview protocol focussed on current practice, cases studies of previous and on-going projects, and their utilisation of both BIM processes and sustainable design activities. Questions were specific to four areas: introductory questions regarding roles and responsibilities; sustainable design; the effect of BIM on individuals' roles and interactions within interdisciplinary work; and lessons learnt from BIM utilisation in interdisciplinary work.

For the purpose of providing a baseline case from which to measure the ROI and sustainable design benefits of BIM the data was thematically analysed by review and comparison. The consideration of BIM as a sociotechnical system was developed through the literature review and informed the approach taken to review and analyse the data. This was used to identify specific themes that determined the extent of the

configuration of people, technology and processes and how these affect the success of a project.

Company A is a multi-national multi-faceted Property and Real Estate consultancy with 4,500 staff at 50+ offices in the UK and internationally. They offer a vast range of professional and technical expertise across a number of services. They have committed to adopt Building Information Modelling (BIM) practices and processes as the default method of working throughout the company and have enlisted the services of an IT design solutions consultancy company to support this initiative. In order to facilitate this and to provide a centrally led induction process a BIM implementation team was set up. However, there is no uniform programme of implementation that each discipline or region must adhere to; BIM is being implemented on a project-by-project basis. The team consists of higher-level users of the software who are expected to champion and roll out processes, methodologies, and decisions made within monthly team meetings in addition to their normal role.

Company A at the time of the interviews had a licencing arrangement whereby the accredited IT design solutions consultancy company deliver services on behalf of a software vendor. Services include project, process and software consultancy, implementation and project support, as well as training and technical support. The consultancy company are nonpartisan to the vendor and offer training and consultancy support for other software solutions. The purpose of this study was to capture the team's effectiveness and the wider implementation issues of implementing BIM within an organisation of this kind.

FINDINGS

Insufficient top-level support

Within Company A only a select few people know what BIM is and what it can achieve; those that do not know often misinterpret it as a bounded software solution applied to existing design processes and practices to increase productivity. However, as the following interview analysis will illustrate the organisational context of Company A forces the technologically deterministic application of BIM at project-level. This exposes the existing communication, collaboration, and cooperation issues at firm level that the technology is supposed to expedite. Conversely the application of BIM, by way of a sociotechnical systems approach that the BIM Team alludes to, relies on organisational restructuring, culture change, and change to embedded practices and processes. Change that is very difficult to implement without support from those who hold the power and authority to make strategic decisions that have an understanding of the underlying principles of BIM. As one interviewee explained:

"... whatever level decisions are made at decisions are made by saying 'well, yes, we understand that we're making this decision because it's going to make the company more money but we're also making this decision because...it's the right way to go forward in terms of the methodologies and processes we have and what we want to then market out as a service'." [BIM Team Coordinator, Consulting Team]

In the case of Company A, the extent of executive management engagement has been the approval to adopt BIM and to fund a licencing and consultancy service agreement that also includes training courses and telephone support. This agreement was based on a business case for higher project-level returns, and a BIM policy statement disseminated company-wide announcing its adoption. However, the executive board have no explicit role in the implementation of BIM. This task is the responsibility of

the BIM Team, which is a group of individuals who have been selected as higher-level users of the software with the necessary technical expertise to train and mentor newer users, and who disseminate the processes and decisions made within the BIM team meetings.

Despite their expertise and their understanding of the type of change management required, their efforts to resource and execute new BIM processes and practices are inhibited by their lack of authority to make decisions regarding changes to localised procedures. For example, the CAD Manager tasked with resourcing and technical support for CAD within the Civils discipline has found his role as a BIM Team member:

"relatively difficult....because I've got no position on our managerial team...the only meetings I go to to do with management of the department is when I go to resourcing meetings where I found out who needs what and that's the only time I found out what [BIM] projects are going on." [CAD Manager, Civil Engineer]

This suggests that the role and extent of the BIM Team as BIM process and practice implementers is misunderstood, inadequately supported and insufficiently embedded. This problem is not exclusive to this discipline and many of the interviewees believe it can be overcome with effective top-level managerial support that propagates the values and principles of BIM methodologies throughout the company.

Currently there is a complete disconnection between top-level management, "...the ones with the money..." and therefore the power to effect organisational change, and what is actually happening on "the shop floor" where process improvement is impeded by the existing organisational structure and associated processes. The problem being that they cannot effectively support the individuals implementing BIM because they are unaware of the issues associated with the existing managerial structure. These issues are further veiled within the communication channels throughout the managerial structure:

"...the only way the executive board communicate...is through a newsletter...that comes down through the managerial structure...you get a raft of management that pass information back up to the board, but as it gets passed up it gets diluted and it also gets phrased in a way that makes the manager look good..." [IPD Strategist, Architect]

The size of the company and disparity between disciplines and regions inevitably creates value inconsistencies and there is a demand for top-level management to become a visible and proactive entity in the promotion and implementation of BIM throughout the company. The self-preservation of middle management is repeatedly mentioned as a bottleneck to implementation success whereby information about cost centre performance is withheld from the executive board for fear of rationalisation, when rationalisation and restructuring is what is actually required:

"...sometimes you've got to confront the truth in order to take the business on to success, and sometimes if you keep things from people, those people can't actually help you...if the executive board don't know what's going on...how can they manage the business?" [IPD Strategist, Architect]

Interviewees believe the implementation of BIM within the company would be better achieved through executive board leadership and support:

"In this business we need to completely change our attitude in the way that we roll BIM out. It needs to be enforced; it needs to be by dictat..."

...this is what you're going to do, and I'm going to help you do it, and that's the difference between success and failure for BIM I believe." [IPD Strategist, Architect]

As it stands many of the BIM team are asked to implement a method of working without the requisite power or support to effect change.

Misunderstanding across the organisation over BIM capabilities

Along with a lack of top-level support many of the issues faced by the BIM Team are associated with a misunderstanding of what BIM actually is, what it entails and the varying capabilities of each discipline and region. The BIM policy statement from the executive board was a broad announcement of the company's aspiration to become a leading BIM-enabled organisation. This has implications for strategy support, the extent of its use at project-level, and creates tension between the capabilities that are promoted when securing bids and the reality of what can actually be delivered.

Interviewees described the problems of senior managers over-estimating the capabilities of the project teams, they have heard that the company is now doing BIM but there is no strategic consideration of what BIM should be delivering, when it should be delivered, or how it should be delivered to realise benefits for both the project and the organisation:

"I think the one difficulty or the one frustration that clients seem to have now is perhaps understanding or clarifying between what we've said we can deliver as a company and what we actually deliver." [BIM Team Coordinator, Consulting Team]

As a result, time, training credits, and resources are used for non-design/construction critical tasks at the request of senior management who liaise with the client and promise outputs that add no real value.

"...they're modelling all sorts of stuff that is on a scheme early stage design, so they're just throwing money away." [Regional BIM Manager, Architect]

This creates additional problems for the BIM team members; frustrating the implementation and use of structured and considered protocol to deliver meaningful and coordinated data by having to use arbitrary processes to meet the advertised BIM deliverables. When asked how this could be improved one interviewee proposed a front-loaded approach with a clear definition of the project's BIM scope to avoid the reactive processes that are currently employed:

"...for me the biggest lesson learnt is trying to get that scope nailed right at the start and getting the senior people who define that scope educated into what they're signing up to...." [Regional BIM Manager, Architect]

There is consensus amongst the interviewees over the need for sincere buy-in to the underlying principles of BIM to give the BIM Team the support and authority they require to navigate through the barriers associated with the current organisational structure. This is difficult when the processes and practices that they are trying to implement have no obvious immediate effect on profit maximisation making it hard to convince users and decision-makers of the benefit of their implementation without some understanding of the change management requirements.

As such, there is no drive to implement a change management initiative to restructure business units or change existing design processes, particularly within the Civils

department previously mentioned. The structure of this department has meant that the anticipated changes to the design culture and processes have not happened as a result of people thinking that BIM is software based since it is only the CAD technicians that are engaging with BIM and then only as a drafting tool:

"...we haven't used the Revit design functionality.

...that hasn't happened principally because the people who are doing Revit designs are former CAD people so they're not switched onto design in the first place and they're not seeing it from a design point of view and our designers are still designing however they designed." [CAD Manager, Civil Engineer]

With regard to the existing procedures for project setup within the same department the interviewee commented on the flexibility of their application and the lack of an authoritative protocol:

"...we have work procedures written internally to tell you how to set up projects. They don't tell you how to set up projects. They advise you how to set up projects. So project managers therefore don't pay a lot of attention to it." [CAD Manager, Civil Engineer]

Consequently, a number of arbitrary folder structures exist that impede design processes and produce duplications and unmanaged data. Despite there being a drive and a need for a structured approach from a managerial level higher up at a Business Management System level procedures are written to compensate for a variety of working procedures. As a result, conflict between operational requirements at project-level and the standard business operating procedures at a higher level exists, which individuals who have the power and influence to prevent any changes to normal operating procedures perpetuate.

These issues come back to the difficulties of trying to implement BIM at project-level within an organisation that is essentially made up of a number of smaller organisations, each with different localised procedures that are impossible to change without top-level support. At the user level BIM team members struggle with the attitudes of staff that do not understand the benefits and are consequently reluctant to change their working methodologies. This is made worse by the support from profit-orientated senior managers who see BIM from a technologically deterministic perspective that concedes it must be an issue with the software, and since targets must be hit users are permitted to revert to traditional methods:

"...it's the attitude of the actual users themselves...."

"...sometimes those people will blame the software and it's believed by the management because sometimes they don't necessarily know any better...and they are trying to hit deadlines and trying to...hit their monthly numbers, and they will push it in a certain way." [Regional BIM Manager, Architect]

One interviewee commented on the miscommunication between the BIM Team and the board of directors and the interpretation of what BIM is and what is required strategically, highlighting this as a contributing factor to poor implementation

"... the two groups were looking at it differently and people flagged up that perhaps that was because the senior management only look at it one way and don't have that, even at a high level understanding of what BIM methodologies and processes are so that they can understand why the [BIM Team] is making the requests they're making..." [BIM Team Coordinator, Consultancy Team]

This problem is perpetuated by the performance data that is used to communicate the progress of the implementation initiative, in a dashboard format, to the board of directors. The dashboard consists of the collective project data from all areas of the business engaged in BIM covering four areas of profit, productivity, sales and staff retention: metrics that are instrumentally rational and prevent meaningful discussion around process improvement strategy.

"...they were looking at it in terms of rather than technically the BIM processes they were just looking at it in terms of is it going to be of benefit to the company." [BIM Team Coordinator, Consultancy Team]

The issues raised within the interviews appear to be an interdependent set of factors that affect project success from both top-down and bottom-up.

Resource allocation

From a technology perspective Company A do not appear to have had any significant barriers in terms of availability; hardware and software has been readily available, as has training. However, throughout the interviews, a significant issue around knowledge and information exchange between cost centres and regions is apparent and this is as result of the organisational structure:

"...it's based on cost centres, the business structure, and each cost centre lives or dies by its own profit and loss account, and its cash flow; it means that there is a lot of internal competition, and it also means that the cost centre politics gets in the way of actually achieving our goals." [IPD Strategist, Architect]

The existence of the BIM Team and the licensing and consultancy agreement become obsolete when the level of the implementation initiative extends beyond the existing organisational operating procedures and normal project setup. Training credits and consultancy services cost nothing in terms of money, however the time it takes to use them is charged to a project. For example, one interviewee discussed the issues with trying to implement BIM on a project when the financing of training and learning new processes is tied up in the normal budget and targets of business as usual. They cannot charge extra time to the project because they very quickly find themselves over budget and in many instances unable to complete the project using the BIM processes and methodologies they initially aspired to use.

"...if you book that to the project the project is over margin before you even start. And then it's almost like 'what's the point?' you're trying to do BIM when it's becoming a money loss. You know, it doesn't work...you need to take the work more now in your own time for the project let alone to learn things." [Designer, Civil Engineer]

These issues exist within the BIM Team itself at an individual level where members are responsible for regions that include a number of disciplines. They are expert in their own disciplines but are also expected to roll out BIM in other areas when they have other roles to complete at the same time:

"...I can cover the architectural side really easily because it's where my background is but when I'm trying to cover M&E, Structures, Civils it's different, it just needs someone else involved in it really to try and cover that side off." [Regional BIM Manager, Architect]

With reference to the effectiveness of the BIM team, many interviewees suggested the need for a more centrally led implementation team to "drive consistency". A select few of the team members who are most advanced in their implementation of BIM are

in high demand across the business to share knowledge and provide assistance but because of the dual roles they now have to fulfil they lack the time to be able to do so. One reason for this is that the BIM Team is not a separate initiative operating outside of normal business procedures, and, as result, project pressures within their own business units become the priority:

"Yeah I mean they obviously spent a fair few quid on the partnership deal but then didn't put, I don't think, the people in place with the resource because they relied on people from cost centres but those people were controlled by their cost centre."

"It should have been a lot better, a lot more resourced." [Project Manager, Civil Engineer]

"Yeah as I could say there's been a lot of outputs but not a lot of outcomes.....I mean lots of training, lots of effort, but not a lot of change." [Regional BIM Manager, Architect]

As one interviewee explained, much of these issues can be attributed to the organisational silos of cost centres:

"There needs to be...a succession plan and infill behind those so that they can be used across the business but whilst you have that in cost centres those cost centres won't release them." [Associate Director, Civil Engineer]

Retention of staff was also a concern associated with the effective resourcing and dissemination of BIM values and skills:

"... we're going to lose them and also if we're not careful others aren't going to learn from them because they're the actual ones still delivering the projects and not mentoring and bringing others through so I think that's something they need to look at." [Associate Director, Civil Engineer]

When asked how the implementation of BIM could be improved all interview participants described a top-level, centrally sourced fund to help make a difference to the way in which resources can be more effectively utilised in implementing BIM across the business:

"... I think it has to be a centrally sourced fund pushing it out because as soon as you send it out to the local cost centres then the first thing that's not spent is that BIM money." [Project Manager, Civil Engineer]

"...I think the only way this will work in terms of our office structure is that the BIM process there's money set aside in the business plan each year to allow for training or self-teaching..." [Designer, Civil Engineer]

All of the interview participants recognise the scale of BIM implementation but are restrained by the organisational structure, which is preventing the effective allocation of time and resource required to embed BIM working methodologies.

Regional differences in implementation support

In contrast to the other accounts of implementing process and technology change, the following interviewee, who is an associate director and profit centre manager, gave a positive account of the transition to a BIM environment:

"BIM came along at an opportune moment really to really drive the need to change the way our IT was setup....neither office did a lot of external work it was mainly for their core clients...That has changed now, as we're five years in we need to build this

business for much more external work and bringing in BIM has forced the issue to move to both offices on to [Company A] systems. It's helped really; this has helped spring a change really in our setup." [Associate Director, Civil Engineer]

At the time of interview, a combination of the restructuring programme, along with the power and influence the interviewee has as a Profit Centre Manager, seemed to have created a favourable context for implementing process improvement. When coupled with the use of a BIM team member who has a specific role as an Integrated Project Delivery Strategist within the architectural discipline the implementation initiative was considered even more successful:

"...I think as far as where we've got to in Oxford I think we've done it the correct way. We had our implementation strategy, we got support to put the BIM Execution Plan in place before the project started, we obtained support from architecture for a consultant to help guide and advise the team to get setup and started and obviously we're using our training and project credits as part of the EBA to deliver support during the early part of the project so I think as far as where we've got to, I mean the support has been really good and I think the issues really for us now are more around the project timescales." [Associate Director, Civil Engineer]

When compared with other accounts across the company this business unit approached the implementation of BIM in-line with much of the literature surrounding best practice. There was a clear understanding throughout that business unit of the impact of BIM on existing practices therefore strategy was developed in consultation with the IT design solutions consultancy, and standardised process and protocol were developed prior to project commencement with assistance from the only member of the BIM Team whose role is defined solely as a strategist. Even though this is an example of success at that particular stage of the implementation process, the interviewee still commented on the difficulty of knowledge sharing from other experts in other disciplines within the BIM Team:

"...there's no sharing, no opportunity to pull other people in from say the M&E team into a regions business to do two weeks of mentoring..." [Associate Director, Civil Engineer]

There is also concern that without a comprehensive strategy that looks at business processes as a whole the value of BIM will only exist on larger projects, despite the potential for its use on smaller projects where standard procedures and protocols make for efficient delivery:

"I think the [BIM Team] isn't successful enough in getting consistent standards across the business, driving consistent process and policy. I think more of that needs to be done."

"...a lot of our smaller projects could be in the 50k to 500k range so you actually might not want to actually knock that project out in the 3D environment unless you can get it working really efficiently.....So our challenge will be....to what level will we drive it down to."

"...you can't leave it to pockets of the business to try and develop it and expect it to come together. It really needs to be driven from the top..." [Associate Director, Civil Engineer]

CONCLUSIONS

Throughout the interviews, the participants were describing the application of BIM as an additional effort to what is already a complicated process. There is tension between existing processes and practices and those that are required to deliver a project in a collaborative and coordinated environment. In this instance the application of BIM as a system to a project was used as a lens through which to examine the inefficiencies of the organisation that already exist and to effectively allocate resources for the purposes of process improvement.

Findings indicated that the organisational context determines the configuration of technology, process and actors within a BIM system and as such, the realisation of the benefits and ROI of a project utilising the system is dependent on these precursory conditions. The successful process improvement initiatives carried out within Company A are a success despite the wider implementation strategy rather than because of it. The interview findings are analogous to the difficulties described in the literature; pockets of expertise and varying levels of power and influence making an even diffusion of BIM capabilities across the organisation difficult to realise. This is an inevitable outcome when the rationality behind resource allocation is based on BIM as a technology rather than BIM as a new collaborative practice requiring effective change management.

Much of the existing literature surrounding BIM implementation is focussed at project-level. But when discussing the difficulties and successes of BIM within Company A the comments almost always resulted in a discussion around the conflict between business objectives focussed on profit, the processes in place to support that, and the investment of time and resource required to implement and manage the changes in process for the purposes of utilising BIM. Therefore, an examination of the process of producing and holding together configurations of different actors, processes and technologies is perhaps a more beneficial contribution to the understanding of the dynamics of BIM in construction, and also in the measurement and realisation of the associated benefits.

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CONSTRUCTION SITE BIM REQUIREMENTS

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Construction are characterized by some overall requirements (e.g. quality, expected time and cost compliance, productivity, profitability, workers' health and safety) to be satisfied. The necessary process to fulfil these requirements should start from the construction site design phase. The aim of the research is the implementation of construction site information in BIM models in order to support the execution phase design since the early stages of the project. These information concern, among the others, the choice optimization of site plants and equipment (i.e. construction site facilities), during the design phase. For this purpose, the creation of a BIM database of construction site facilities is needed. Each record of the database has thus to discharge a panel of BIM construction site requirements, each of them characterized by a set of physical and operational parameters whose relationships with project information lead the choices of the site designer. The methodology for the identification of these kind of BIM requirements has followed these steps: (i) definition of a set of information characterizing building elements/materials from a construction site point of view; (ii) construction site facilities identification and classification; (iii) first investigation in order to assess which is the adequate detail level of site plants and equipment graphic representation in order to create the above mentioned database. A case history is presented in order to show how BIM is useful for construction site designers to optimize their work, sharing information with the other figures involved in the construction process.

Keywords: BIM, information management, design optimization.

INTRODUCTION

Construction site design can play a strategic role if it starts from the early stages of the project since its requirements need to be satisfied both from the client point of view and the contractor (Chan 1999). In addition, many studies and experiences related to the use of Building Information Modelling (BIM) support the thesis that BIM method for construction site design and management can help the players of construction process to satisfy those requirements. Particularly, the wide options provided by the so-called Field-BIM allow, if properly developed, a significant increase of the quality of the whole manufacturing process, reducing time and costs (Ciribini 2012). This thinking is shared by other researchers whom describe BIM as a method to link in a better way designers and contractors (Harty 2010) in order to improve quality. Some other studies on times and costs evaluation have been carried out using 5D model able to drive cost control measures with work programme (Haque 2007). Other site aspects already taken into account are the production of safety plan using BIM (Zhang 2013) or "*falling prevention plan*" consisting in the insertion in the model of prevention and protection devices for workers safety, assuring a better hazard visualization through

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the use of 4D models. (Sulankivi 2010). Some safety information have been furthermore added into BIM (Sulankivi 2013) in order to check automatically some safety rules (e.g. automatic control of falling risk and need of falling protection guardrail). Significant trends are also carried out by international administrations, that propose guidelines concerning construction site standard using BIM. An example is the Finland CoBIM standards in which is present a specific file about safety plans.

This brief literary review shows an undeniable attention of researchers to the issue of construction site management using BIM, but at the same time is possible to perceive a lack of attention to construction site design issues. Literature, in fact, focuses a lot on 4D scheduling and planning of construction sequences and on the visualization of site layout planning, safety planning and fall prevention planning without a definite design method.

Therefore, our research objective is to investigate the use of BIM in construction site design, focusing on construction site production elements (e.g. excavator, concrete mixer, et.) BIM requirements. Our goal is to cast light on the relation between the building model and its construction site, mainly in terms of construction players collaboration and information sharing between models, therefore postulating the need of a proper Construction Site Information Model (Co.S.I.M.) for each project.

OPERATIONAL INFORMATION MANAGEMENT

Usually, designers collect information on building elements and components oriented to their technical requirement performance. Nevertheless, those information contain operational information as well. On the same time, site production elements are characterized by a number of operational parameters (e.g. fork-lift max load) addressed to match building elements operational requirements (e.g. brick pallet weight). The two set of information are affected by project context criticalities that drive the final design choices (e.g. slab load bearing capacity). Each set of information can be incorporated in a nD model, creating the well-known BIM model and the postulated Co.S.I.M. . Figure 1 shows the relation between the above mentioned information typology set.

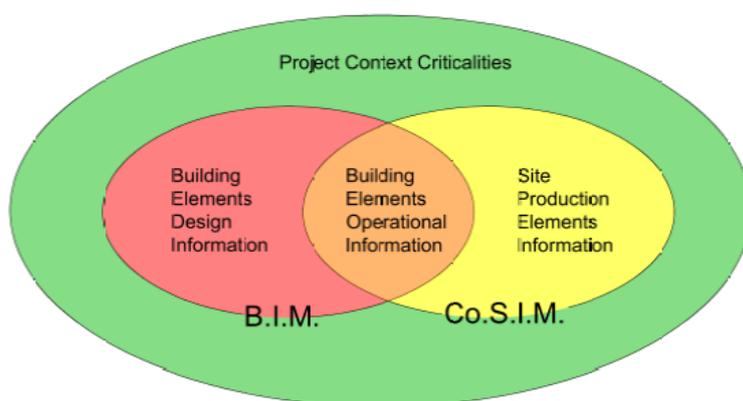


Figure 1: Information set relationship in construction

Since the starting point of construction site design is the operational analysis, it is necessary to follow a systematic approach in order to find out and extract, within design documents, any information necessary to make choices about the site. The operational information of building elements/materials have thus to be examined along their five life stages on a construction site as follow (Di Melchiorre 2005):

- Procurement: set of information about the provision of each element on construction site (e.g. dimension and type of packaging of products, etc.)
- Stockpiling: set of information about the temporary placement of a specific product on construction site (e.g. restraint mode, max overlay, etc.)
- Handling: set of information about moving a product on construction site (e.g. product weight, product fastening, etc.)
- Provision: set of information about modifications or adjustment of the product (e.g. preliminary cutting, folding, etc.)
- Laying: set of information about the final installation of a product (e.g. scaffolding, electric plant, etc.)

These information allow site designer to define construction site needs in term of the construction site facilities to be used in order to guarantee the correct performance of the product life stages on construction site.

The critical information related to the context have to be searched, instead, within the principal characteristics of construction site area (Turchini, G. et. Al. 2007) such as:

- Available spaces: characteristics strictly related to dimensions of the spaces usable for construction activities.
- Surface features: characteristic of technological-architectural, urban and naturalistic pre-existences
- Aerial restriction: characteristic related to aerial handling constraints such as plant networks
- Soil and underground features: characteristic related to the soil and floor and to the presence of underground plants
- Interference with other activities

The environmental condition analysis of the site area above described, can address designer choices in term of site elements properties, beyond the needs of the building elements/materials, and properly ensure a careful site layout and a detailed study of each phase of the work. (Trani 2012)

Starting from a first selected panel of site production elements, our study went on setting, for each one, an open list of "*work oriented*" requirements aimed to identify their operational potentiality, useful to be compared with building elements operational information as well as site context information. The following list provides an example of some requirements.

- Accessibility: requirement of the site element to enter/to be carried and move across construction site areas (e.g. dimension of truck)
- Stay: requirement of the site element to stay/be stored in specific construction site areas (e.g. weight of the element)
- Installation: requirement of the site element to be prepared for work in term of placement in operational area and connection to site plants (e.g. dimension of the element in working phase)
- Usability: requirement of the site element to need specific spaces surrounding for its use
- Productivity: requirement of the site element to conduct his function in a specific way

Next table provides an example of one record of the database of site production elements (i.e. mobile crane) in order to show how to manage its requirements

performance on a construction site, applying its characteristics operational data. Particularly, in the last column, the table shows the relationship between the mobile crane characteristics, the site situation and the building elements, giving therefore information to address the choice of crane performance needed.

Table 1: Mobile crane requirements, characteristics and possible operational relationships

Requirement	Characteristics	Relationships
Accessibility	Dimension	Compatibility with the dimension of construction site gates and roads
	Turning radius	
Stay	Rest dimension	Compatibility with the dimension of storage area
	Weight	Compatibility with the load capacity of storage area
Installation	Operational dimension (open outriggers and counterweigh)	Compatibility with the dimension of working area
	Operational lifting capacity on outriggers	Compatibility with the load capacity of storage area
Usability	Additional space needs over physical dimension	Compatibility with the dimension of working area
Productivity	Boom radius	Compatibility with position of building element
	Height under hook block	Compatibility with height of building element
	Load diagram	Compatibility with weight of the element

BIM SITE PRODUCTION ELEMENTS

As it is known, BIM is principally based on an *"object oriented"* methodology of design characterized by the digital representation of the physical and functional characteristics of the building. The research of information within building and context elements is, obviously, simplified by the use of this methodology that allows to have in a unique box both graphically, numerical and/or textual data. Thus, construction site designer can query the model to reach all information needed instead of research *"by hand"* in different type of design documents. The real time interoperability offered by BIM technology allows also a more simplified way to obtain design update. The information contained in the design *"object oriented"* model (e.g. dimensional parameters, weights, supply unit quantity, etc.) can be transformed into operational information, setting a *"work oriented"* model that help construction site designer in the choice of site equipment.

This is the starting point for the development of a database of site production elements made up by a series of BIM objects characterized by their proper standard requirements, as the example showed in table 1.

The same object (i.e. mobile crane), is studied in function of the graphical and informative detail level chosen for a specific project phase .

In the tender phase, when construction site designers make the first choices about site equipment to be used in the execution phase, the object must be characterized by flexible information in order to fit possible changes of the project until its conclusion.

For this reason, in this stage is better to create a simplified but more flexible model in order to fit simply continuous design update. The characteristic inserted represent in this stage a guide number (i.e. a range, a maximum or minimum) that assures the satisfaction of requirements. The exact characteristic will be given in the execution

phase in which parameters have to satisfy guidelines of those given in the tender phase. Figure 2 shows the flexible characteristic of the mobile crane to be used in the tender phase and an example of a BIM representation of a real mobile crane that fits all the requirements given by the first one.

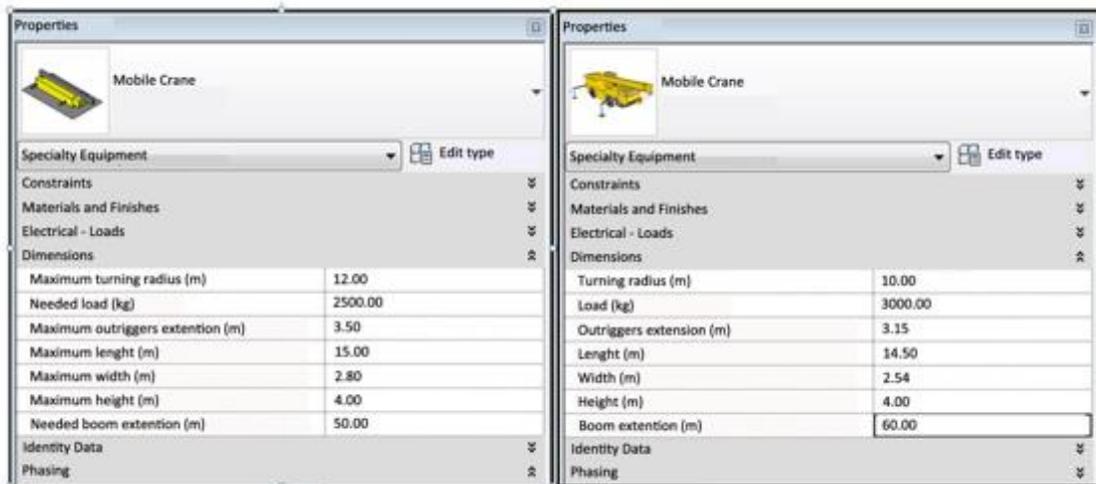


Figure2: Parameters of a BIM mobile crane for the tender and the execution phase

The following case history shows the use of this object in a real construction site during the tender phase, highlighting in particular the relation of the parameters of construction site object in function of the information obtained by design model that guide, then, the choice of the real machine used.

CASE HISTORY

The case history consists in a metal carpentry assembly for a restoration site of a building tower located in the centre of Milan. The metal carpentry is designed to support the scaffold that will be used for the façade restoration. The most difficult work phase of the carpentry assembly is characterized by the biggest steel beam of the project and the worst condition in term of spaces and constraints.

Table 2 shows the information of the steel beam used for the choice of the mobile crane requirements and how to achieve these information in the model.

Table 2: Steel beam information useful for mobile crane choice

Information	Value	Achievement of the information
Type	HEB 600	Structural design
Length	12 m	Structural design
Height	0.6 m	Structural design
Weight	2,5 t	Calculation from linear weight and length from structural design
Position	Graphical	Structural design
Lifting height ⁵	9 m	Calculation from lashing angle and length

As explained, the characteristic of the equipment must be related with some area information in particular for ensure the absence of interferences for the workplace.

Table 3, similarly to table 2, shows area data obtained from the design model. Information obtained graphically led to a visual comparison at the moment of

insertion of the crane and determined its dimensions in function of the minimum distance needed to avoid interferences.

Table 3: Area information useful for mobile crane choice

Information	Value	Achievement of the information
Dimension of available area for installation	14 m x 6 m	Graphically
Aerial restrictions present in working area	Part of the building Street light	Graphically
Surface restriction	Bike parking Underground station Altitude gap	Graphically

Tables 2 and 3 summarize a set of information to be related to the flexible parameters inserted in the site object. Thus, when the object is inserted in construction site model these information represent some constraints that the crane have to satisfy by its requirements

Hence, according to the dimension of the available area of installation, mobile crane must be maximum 12 m length (considering at least 1 m on each side to allow pedestrian way around the crane for workers). The angle and extension of the boom has been decided in function of the position of the beam and the lifting height and has permitted to verify (by checking the load diagram with the weight of the beam) if the dimension obtained was correct or if it was necessary to find another solution. Figure 3 shows the final solution with all the parameters requirements to satisfy the need to assembly metal carpentry elements in that conditions. The mobile crane selected by construction firm during execution phase matches all the parameters requested.

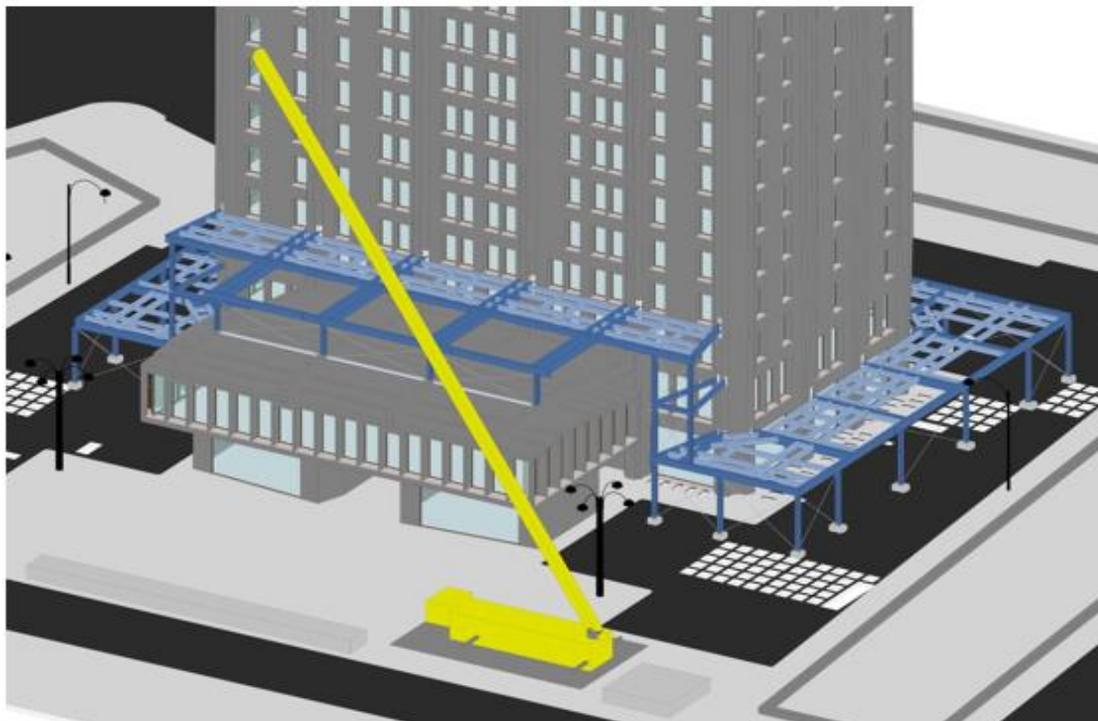


Figure 3: Insertion of the mobile crane into the model

EVALUATION OF THE METHOD

In order to evaluate the possible improvement of Co.S.I.M, a questionnaire concerning the use of BIM for construction site design were proposed to a number of about 100 Italian professionals expert in construction site but, in general, not in BIM use. The questionnaire proposed, in a clarity and practicality perspective, consists of 15 quick questions and 1 final open question with the ability to write any comments or suggestions regarding the topics. The questionnaire is very simple and easy to be compiled in about ten minutes in order to avoid waste of time of the survey sample. The questionnaire, divided into two sections begins with the fateful question, "*Do you know what is BIM?*". The first section has the objective, through a simplified explanation of the BIM concept for those who answer "*NO*", to get a first opinion about its applicability and usefulness on construction site.

The second section, made after a brief explanation of the method proposed, consists of 5 multiple choice questions whose purpose is to understand BIM key benefits combined with the applicability on the construction site. The questionnaire ends with a registry part is made deliberately in conclusion in order to understand what is the opinion of the respondents according to their occupation, their age and their construction experiences . In particular, this part has allowed us to be able to divide the different opinions from those who works for the company (i.e. employers, H&S managers and assistants, site managers, construction site supervisors and who work for client side (i.e. designers, Safety coordinators and Construction supervisors). Finally the last question allows the compiler to freely express his own opinion on the proposed themes also giving any suggestions on the proposed topic and to create possible ideas for future improvements. It happened that some professionals who did not know before the BIM, once they understood at a glance what it is, they seemed very interested to know in detail and, maybe to apply it into their work in the future.

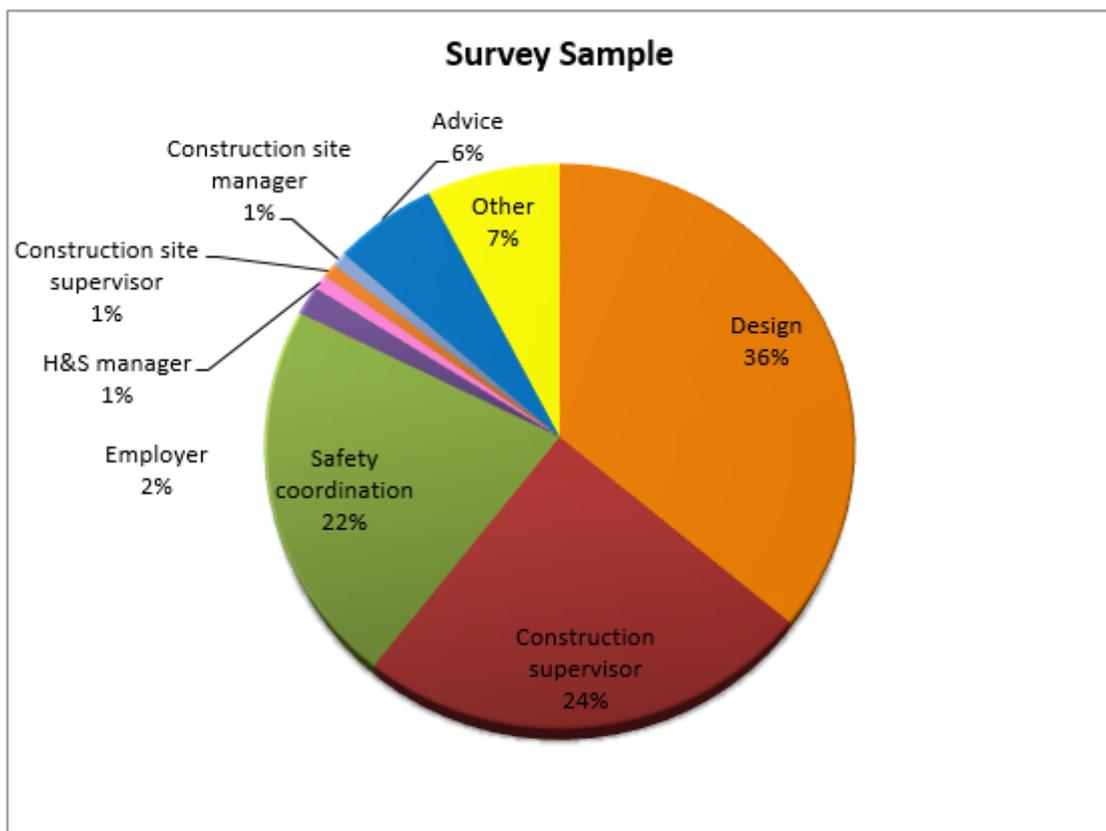


Figure 4: Survey sample

The results of the first part of questionnaire show good results about general use of BIM and also for the management of construction site, but only about the 50% thought that it can improve workers' safety. The results of the second part of questionnaire shows, instead, that a lot of interviewed thinks that this approach can really improve some site aspect like site plan production, scheduling, risk assessment and preparation of safety procedures for workers.

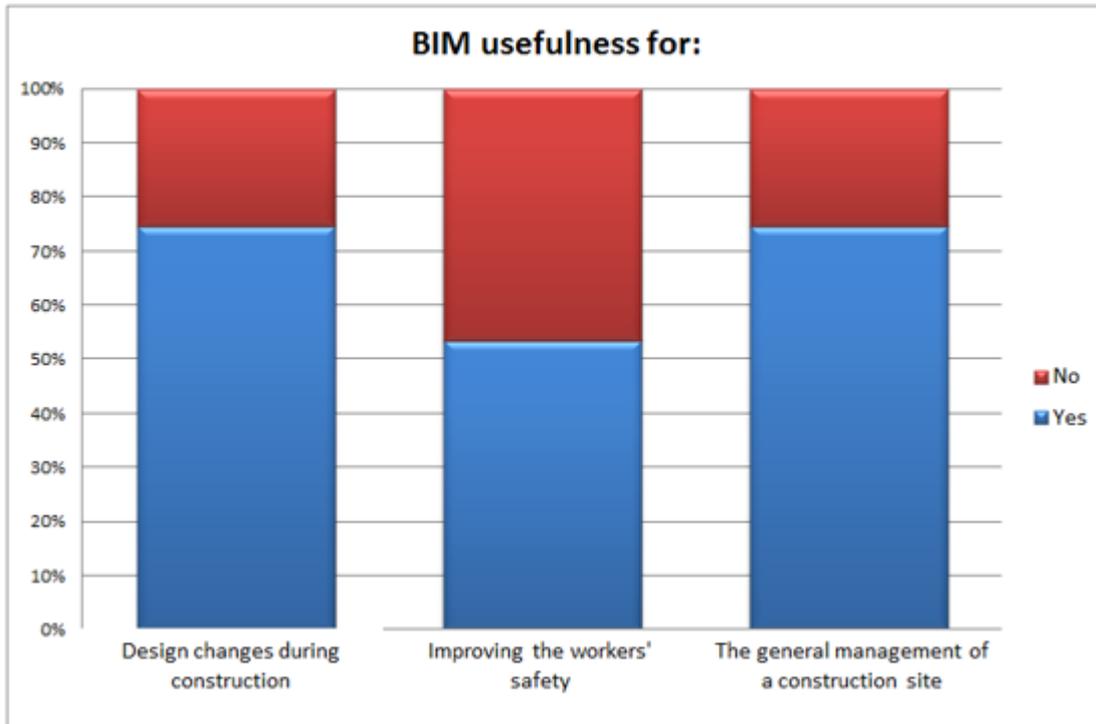


Figure 5: Results of first section of questionnaire

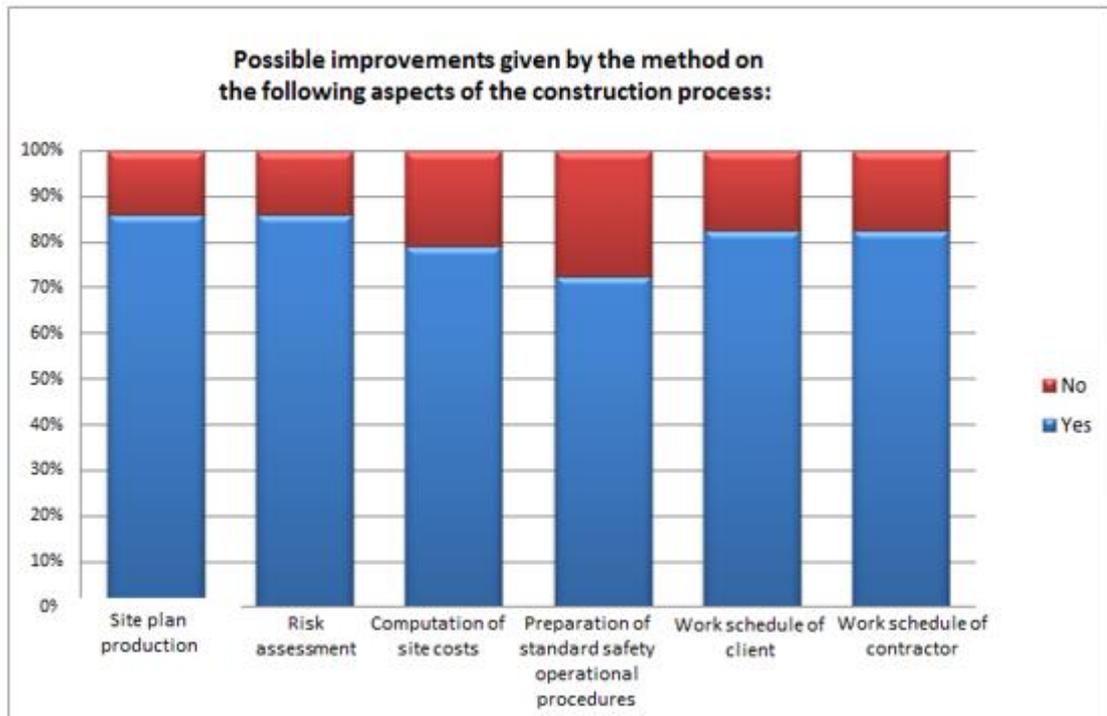


Figure 6: Results of second section of questionnaire

CONCLUSIONS

Optimization means, as well, the satisfaction as much as possible of the overall needs of a construction site such as productivity, time, cost and safety of workers. Since the strategic role of construction site design for a successful project it needs to be supported by a methodological approach. Since its quick diffusion, BIM can be the way to implement this approach. The implementation of the construction site design for its integration in a BIM design process is still long. It starts from the three dimensional design of the site phases thanks to 4D application. Other aspects were studied, like the visualization of single workplaces in order to study in detail safety aspects and, thus find a way to communicate these issues to workers in order to better ensure their proper safety. In order to achieve a better integration between construction site design and other disciplines a good information management must be ensured. As showed, construction site designer need a specific set of information related to each object of the model that he has to take into consideration and these information must be related to the elements that he has to put into construction site plan. Thus, the need to develop a standard database arose. On one way, there is the need to classify all the construction site information that construction site designer can squeeze from the project in order to guarantee a more complete and speedy availability of useful operational data. On the other side, there is the need of the availability of a wide range of elements typical of construction site whose characteristics can be related to the information achieved. The implementation process of these database is very long since the difficulty to find flexible parameters for each different type of element (handling machine, earthworks machines, scaffolding, protection system, small equipment). The final aim is to make the work of construction site designer faster and of high-quality. The development of a complete database can bring, then, the research to study the use of advanced method to check automatically the relationships between information and warn if there are some

criticalities to be solved. These methods are searched among clash detection and model checking instruments which will be studied specifically for construction site needs.

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THE IMPLEMENTATION AND USE OF 4D BIM AND VIRTUAL CONSTRUCTION

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The 2013 UK Government construction strategy, presented at its 'Construction Summit' set targets for 50% faster project delivery and reductions in the overall delivery time for new build and refurbished assets. Despite the best efforts of constructors, who have considerable in house experience, skills and knowledge in project delivery, more than half of all UK construction projects exceed their agreed time schedules; with current data revealing the worst performance for 12 years. The concurrent drive for all centrally procured public construction projects to be working at BIM Level 2 by 2016 is seen as an important step in improving the quality of project information, which, in turn, should result in improvements in project predictability, including predictability of both time and cost. The current research investigates how contracting organisations have adapted their existing practices to utilize BIM and improve project delivery. As part of the work a quantitative survey was undertaken that focused upon the current use of virtual construction. Results show a high level of BIM awareness and a more limited degree of experience of using virtual construction practices to improve construction planning. There was, however, a generally high level of recognition of the potential value of 4D planning. With additional data, the study will investigate whether potential benefits of 4D planning are being actualised, as well as exploring associations between the extent and nature of its use and characteristics of the user organisations.

Keywords: 4D planning, building information modelling (BIM), construction planning, construction scheduling, virtual construction.

INTRODUCTION

Lean processes and new technologies including Building Information Modelling (BIM) have regularly been proposed for tackling the construction industry's production problems. In order for such initiatives to succeed, the industry must continually measure its own performance and act upon the results, something it has, in part, achieved by the widespread adoption of Key Performance Indicators (KPIs). Currently, however, more than half of UK construction projects exceed their agreed time schedules; 'time predictability' KPIs for 2102 are the worst in 12 years (see Table 1, below) with only 34% of projects being delivered on time overall and only 42% of construction phases completing on time (Constructing Excellence 2012).

Crotty (2012) has highlighted 'poor predictability' to be one of the 'first order issues' facing the construction industry; poor quality project information to be its primary cause; and the use of BIM, mandated for all centrally procured public construction projects by 2016, to be an important step in improving this situation.

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Table 1: Construction time predictability for years 2007 - 2012 -percentage of projects and phases delivered on time or better. Table adapted from *Constructing Excellence* (2012)

KPI	2007	2008	2009	2010	2011	2012
Predictability Time: Project	58	45	45	43	45	34
Predictability Time : Design	58	58	53	69	51	48
Predictability Time: Construction	65	58	59	57	60	42

Since the announcement of the 'BIM mandate' in its 2011 Construction Strategy (HM Government, 2011) there has been a large volume of work published on aspects of BIM implementation. The specific aim of the present study is to investigate the extent to which contractors are using 'alternative' BIM-based methods of planning construction work. The following discussion briefly considers key aspects of conventional construction planning then focuses on 4D BIM.

Conventional construction planning

Cooke and Williams (2009) see the planning process as involving: gathering information (including establishing key dates and constraints); identifying key activities and events; assessing of durations; establishing logic and sequence; and presenting the plan in a suitable medium.

Historically, the key elements of the construction plan were activities, durations, sequence and timescale, communicated on the earliest (circa 1910) hand drawn programmes. The introduction of networks in the 1950's allowed logic links to be established, and use of the critical path method (CPM) allowed critical tasks and float to be determined. From the 1980s, the use of construction planning and scheduling software enabled the planner to use the bar chart format - preferable to many over the network view - to make explicit logical relationships, float and task criticality. Using CPM software also enabled project progress to be recorded, delays to be identified, and the impact of resources and costs to be clearly communicated. Criticisms of these conventional methods of presentation included their failure to take necessary account of spatial and location-based aspects when activities are sequenced: the formats used to communicate the plan are independent from the building design and addressing the spatial aspects is left to the experience and intuition of the individual planner (Winch and North 2006). Others criticise the fact that project control frequently overshadows action planning, and scheduling is overemphasised at the expense of methods planning (Laufer and Tucker 1987; Faniran *et al.* 1994).

Building Information Modelling and 4D virtual construction

Koo and Fischer (2000) have argued that the addition of a 'fourth dimension' (i.e. time) to a 3D-model could be useful for project and construction management. Subsequent work has employed a range of terminology, including: 4D CAD (Koo and Fischer 2000; Heesom and Mahdjoubi 2004); 4D-Modeling (Buchmann-Slorup and Andersson 2010); 4D Planning and Scheduling (Rischmoller and Alarcón 2002); 4D Simulation (Heesom and Mahdjoubi 2002; Tulke and Hanff 2007); 4D site management model or 4DSMM, (Chau *et al.* 2005a; Chau *et al.* 2005b) and 4D Technology (Wang *et al.* 2004; Hu *et al.* 2008). Amidst this terminological variety it is clear that 4D planning involves linking a time schedule to a 3D-model to improve construction planning techniques through:

- visualisation of the time and space relationships of construction activities (Liston *et al.* 2001; Heesom and Mahdjoubi 2002; Buchmann-Slorup and Andersson 2010);
- analysing the construction schedule to assess its implementation (Koo and Fischer, 2000);
- reducing errors through plan interrogation/validation, simultaneously improving communication between project team members (Dawood, 2010).

The origins of 4D can be traced back to the late 1980s in a collaboration between Bechtel and Hitachi Ltd (Rischmoller and Alarcón 2002) and to the work of Fischer and associates from Stanford University who created the original technique for producing visual 4D models (Dawood and Mallasi, 2006). Over time, technology has advanced. Whereas earlier versions simply made use of 3D 'dumb' design in design software and allowed for the incorporation of time associations, dedicated virtual construction (VC) tools now enable the incorporation of multiple models and schedule data to link intelligent objects to individual resource-loaded and logic-linked activities.

The functionality of the planning process may be improved in a number of ways through the use of 4D. These include: the ability to gather information from a coordinated project information repository; improved ability to identify activities through model interrogation; and calculation of durations using automated quantity extraction processes. These enhancements should enable the planner to produce more accurate schedules and more effectively communicate aspects of the plan (including construction methods and sequence, directing the plan recipient toward the exact location of work content, and the impacts of resource movement and site logistics). Hazardous activities can also be emphasised.

Chau *et al.* (2003) have identified the inputs necessary for a 4D model as follows:

29. a 3D geometric model with building components and operational objects;
30. a construction programme (with activity data, durations, logical relationships) ;
31. a central processor in the form of a 4D simulation tool that allows the linking of the 3D model and the programme data.

Tulke and Hanff (2007) provide a detailed description of the process (and the challenges) of importing and linking the separate 3D model and programme data before defining the visual parameters of how and when objects appear in a 4D simulation.

The interaction of BIM and Lean

Along with performance measurement and prior to BIM, one of the more prominent process improvement efforts championed within the construction research community was that of lean principles and concepts applied to project delivery. There have been several significant successes in improving the time predictability of construction projects using approaches such as the 'Last Planner System' and 'Lean Project Delivery System' as promoted by the Lean Construction Institute. Furthermore, Sacks *et al.* (2010) have recognised potential synergies between Lean and BIM and proposed 56 distinct interactions as opportunities for further research. Seven of these interactions were incorporated into the design of the current research (see Table 2, below).

Table 2: Lean/BIM interactions and current research questions

Interaction description (adapted from Sacks et al., 2010)	Interaction	Question
Building complexity - BIM simplifies the task of understanding designs, helping construction planners deal with complex products	3	23, 28, 32
Automated task generation for planning helps avoid human errors such as omission of tasks or work stages.	14	32
Discrete event simulation used to test and improve production processes and to run virtual first-run studies which are often impractical	15	31, 33
Animations of production or installation sequences can be prepared. These guide workers in how to perform work ensuring standardized procedures	17	31, 32
Discrete event simulation can reveal uneven work allocations and support assessment of work assignments to level production	37	38
4D sequences provide opportunities to visualize construction processes, identify resource time & space conflicts for optimization	40	28, 29
Visualization of proposed schedules and visualization of ongoing processes verify and validate process information	47	31, 32

RESEARCH METHODOLOGY AND FINDINGS

The target population of the study were those involved in the delivery of construction projects, including those who provide professional design and management services. A questionnaire survey was considered to be an appropriate means of data collection for this study. A structured questionnaire was developed and distributed direct to 321 randomly selected construction professionals between July 2013 and March 2014. A total of 122 full responses were received, giving a response rate of 38%. An additional 39 partial responses were received although these were excluded from analysis due to their incompleteness.

The first section of the questionnaire required the respondents to provide information about their industry profile, and consisted of general demographic questions over company size in terms of number of employees and annual turnover. The respondents were to provide detail as to the total number and value of any projects they had been associated with that had incorporated BIM in any capacity. Section 2 focused upon issues around BIM implementation including adoption timescale and maturity of their own company and wider industry, along with any implementation strategies demonstrated by their own company. This section required respondents to rank external barriers to BIM adoption, internal factors that influenced implementation, and its benefits. The third section focused upon 4D planning, virtual construction (VC) and the virtual construction environment (VCE). This section required respondents to identify how their companies had used any elements of VC and VCE and compare 4D planning and new methods of working afforded by BIM with conventional planning. Only a selection of the findings is presented in this paper due to space constraints.

Findings

In terms of job function (Q3), the highest proportion (46%) of respondents was, appropriately, 'Planners'. In Q8, 55% of the respondents identified themselves as working for large companies, (250+ employees) with 25% working for a small company (1-49 employees) and the remaining 20% for medium-size enterprises. In Q9 the largest percentage (25%) gave their firm's turnover as 'over £500 million per year'. In Q12, 55% of the respondents indicated that they had been involved in 1-5 BIM projects and 7% that they had been involved in 6 to 10 projects. Interestingly 3% of

respondents reported an involvement with 50+ BIM projects, and in response to a separate question (Q13), 16% indicated that the approximate total value of the BIM projects that they had been involved in was over £100 million(s); though 26% reported that they had not worked on any project using BIM 'in any capacity'.

Section 2 revealed details about if and how the respondent's organisation was implementing BIM. A majority (64%) confirmed that their company had started implementing BIM (Q15), and 22% they were 'planning to'. Most respondents (61%) thought the government 2016 target to be 'realistic' (Q16). In Q17, 50% assessed their companies' BIM maturity at Level I, and 30% at Level II. A majority of respondents (62%) predicted that by 2016 their company would meet the Level II requirements (Q19) with 19% believing that they would be in the Level III category.

A concern the industry faces in the implementation of any new initiative is overcoming cultural barriers to its acceptance. For Q18, which addressed this, Alarcon and Conte's list of 'critical organisational elements' (Alarcon and Conte, 2003, cited in Johansen *et al*, 2004) was used (see Figure 1, below).

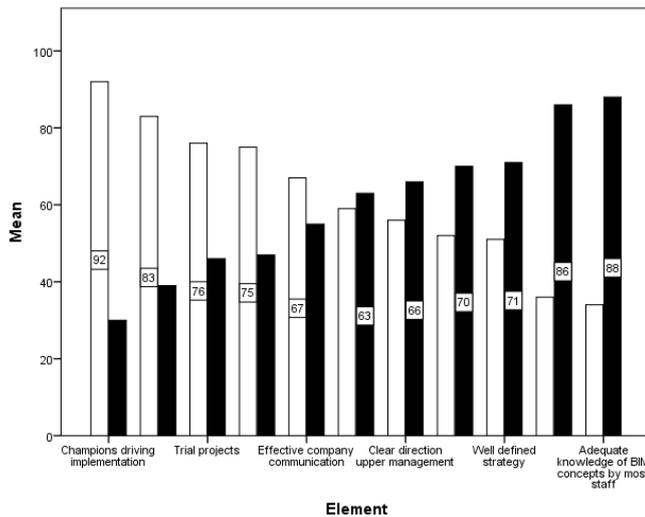


Figure 1: In terms of BIM implementation would you agree (white bins) or disagree (black bins) that your company has the following elements. Highest counts only shown

Highest scoring 'agreement' categories include 'key personnel or champions driving implementation' (75%; n = 92), 'high commitment from upper management' (68%; n = 83), and 'special task force driving implementation' (62%; n = 75). Highest scoring 'disagreement' categories were 'a lack of adequate knowledge of BIM concepts' (72%; n=88) or 'BIM implementation efforts' (71%; n = 86) from staff at the same level as the respondent. Despite high levels of management commitment indicated, there are many who believe their company does not have 'well-defined implementation strategy' (58%; n = 71); that there is 'no clear direction from upper management' (54%; n = 66); the company 'does not have a clear methodology' (54%; n = 66) and does not 'effectively communicate lessons learned throughout the company' (57%; n = 70).

In Q20 respondents were provided with a list of 8 'external barriers' to BIM implementation identified from the literature, and were asked to place these barriers in order. Using a weighted calculation (items ranked first valued higher than following ranks), the result show 'the fragmented nature of the industry' itself (649) as the most important issue, with 'time and commercial pressures' (625), 'culture and human issues' (623), a 'lack of adequate BIM awareness and understanding' (619) and 'the

structure of procurements and contracts' (601) grouped closely as the next most important reasons. Respondents ranked 'lack of leadership' (474) and issues around education and training (404) as less important with 'lack of proof of performance from measurement systems' (397) ranked as the lowest external barrier. Qualitative comments were also sought regarding further external barriers, and responses demonstrated a preoccupation with client issues. These included,

"Unclear benefits for Client, the majority of the benefit lie with the contractor."

"Clients not understanding that they need to define what they want from BIM and how they want it using on a project."

"Feel that generally, projects that will implement BIM will be driven by Clients who want to be market leaders and not by contractors or design teams."

"There is still a lack of client demand for principal contractors to implement BIM..."

"Lack of client awareness ... and mentality that a traditional BOQ project is cheapest"

In Q22 respondents were asked to rank, in order of importance, the three aspects of organizational infrastructure as identified by Sacks *et al.* (2010). The intention was to determine the real internal challenges to BIM implementation. Using the weighted calculation the respondents scored 'people issues' (272) as being the most significant internal challenge followed by 'process issues' (251), then 'technology issues' (209). Using the same method, Q23 asked respondents to rank the broad order of BIM benefits. 'Improvements in communication and collaboration' scored highest (305) with 'improvements in product (asset) modelling' scoring (214) and 'process modelling and analysis' scoring almost equally (213).

Section 3 of the survey specifically focused on the use of 4D and VC techniques. In Q27, respondents were asked to confirm any use of VC within their company. It was confirmed by 53% of respondents that their company had used elements of VC on live projects, with a further 14% reporting that their company had investigated its use but not yet used any elements on live projects. A further 21% answered that the company had not used it before and 12% were unsure. Q28 asked respondents to confirm use of VC within the categories shown in Figure 2 (below).

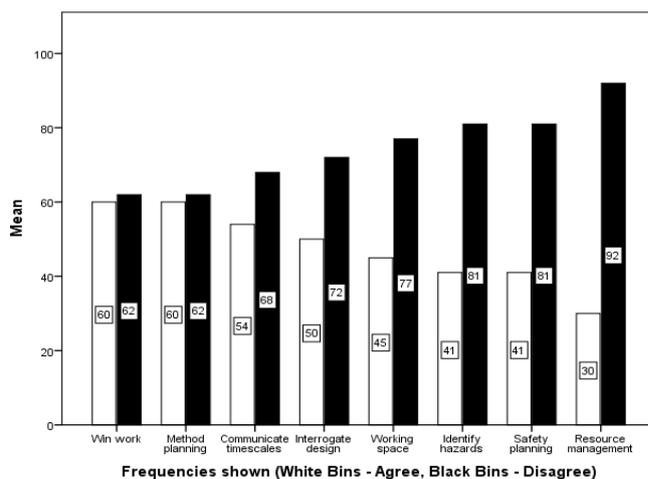


Figure 2: Categories of VC use.

Figure 2 shows that whilst all categories score higher in terms of negative responses nearly half of all respondents are aware that VC had been used in their organisation to help work winning activities and to assist in the planning of construction methods.

Both categories showed 49% (n = 60) as 'agree'. In Q29, respondents were asked to confirm any use of a Virtual Construction Environment (VCE) for site layout planning within the categories shown in Figure 3 (below).

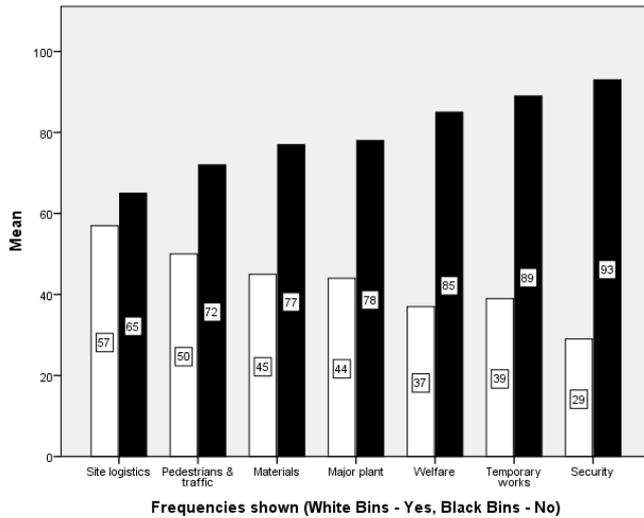


Figure 3: Categories of Virtual Construction Environment (VCE) for site layout planning

As previously, all categories scored higher negative counts for 'use of the virtual construction environment', but nearly half of all respondents were aware that the VCE had been used in their organisation to plan site logistics (47%; n = 57), and in 'pedestrian and traffic management planning' (41%; n = 50).

In Q30 respondents were asked the value that 4D planning would add to their business. As shown in Figure 4 (below), most respondents agreed that 4D planning would add value to their business: as indicated in Figure 4, the mean and median scores were 3.79 and 4.00 respectively.

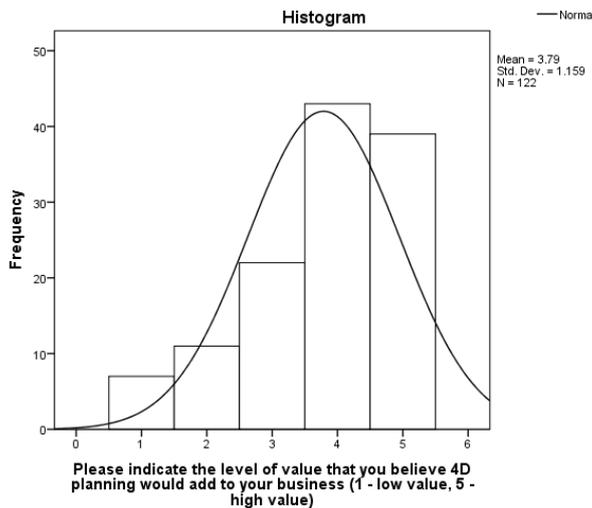


Figure 4: Value of 4D planning

Further comments were on project complexities, sector inefficiencies, and work winning/schedule validation; examples being:

"... [it's] for sufficiently complex projects, with sufficiently ambitious goals"

"Only...sector which has not improved in efficiency and productivity is the construction industry....slow at adopting digital tools that allowed others...to progress"

"... schedule validation before construction starts can help to reduce ... risk, avoid unforeseen costs such as those associated with having to dismantle plant, help with crane planning etc., and helps improve ... decisions made early in the design phase"

"There isn't a big difference between selling/convincing mode and testing/validating mode. Just the audience"

In Q31 respondents were asked to rate how 4D planning may offer improvements over traditional planning processes in a prescribed number of aspects of the planning process. The responses, graded between '4D can offer significant improvement' and 'Traditional planning [is] better' are shown in Figure 5, below.

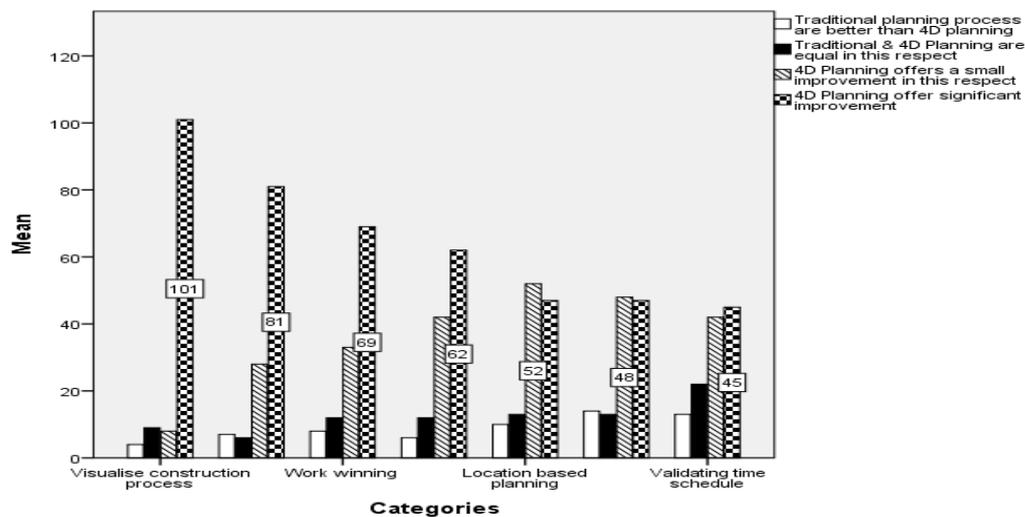


Figure 5: Traditional planning process versus 4D planning processes, highest counts shown.

Despite high negative responses received for questions 28 and 29, this question clearly shows that in nearly every category, respondents thought that 4D planning offered significant improvements over traditional planning processes.

The highest-scoring category was visualising construction processes (83%; n = 101), and understanding construction processes (66%; n = 81). The two categories where respondents believed that 4D planning processes offered small improvements against traditional planning processes were in location based planning (43%; n = 52) and progress reporting (39%; n = 48). Traditional planning processes scored low across each category.

In Q32, respondents reported how new methods of working may offer improvements over traditional methods at each stage of the planning process, using the same available response options and the results of this question are shown in Figure 6 below.

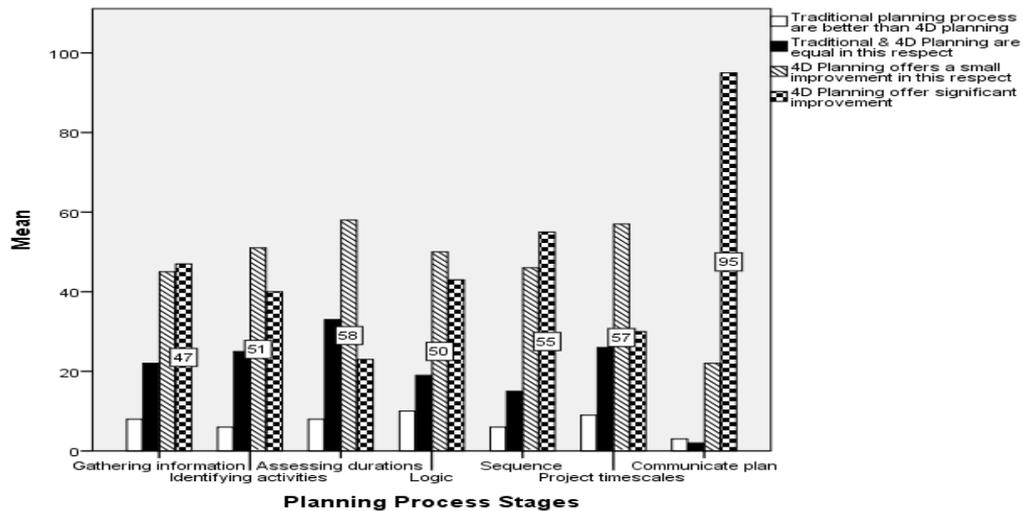


Figure 6: Traditional methods versus new methods of working: stages of the planning process

The highest-scoring area of benefit that new methods of working were seen to offer was in 'communicating the plan' (78%; n = 95). Two areas where new methods did not seem to score particularly well were in 'assessing durations' and 'communicating project timescales'. The final two questions (33 and 34) were to determine the extent to which the respondents' company has used VC in both the method planning and time scheduling. Although the most frequent response was that companies had not used VC for these elements, companies that have used VC have used it primarily to communicate methods (36%) and timescales (25%).

CONCLUSIONS

Results indicate a high level of BIM awareness and some experience of use of VC, particularly for work winning, methods planning, and the visualisation and validation of construction processes. The study as it stands shows a general recognition of the value of 4D planning, the extent of its use, and what elements of planning are its principal targets. It provides an up-to-date and informed view of drivers and barriers.

With additional data, analysis will be extended in a number of directions. Firstly, the likely response rate would permit inferential statistical analysis to explore the associations between the extent and nature of 4D planning use and the characteristics of the user organisations. Secondly, the suggestion by Dawood and Mallasi (2006) and Dawood (2010) that 4D planning can help reduce scheduling errors and improve communication between project team members, can be tested, as can other assertions from the literature regarding its greater efficiency and effectiveness over traditional methods. Ultimately, the work will consider whether the potential benefits of 4D planning are being actualised, as well as exploring their extent.

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PERCEIVING SPACE FROM MULTIPLE PERSPECTIVES FOR BUILDINGS USING BIM

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The way that space is being perceived during the building design stage affects the way it is delivered. This becomes more complex when considering not only the geometric view of space, but also the building as a whole with all its uses. It is recognised that different users have different needs particularly as regards their use of space. It is proposed that building information modelling (BIM) can accommodate different perspectives on space held by the building design team, facility management team and building occupants. This paper investigates various views on the way that space is perceived from different perspectives. Data have been attained from a university building under construction in the United Kingdom using interviews with the building design team, and questionnaires with the facility management team and building occupants. The collected data demonstrate the complexity of space including the effect of 2D and 3D views on perceptions. The paper concludes with highlighting these different perspectives emphasizing the need for collaboration. Further work is needed to explore different space algorithms, which can accommodate these different perspectives in the BIM model. The paper provides an initial basis towards understanding the problematic nature of space from a holistic approach and its implications of the way it is being perceived.

Keywords: building information modelling (BIM), multiple perspectives, space visualisation.

INTRODUCTION

Buildings in their nature are fundamentally complex environments and because of this, it is often claimed that buildings do not perform as anticipated. The way the built environment is perceived can affect the delivery of several aspects within the building (Vischer 2008). Space is considered as one of the complex aspects involved in the core design of buildings. This complexity becomes apparent when looking back at the ambiguous nature of the concept of space (Dovey 2010). There are many aspects within the building that are affected by space such as layout, utilisation and spatial planning. BIM has supported the geometric coordination and visualisation of these aspects through smart object modelling and the integration of different building systems in one single model. However, in keeping with Vischer's (2008) built environment theory, which identifies building use and user as critical design determinants of buildings, a BIM model should serve all stakeholders' needs. Different stakeholders have different requirements and this require multiple perspectives in space perception to be included in BIM environments. BIM model

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can help to identify these different perspectives as it provides a user-friendly tool for collaboration to understand the needs and requirements of different user groups. This paper explores the different perspectives of the building design team (BDT), facility management team (FMT) and building occupants (BOs). Data are collected from FMT and BOs separately by asking them questions about a BIM model of an educational building under construction. Data have also been obtained from BDT using semi-structured interviews. The analysis of this data highlights the different ways in which these groups perceive space, emphasizing the complexity of space.

OVERVIEW ON SPACE COMPLEXITY

Space as a complex aspect

The study of space is complex where form and function of the building plays the main role in determining how space should function, be laid out and utilised. The term 'space' began to emerge in the discipline of architecture by the end of the 19th century with volumetric theories and continued with aesthetic theories (Dovey 2010). In volumetric theories, space is described as 'enclosure space' (Hensel *et al.* 2009) and aesthetic theories describe space as the 'aesthetic effect of architecture on subjects' (Holt-Damant 2005). Ching (2007) has identified several factors that affect the architectural space:

- Function of architectural spaces at different time.
- Amount of human-oriented (ergonomics) characteristics of the building space.
- Method of locating the vital and critical areas in the buildings.
- Independency of the building spaces.
- Density of the building spaces.

In modern architecture, it is claimed by Forty (2000) that space appears to be a homogeneous concept, partly because architects consider space via representations (abstract space) rather than experiencing space by living it (lived space). However, Hensel *et al.* (2009) pointed out that bridging the gap between lived and abstract space will result in another level of complexity, stopping any change from current practice. Therefore, it can be realised that the concept of space is complex and its trans-disciplinary nature increases its complexity.

Space planning in buildings and BIM

Space planning is considered to be one of the initial steps during the preliminary design process of the building (Duffy *et al.* 1976; Autodesk 2013). Guidelines have been developed for various building types such as: educational buildings (Stanford University 2009), office buildings (Duffy *et al.* 1976), hospitals, etc. There are many elements involved in space planning such as flexibility, efficiency and consistency. Furthermore, spaces in a building can be identical, unique or defined based on the client's requirements to perform a particular function. Bitrafan *et al.* (2013) have described space based on functionality where spaces are divided into three different types: flexible spaces, adaptive spaces and single functional space. This distinction between spaces becomes important when methods such as spatial planning take place. Spatial planning is a branch of space planning and can be described as the distribution of human ergonomic arrangement of objects in a space (Douglas 1996). However, the planning of space becomes more complex when all building systems are involved

during the design process, which require an effective tool that can manage these different systems effectively.

BIM has supported the integration of these building systems providing an interdisciplinary data platform where information can be shared, updated or modified. BIM forms a reliable basis for decisions, providing a shared digital representation of physical and functional characteristics of any built object (Volk *et al.* 2014). This has resulted in a more accurate layout of space, effective space utilisation and better space visualisation (Porwal and Hewage 2012). BIM uses parametric modelling and this had led researchers to propose improved design solutions (Eastman *et al.* 2011), which serve a particular need. This is because BIM can manage semantic information on building components and spaces. Jeong and Ban (2011) proposed computational algorithms to evaluate design solutions using Space Syntax based on recognising building information. Li *et al.* (2014) have used BIM models to extract building geometries to support the functionality of an add-on to enhance the accommodation of escape of occupants trapped in building fires.

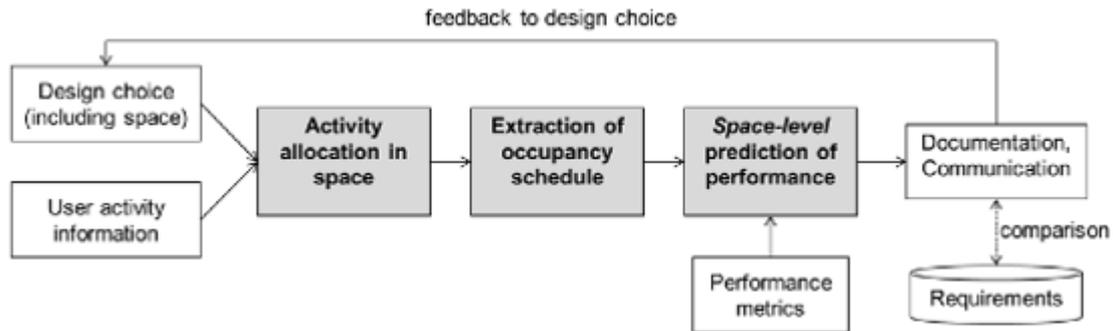
Perceiving space and BIM

Space perception can be composed from the properties and relationships of objects in space with respect to direction, size, distance, and orientation. In an environment, object relations can be described in terms of a Euclidean coordinate system (Richards 1975). The 3D environment provides this Euclidean framework for our perception of spatial relations. Loomis *et al.* (1992) stated that in the study of visual space, it has been assumed that an observer has an internal representation of surrounding physical space, and then attempts to measure the properties of visual space to establish how well various properties of physical space are preserved in the mapping to visual space. The complexity of visual space can be looked at using in-depth psychophysical procedures, but for the purpose of this paper, this depth will not be considered. However, understanding the complexity is important when designing space using BIM.

BIM is suggested to be a collaborative tool where divergent perspectives could be accommodated to achieve better design solutions (Sabot 2008). Currently, 3D and 4D simulation (e.g. Navisworks) using BIM models have enhanced users' understanding of the design allowing a third person view to support users' in obtaining a sense of scale, but this navigation is relatively simplistic (Khemlani 2008). There are some recent research attempts where end-users and facility management teams have been involved. For example, Lee and Ha (2013) have proposed a BIM-based tool for residential buildings to meet different customer needs. The solution proposed a customer interactive building information modelling (CIBIM) tool, which would allow customers to be involved in decision-making. It was found that collaboration using the tool helped to meet customer needs for the optimum use of space. Kim *et al.* (2012) have formalized activity-space-performance relationships to improve the accuracy of space performance analysis (see figure 1). Furthermore, Shen *et al.* (2012) proposed a user activity simulation and evaluation method (UASEM) that aimed to enhance the user's visual experience of the built environment, but did not explore whether such simulations have an impact on improving design solutions. Previous work has therefore researched space from the use and utilisation point of view rather than understanding the way that different parties perceive space. Moreover, understanding these different perceptions from multiple perspectives may contribute

to a more holistic view of space. This research is going to consider how both FMT and BOs perceive space using BIM models.

Figure 1: Proposed Framework to Enhance Accuracy of Space Performance Analysis (Kim et al., 2012)



APPROACH

In a construction project, different stakeholders have different requirements and as the input from these stakeholders is not the same, then this can lead to contradiction during the design. This will also result in different views of space, which is the subject of this research. Multiple perspectives on the way that space is being perceived was explored from the perspectives of the BDT, FMT and BOs on an university building that is currently under construction. Data have been collected using semi-structured interviews with the BDT and open-questionnaires with the FMT and BOs.

From the BDT, three interviews were conducted with the project director, BIM coordinator and building designer (BIM manager). These individuals were selected based on their vital role in space planning and layout. They were involved in the development process of the BIM model and monitored changes that occurred throughout the construction process. Data were collected individually from the BDT using semi-structured interviews to capture a richer image of BDT's view of spaces in buildings. The questions were put in the context of the selected case study (under construction university building) to reflect upon recent experiences with BIM and how it had been utilized in relation to space and its related aspects.

From the FMT, the facility manager and building services supervisor were selected for the study, because these different roles may affect the way they view spaces within buildings. The questionnaires were designed to explore the familiarity of both FMT and BOs with building plans (2D drawings) and space related problems that they have experienced.

A number of building occupants were chosen to participate in the study, which involved showing them a navigation through BIM models using Autodesk Navisworks followed by questionnaires about the experience. It is important to acknowledge the lack of familiarity of both parties (FMT and BOs) with the BIM models, and thus a quick brief was provided to obtain meaningful data.

The purpose behind using interviews for BDT unlike FMT and BOs, where questionnaires were used, is that the BIM model has been developed by the BDT, and thus getting their views on space using interviews would be sufficiently useful to compare it with the way that FMT and BOs see space. It was necessary to navigate FMT and BOs through the BIM model to get their views on different spaces and the way they perceive it. Throughout the navigation process, prompts about different spaces were given because some 3D components did not have an adequate level of

detail and to increase the consistency of the feedback collected from both parties (FMT and BOs).

Table 1: Different Perspectives on Space from BDT, FMT and BOs

	BDT	FMT	BOs
Defining space	Normally confined by the design of the building and defined by four sides with single or multiple accesses and designed to perform a particular function.	An owned area by the client and defined by what facilities are in it.	An environment that allows me to perform a certain task or daily job comfortably.
What is important in a space?	Size, route access, communication and collaboration between staff, thermal comfort, and internal air quality (IAQ).	Number of occupants, movable facilities, and temperature.	Arrangement of objects (facilities), route access, thermal comfort, lighting (sun and artificial).
What are the common issues faced in a space?	Functionality, space layout, space efficiency and facilities layout.	Noise level, ownership of the space, functionality of the space, and maintenance.	Accessibility, privacy, noise level, control of temperature, and flexibility of space.

For the purpose of the paper, a selected space from the case study, which was shown during BIM model navigation to the FMT and BOs, will be used to demonstrate the differences in perception between FMT and BOs. The structured information charts identify the entities and attributes related to that particular space where 2D and 3D views are assigned to them based on the responses from the FMT and BOs. The charts in Figures 2 and 3 present the way that FMT and BOs perceive space.

Figure 2 and Figure 3 interpret the responses from FMT and BOs using entities and attributes based on the responses from FMT and BOs. To demonstrate better understanding of the way that space is being perceived, the research is proposing that a particular space has number of properties, where the hierarchy of these properties is presented as entities and attributes. Each entity/attribute is associated with 2D, 3D or no view reflecting the participants' perceptions.

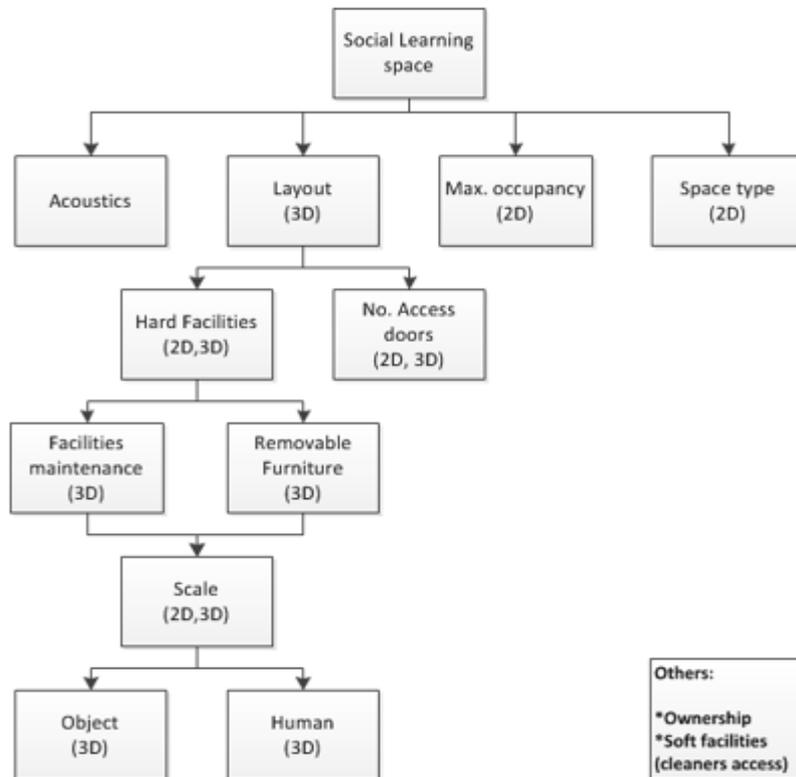


Figure 2: How One of the Spaces from the BIM Model Navigation was Perceived by the FMT.

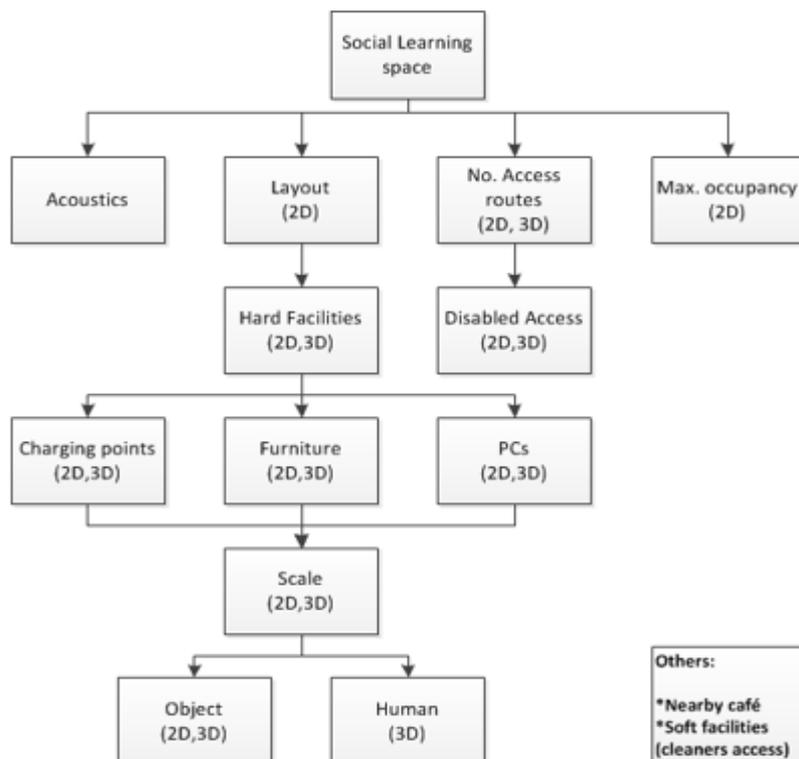


Figure 3: How One of the Spaces from the BIM Model Navigation was Perceived by the BOs

DISCUSSION

The results presented in the previous section have provided an overview of the way space is viewed and perceived from different perspectives. This section discusses how

space is defined and understood by BDT, FMT and BOs in order to gain insight towards understanding the nature of space from multiple perspectives. Differences of how space is perceived in 2D and 3D environments from the FMT and BOs from the above figures are also considered.

Space as a complex aspect

The findings provided in table 1 demonstrated the different views with regards to space in buildings. As expected, the BDT defined space from a geometrical view, where space is described as an enclosure space confined by building components (e.g. walls). The BIM manager (project architect) has emphasized the complexity of space due to his role managing the central BIM model where all building systems are integrated. The project director and BIM coordinator explained that the nature complexity of spaces arise from different requirements from the client, where this becomes problematic when changes occur during the construction process. The FMT, described space as a property whose identity is defined by type of the facilities in it. There are two implicit findings from this definition: first, the FMT's view of space is driven by the management of space in the building, and second the team had limited involvement in the development of BIM models. These findings have many major implications for space design, which need further exploration but are outside the scope of this paper. Lastly, building occupants described space based on their personal needs, which is a sensory response based on their role. However, their definition of space as a 'comfortable workplace' was associated with the other building aspects such as temperature, which supports the literature findings about space and its effect on various building aspects.

The initial findings from these three perspectives have demonstrated that space is yet to have sufficient and clear definition that satisfies different views. One way to simplify this conflict about space is to understand the spatial relationships between the components, which are important to the different stakeholders (Motamedi *et al.* 2014). The use of BIM models should enhance the way of capturing knowledge about these relationships in buildings, which is the case for FMT and BOs. On the other hand, it is also important to acknowledge that terms such as functionality, flexibility and accessibility are complex and influenced by many factors such as policies or building type, but for this paper, they are described within the context of a university building.

Perceiving space in 2D and 3D Environment

Bouchlaghem *et al.* (2005) pointed out that development of 3D modelling has been driven by architectural design. In other words, the shift from 2D to 3D was mainly to allow architects to visualise and immerse themselves in their designs. However, during navigation of the BIM model in this study, both 2D and 3D models of the environment were provided to explore the stakeholders' differences in perception. The FMT claimed that they preferred the layout in 3D whilst BOs suggested that it is clearer to represent the layouts in BIM's 2D environment. The FMT stated that the 3D view of layout would allow them to identify the space needed for maintaining the facility(s) in that space. Other authors have used 3D components to visualise the asset condition during construction and operation phase through the use of colour-coding (Hammad and Motamedi 2007).

The occupants also preferred the 2D view for route finding in and out of the space as well to identify their own workplace. Although it may logically seem that occupants are more likely to understand 3D environments more easily (Smith and Tardif 2009), findings from this research showed that they preferred to see aspects such as layout in

a 2D environment. In addition, some space related aspects from BOs' perspective such as occupancy level cannot be currently represented in a 3D environment. Although 3D avatars have been claimed to improve the users' understanding of space and activities (Shen *et al.* 2012), this research shows that understanding the scale aspect for both FMT and BOs was problematic and contradictory in terms of the way they referred to it. This was critical for the FMT when referring to what facilities are fixed or removable where this could only be visualised effectively in 3D environment. The BOs had many queries with regards to human to object scale, as they wanted to see the space in use. This can be somewhat contradictory to what BIM is supposed to provide in terms of clarity and visualisation as a virtual reality (VR) environment but highlights the needs of BOs.

To sum up, the representation of spaces through their entities and attributes (figure 2 and figure 3) will support the BDT in terms of understanding different requirements by FMT and BOs. This needs to be incorporated in the way space is being modelled using BIM models during the design stage. It also promotes collaboration at an early design stage (Choi *et al.* 2013) with facility managers and end-users to obtain more efficient design solutions.

CONCLUSIONS

BIM provides a good visualisation of space, but the way space is perceived from different perspectives can be contradictory and problematic. The literature has identified several efforts by researchers to optimise design solutions for space. In addition, it was emphasized how BIM played an important role in terms of visualising the space and use of semantic information to enhance spaces in buildings. The use of BIM to facilitate the different perspectives on the way that space is perceived will allow the involvement of the participants (FMT and BOs), which will gain a richer design of spaces in buildings. The analysis of these different perspectives may provide a means to re-establish the social aspects of space and to consider it as a heterogeneous concept, which is influenced by the interdisciplinary world of involved stakeholders. This can also have a positive impact on space performance of the building, which can serve different needs. The mystery of 2D and 3D in terms of their contribution to solve needs and address the requirements for stakeholders needs further research. This research suggests that 3D is not the only way to solve built environment complexities related to the perceptions of space.

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BIM'S IMPACT ON THE PROJECT MANAGER

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Building Information Modelling (BIM) has been drawing increasing attention since the announcement by the UK government in 2010 that BIM will become compulsory for all major centrally procured government construction projects by 2016. Not only is BIM an innovative design tool, it may fundamentally change the way how a construction project will be procured, constructed, managed and maintained. This paper examines the new challenges faced by project managers who play a central role in a construction project and the inevitable adaptations needed to work in a BIM environment. Based on an extensive literature review, semi-structured interviews were conducted with project managers who have had BIM project experience. This research found that although it has indeed started to impact on the construction industry as a whole and on the projects themselves, BIM's impact on the project manager and the project performance is actually far less substantial than expected. BIM is still at a relatively early stage of development in the UK and even though it represents a new way of undertaking a project, it is not necessarily changing the way a project is currently managed. In addition, BIM is advancing very fast and yet few companies have directly and fully supported the project managers and none was found to have updated the governance and/or project management process. Furthermore, many of the project managers simply are underprepared and not exploiting BIM to anywhere near its full potential, which is leading to missed opportunities. It is recommended that the industry needs to learn to embrace the full potential of BIM across all project team members. The resistance to change should be identified and managed more effectively to achieve a successful BIM implementation.

Keywords: BIM, project manager, adaptation, change.

BIM AND THE PROJECT MANAGER

The UK construction industry is facing increasing pressure with regards to Building Information Modelling (BIM) following the announcement in September 2010 by Paul Morrell, chief construction advisor for the UK government, that by 2016 all major centrally procured government construction projects must use Level 2 BIM (Rawlinson, 2013). This government strategy is regarded as a key catalyst to the momentum towards BIM (Davidson, 2013) because the UK government currently procures around 30% of the overall construction industry output and thus represents a substantial client to construction industry (HM Government, 2013). Many UK construction firms are already finding that both public and private sector clients are seeking to use BIM well in advance of 2016 due to the amount of benefits that it can bring to a project. As a result, the pace of adoption is increasing substantially throughout the industry (Malone, 2013).

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BIM has been in existence for far longer than people realise. The first notion of virtual buildings came about in the 1970's (Eastman and Teicholz, 2011) and it really came to the forefront of thinking when the term 'Building Information Modelling' was used in a paper by Van Nederveen and Tolman in 1992. Moving the development further was a white paper aptly titled "*Building Information Modelling*" by Autodesk in 2003 (who also introduced the acronym "*BIM*"). However, to define BIM is problematic as no single agreed definition of BIM seems to exist. Some authors tend to look mainly at the technological elements of 3D modelling (Smith and Tardiff, 2008; Lewis, 2012), whereas others appear to concentrate mainly on the organisational transformation and integrated project delivery (Eastman and Teicholz, 2011; FM and Beyond, 2011; O'Grady, 2013). Regardless of this, what BIM requires is that all project team members can access and work on a single collaborative design from a single centralised information pool. Therefore, BIM is far more than a simple transition to 3D modelling (offered by the likes of Autodesk Revit and Bentley Structural) but represents a change to the way projects are undertaken and managed as the fundamental issues of the business process and workflows have also changed (Smith and Tardiff, 2008). BIM is a socio-technical system which requires centralised commitment from the companies involved along with substantial organisational changes. It is as much about people and the processes as it is about technological elements (Harty *et al.*, 2010; Martin, 2012). Therefore, BIM will have a profound impact on participants involved in a construction project.

Literature (Construction Executive, 2013; Mott McDonald, 2013; RICS 2013) is conclusive in agreeing that BIM can bring multiple benefits to project management, as summarised in Table 1 below. But BIM does come with some reported disadvantages, the most prominent of which are the initial software outlay costs, software interoperability, the level of training required and legal issues surrounding design liability (Hardin, 2009; Olatunji, 2011; Jenkins, 2013).

Table 1 Potential Benefits of BIM to Project Management

Potential BIM Benefits to Project Management	Rationale
Project programme and budget control	A BIM model can instantly update both the programme and budget when modifications are made to the design.
Design team collaboration	A BIM model can enable the impact of changes to be fully analysed and thus the scope can be monitored to enable the PM to liaise easily with the design team and clients.
Subcontractor control	Increased knowledge on clash detection changes, information requests etc. results in sub-contractor work becoming more predictable.
Request for Information (RFI) and change orders	The increased certainty brought about by BIM should result in a marked reduction in the number of changes and RFI's.
Progress monitoring	By utilising BIM, the PM has more tools available to understand and report on progress.
Client understanding	The client can understand a virtual model far easier than a 2D drawing, thus increasing understanding and satisfaction about the end product.

Project closure	BIM captures O&M information which can be used throughout the life of the building. This also saves significantly on administration costs as well as on-going management.
Mandatory BIM and growth	As clients increasingly request BIM, the PM firm can become skilled and grow faster than competitors.

The Project Manager (PM) is a key player because he/she is ultimately responsible for the successful delivery of a project through managing a multitude of factors such as cost, time, quality, sustainability and safety in a project's lifecycle from initiation to completion (PMI, 2013). Meredith *et al* (1995) identified five key skill areas which a PM needs to have: ability to communicate, team building, leadership, coping and technology. Katz (1991) advocated just three key skills areas: personal relationships, conceptualisation skills and technology skills. However, more importantly, the PM needs to be able to adapt and has a high degree of versatility (Oz and Sosik, 2000) as he/she has to work on different projects in differing environments with different resources (Keller, 2001). And BIM is the latest change a PM is facing.

There are some researches on how BIM may change the project team and their roles in a construction project. For example, because BIM can hold a vast amount of information such as specification properties, resource, programme activities, quantities and costs, it may take only 30 minutes now under BIM for a QS to measure a building rather than the normal two days in the traditional way (Rendall, 2011). But this automation is no substitute for using a Quantity Surveyor (QS) with experience, especially when it comes to looking at the interpretation, details and omissions. As a result, the QS will certainly have to adapt accordingly to a more consultancy role (Hamil, 2012). Another possible change is the introduction of a BIM manager to provide professional support to a project, apply the standards and advise on technology and overall coordination (Howard and Bjork, 2008). The traits a BIM Manager must have resemble those a PM must also have, such as knowledge of the industry, project interface, stakeholder empathy, communication and leadership (CICRP, 2009; Reinhardt and Lanzetti, 2011). A BIM Manager should also develop plans which ensure the project deliverables are met with the right project team members in place and provide ongoing guidance especially in the decision making process (Kymmell, 2008). These are all activities which are similar to the traditional PM role and thus the PM could take on. However this role is arguably more suited to those who currently undertake a CAD Manager role due to the level of technical and engineering knowledge and the PM being required to oversee the project rather than manage the BIM process (Hamil, 2012; Jenkins, 2013).

But there is very little research from a PM perspective and on how a PM's role may change in a BIM environment so far. One could argue that the output is still the same as well as the core job role and BIM is no more onerous for the PM to adapt to as working under a different contract, or perhaps working in a different country, but this is far from certain. Therefore, this paper aims to investigate the impact of BIM on PM and how the PM profession can adapt to this change at both the organisational and individual level. Based on a semi-structured interview with practicing PM who have had BIM project experience, this paper will present a snap shot of the current situation of BIM implementation in PM. Conclusions and recommendations on how PM can effectively adapt to BIM will be made through critical analysis and discussion.

RESEARCH DESIGN

This research took a qualitative approach because BIM is still a relatively new practice in the UK construction industry and it would be very difficult to secure a large number of PMs with BIM project experience for a quantitative research. A semi-structured interview has been chosen because with a basic template, it can not only ensure consistency and ease of analysis, but also allow deviance to explore new lines of questioning so that the complexity and subtlety involved can be fully explored and generate rich and in-depth data.

In total, seven interviews were carried out in the summer 2013 with practitioners from five different consultancy companies in the West Midlands, UK, of which five were PMs and two were Regional or Associate Directors (see Table 2 below). Each participant had managed between 1-3 BIM projects at the time of the interview, and each interview lasted between 30-50 minutes. All the interviews were recorded to ensure the interviewees had all the attention and were not distracted by the note taking. This also allows for playback later to create transcripts to ensure nothing has been missed. A copy of the transcript was offered to each interviewee for proof reading to ensure points are captured accurately. The interview questions started with their roles and practice in managing their projects, and then moved to how BIM brought changes (if any) to their daily job, and how they and their organisation adapted these changes.

Table 2 Interviewee details

Interviewee 1	Assistant Project Manager	3 years in the industry
Interviewee 2	Project Manager	10 years in the industry
Interviewee 3	Project Manager	5 years in the industry
Interviewee 4	Project Manager	15 years in the industry
Interviewee 5	Senior Project Manager	15 years in the industry
Interviewee 6	Associate Director	40 years in the industry
Interviewee 7	Regional Director	25 years in the industry

RESULTS

In this section, the key results from the interviews are summarised and presented.

Does BIM actually bring a change?

Compared to the traditional projects, the interviewees did feel some benefits from BIM. For example, the 3D model can detect design clashes, and the client and stakeholders find BIM very useful in order to visualise the end product, as Interviewee 3 stated:

“The model is fantastic, it really is. It creates buzz and the clients love it”.

Interviewee 2 particularly praised the ability of BIM in handover as he detailed example of where in a previous project they had shelves of Operation and Maintenance (O&M) manuals, whereas now it is all built in, so the quality of this element has certainly been improved. Interviewee 1 gave an example of the efficiencies of BIM on QS's that a bill of quantities would take only 4 hours with BIM instead of the previous 4 weeks.

However, all the interviewees found very little real changes in a BIM project from a PM perspective, as explained by Interviewee 4:

“(BIM) may have changed a project but not the way you manage things.”

In terms of project specific issues, such as requests for information and change control, many people stated that they hadn't noticed any difference. As for the project performance in cost, time and quality, not a single interviewee stated that it directly improved any of these elements. On the contrary, Interviewee 1 found that BIM was actually a disadvantage as the lack of collaborative working meant version control was lost which made it (time and quality performance) worse. He gave an example where items were drawn in 2D AutoCAD first and then were passed to the others to put into BIM, effectively doubling up the workload. This is because everyone still worked separately, as pointed out by Interviewee 3:

“BIM in theory should be about everyone getting together but I didn't find it to be the case. The engineers and designers still worked in isolation”.

Although all the interviewees agreed communication is a primary role of PM, no one said that communication changed for the better or worse as a result of using BIM, indirectly or directly. Interview 3 stated:

“In theory I guess communication should improve as everyone talks to everyone. But in reality this didn't really change much.”

But they do expect a wider impact once BIM is fully developed / established.

How can PM adapt BIM?

Most of the interviewees stated that their respective firms have a centralised BIM strategy and often a working or steering group, but generally this failed to resonate at a project level. They expressed concerns and dissatisfaction with the company support they have received, which is highlighted in Interviewee 1's comments:

“the organisation hasn't supported me so I need to learn as I go”.

This was concurred by Interviewee 3:

“...apart from getting a lot of information about BIM, (the company guidelines) didn't help me figure out how to approach and manage a BIM job”.

Interviewee 6 felt that BIM needed to be *“introduced sooner”* in order to have time to adapt.

Most interviewees realised the importance of experience and knowing all about BIM. Interviewee 5 said he would encourage his PM team to go to webinars, speak to peers and engage with the steering group. Interviewee 6 also believed that investment in people's abilities is needed now otherwise you will be left behind. Interviewee 7 was similar in the people element, which is unsurprising considering the seniority, but really felt passionate as

“no one in the business was ready or trained for it....thus needs to be trained how to manage it in conjunction with our governance”.

Another issue raised in the interview is that the corporate management system. It defines the parameters in which project managers can operate, and it must be adhered to, or risk professional misconduct. It is also used to audit the project performance. But this corporate management system has not been updated to incorporate the BIM element.

As for the resistance to change, they reported a generation gap because it seems that the younger generation pick it up easily and go with it fast, while the older generation have a general fear of new technology and the risk of being replaced by machines.

How can the industry adapt BIM?

There was an agreement that the construction industry is slow in adopting change, as reflected in Interviewee 2's comments:

"The industry has always been slow to change unless it has been imposed on it".

Everyone was also in agreement that BIM was good for the industry overall, if not necessarily unified agreement that it benefited at a project level at the moment. Many of them are very enthusiastic about BIM, as stated by Interviewee 4:

"I absolutely love BIM, I love technology and I can see it's the way forward".

However, as Interviewee 5 contrasted:

"No one in the team really drove it. I think the architect should have done but they didn't really. It's hard when people work for different companies of course!"

The 2016 deadline was mentioned by many, and they thought this target helped to focus people's mind, and this mandatory change can bring benefits to the industry as a whole. There is also a sense of urgency among the practitioners, as demonstrated in Interviewee 6's comments:

"In terms of the wider industry, well, BIM is coming in 2016 whether they like it or not."

Some interviewees cited examples where the enthusiasm of clients drove BIM forward but none stated that the engineering/design team did. It is clear that the thought of integrated project delivery (IPD) being a key driver to make things happen is not being realised. The general feeling was everyone knew BIM is coming and is a huge issue, but none could actually give any evidence that any form of industry shift was occurring on the ground.

DISCUSSION

Previous researchers such as O'Grady (2013) state that project level change is essential to implementing BIM, yet no interviewee in this research noticed any significant project performance improvement (in cost, time and quality) or how a project was managed. Construction project management has well-structured and widely accepted practices which BIM cannot feasibly change significantly in a short period of time. Therefore, an alignment between the BIM tools and the existing project management practices and corporate business models is needed in order to achieve project performance improvement (Hartmann *et al.*, 2012; Davies and Harty, 2013). Harty *et al.* (2010) and WSP (2013) also contend that sociological changes are required in order to introduce innovations in practice, and this was in fact confirmed by some interviewees but not to the extent expected. This is probably due to the novelty of BIM and the lack of experience, because all the interviewees had only used BIM for the first time in the past 12-18 months, and thus there was an overall sense of finding their feet with regards to projects. It is thus not surprising that the maximum potential of BIM has yet to be extracted. Another explanation could be down to how easily BIM fit into the project or it could be simply that BIM does not help at all. In either instance, it again contradicts the findings from the literature study which

suggested that a drop off would be found (Construction Executive, 2013; RICS 2013; Mott McDonald, 2013). It is recommended to initially implement just certain elements of BIM, ideally those which bring about short-term benefits and have fewer barriers to implement. This staged approach can encourage practitioners to adopt BIM methods as the initial change required is minimal versus the reward (Jacobsson and Linderoth, 2010).

BIM and IPD should be totally interlinked and the communication within the project team can be improved (Korte, 2008; Eaton, 2011; Smith and Tardiff, 2011) but no one could present evidence of a notable shift in this phase of a project. Whether this is as a result of inexperience of the interviewees or a general fact of BIM is hard to judge. But one hypothesis is that consultants usually work under separate contracts and almost always in separate offices. Research shows that while BIM makes visible the connections among project members, it does not foster closer collaboration across different companies (Dossick and Neff, 2010). The physical separation of a project team whose members may come from different departments of a company or from different companies is undoubtedly an issue. And even though the end model may be a collaborative design, the process of getting there is not. For the project management, this does not particularly cause any change as the same issues will still arise no matter what. Undoubtedly, the PM will still have to chase for updates and for deadlines in the same way they do now, and the only real difference will be the deliverables. The introduction of a BIM Manager/Coordinator into the project management team may be a way forward in order to centralise the BIM support.

The results show that although practitioners have generally realised the importance of BIM and the need for training, it seems that the advent of BIM has been faster than the ability of companies to adapt their corporate governance by incorporating BIM into their corporate management system. Many companies are yet to be convinced of the additional cost and the actual benefits of adopting BIM (Li *et al.*, 2009; Barlish and Sullivan, 2012) so they are still at the preliminary stage and only manage to provide some basic facts of what BIM is, not the more practical guidance on how to use BIM to actually manage a project. They have not had a well-thought strategy in place to manage the changes, and it is up to the individuals to invest time and effort in learning and educating themselves about BIM. Jung and Gibson (1999) point out that companies need to have a corporate strategy and management system in place. Without a comprehensive support at the company level, it is questionable how a PM can fully adapt to BIM. No surprise there exists resistance because many felt that BIM has been forced upon people who are simply not ready for it.

This is quite worrying because this shows the industry is far from ready to fully embrace BIM and the changes from it. Preparation is crucial in successful BIM implementation, and the social and organisational contexts need to be taken into consideration when adopting BIM (Taylor, 2007). Any failure to address these from the outset can lead to failure. It is anticipated that with the progress of BIM, practitioners will request more practical guidance and training, and both organisations and individuals have to up their game to truly embrace BIM. On the other hand, PMs have to be flexible and able to adapt as they have to manage different projects under different circumstance such as different forms of contract and different resource restraints, thus BIM can be said to simply be an extension of that need to be flexible as part of the job.

CONCLUSIONS

It has been widely believed that BIM is a change for the construction industry and is here to stay indefinitely. This research did identify some benefits from BIM such as design clash detection, visualisation of the final product and ease for O&M manuals, but did not find any noticeable changes in either the PM practice (e.g. change control) or project performance in terms of cost, time and quality. The impact of BIM is much lower on the day to day project management profession than expected. This could be due to the novelty of BIM and absence of established data and knowledge, and BIM is still yet to be used to its full potential. This may improve when BIM becomes more widely available.

This research also highlighted the lack of preparation for BIM, a large part of which comes down to the lack of organisational support. The corporate governance of many companies has found not to have been updated to incorporate BIM to support the PM drive the project through within the parameters of the company quality systems. Internal training needs to be expanded so that it directly reaches those who will manage a BIM project before the rush to commence a project without adequate preparation.

The construction industry is renowned to be slow to change. It is not surprising that the idea of IPD is not yet manifesting itself at a project level as people are simply not engaged enough and also not exploiting BIM to its full potential. But BIM's arrival is imminent due to the UK government's 2016 target. Whether liking it or not, the industry needs to wake up to BIM and fully embrace it. An improvement in collaboration and integration between the project team members is urgently needed where the PM should be instrumental in driving this.

Due to the relatively small size of the samples from a limited geographical area, this research does not necessarily present a representative picture of BIM in project management profession in the UK construction industry. Instead, it presents a snapshot of the reality at the project and company level, and identifies the problems and barriers faced by PM practitioners when implementing BIM, which can help PMs and other construction practitioners more effectively use BIM to improve their project management practice and project performance.

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THE ROLE OF BIM IN PREVENTING DESIGN ERRORS

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Design errors are claimed to account for 26% of the cost of defects, these in turn are stated to encompass 2-9% of production cost for building and constructions. Lack of knowledge and information has been identified as a major reasons for design errors. Recently Building Information Modelling (BIM) has been considered as a mean for reducing design errors. However, limited research has been conducted on the role of BIM as a means for transfer and sharing knowledge in order to reduce design errors. The aim of the paper is to analyse BIM's role of facilitating knowledge and expertise sharing in order to prevent design errors. The aim is achieved by analysing a case study of design errors in a construction project. By drawing on the concept of boundary object it is confirmed that BIM can serve a mean for preventing design errors by facilitating knowledge and expertise sharing, across discipline, time and space, and professional boundaries. Depending the kind of boundary knowledge and expertise should be shared across, different challenges emerge in organizing the knowledge and expertise sharing

Keywords: design error, BIM, boundary objects, knowledge sharing.

INTRODUCTION

Design errors are claimed to account for 26% of the cost of defects. Cost of defects are in turn stated to encompass 2-9% of production cost for building and constructions (Josephsson and Hammarlund, 1999). The sharing of knowledge and information can be assumed to play a pivotal role for the reduction of design errors, because lack of knowledge and information has been identified as a major reasons for design errors. In their study, Josephsson and Hammarlund (1999) show that design errors were mainly caused by lack of knowledge (44%), lack of motivation (35%), lack of information 18%, and risk and stress (3%).

A variety of approaches and methods for reducing design errors have been suggested, and recently building information modelling (BIM) has been considered as a mean for reducing design errors, for example by automated clash detections and that visualization enhance peoples understanding of what an accomplished building, or construction would look like(see e.g Jongling, 2008). In this sense BIM can play a pivotal role as a mean for transfer and sharing of knowledge and information that has a potential for reducing design errors. However, limited research has been done on the role of BIM as a means for transfer and sharing knowledge and information in general. A few papers have been published on BIM and knowledge, for example BIM in the maintenance stage (Motawa and Almarshad, 2013) and BIM for knowledge sharing by feedback (Ho *et al*, 2013). On the other hand is there a rich body of

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literature on the transfer and sharing of knowledge in project based organizations to draw upon when the role of BIM as a means for transfer and sharing of knowledge should be analysed. In this literature the constraints on ICT's capabilities to capture and codify knowledge have long been recognized (Fahey and Prusak 1998), when taking into consideration the embeddedness of knowledge in organizational systems and processes, and the fact that knowledge is embodied in skills and competencies of groups and individuals (Blacker, 1995). Basically, the problems revolve around the sharing and transfer of explicit, respectively tacit knowledge, and making the tacit knowledge explicit.

In the literature on computer supported cooperative work (CSCW) the idea that tacit knowledge can be made explicit has been criticized (see e.g. Ackerman *et al* 2013). Ackerman *et al* (2013) argue that Nonaka and Takeuchi's (1995) interpretation of Polanyi's (1967) terminology of tacit and explicit knowledge, nurtured the idea that tacit knowledge can be made explicit, which also could be design goals associated with IT tools, but Ackerman *et al* state that the term "*tacit*" exactly describes that certain kind of knowing is difficult, if not impossible to verbalize. Research on CSCW have moved away from the distinction between tacit and explicit when knowledge sharing is discussed and instead used the concepts knowledge sharing and expertise sharing. When knowledge sharing is discussed the externalization of knowledge in the form of computational or information technology artefacts or repositories play an important role. Whereas in expert sharing the capability to get the work done or to solve a problem is instead based on discussions among knowledgeable actors and less significantly supported by a priori externalizations (Pipek *et al.* 2012; Ackerman *et al.* 2002). Against this background the aim of the paper is to analyse BIM's role of facilitating knowledge and expertise sharing in order to prevent design errors.

It should be noted that by using the concepts knowledge- and expertise sharing we follow Ackerman *et al* (2013) who not differentiate between knowledge and information and state that "*We could easily spend several lifetimes teasing the two apart, and colloquial uses are sufficient (as argued in Normark and Randall 2005)*" (Ibid: 562).

THE MANAGEMENT OF KNOWLEDGE IN PROJECT BASED ORGANIZATIONS

The development of knowledge transfer capabilities between projects, or to the permanent organization has been recognized as a critical competence for organizations in order to achieve competitive advantages (Nonaka 1994, Scarborough *et al.* 1999). In the quest for the supporting factors for the management of knowledge, early debates had a tendency to focus on the use of information and communication technologies as means for knowledge transfer between projects (Cole-Gomolski 1997, Finerty 1997). But it is well known that ICT's capabilities constrains the capture and codifying of knowledge (Fahey and Prusak 1998). In order to overcome knowledge transfer barriers, research has recognized a range of interventions taking into consideration the embeddedness of knowledge in organizational systems and processes, or the fact that knowledge is embodied in skills and competencies of groups and individuals (Blacker, 1995). These interventions can be classified along a continuum from cognitive to community models of the management of knowledge (Swan *et al* 1999). In the cognitive models the codification of knowledge and its transfer within the organization is primarily emphasized (Cole-Gomolski 1997). The codification of knowledge takes place e.g. by process-based or documentation-based

debriefing methods where experiences from projects are recorded (see e.g. Schindler and Eppler 2003). However, the assumptions the cognitive approach is built on have been challenged by questioning the bias towards explicit knowledge and possibilities of codifying knowledge and inscribing it into an information system (Spender 1996, Tsoukas 1996). In the community model of knowledge transfer, the focus is on the tacit dimension of knowledge and its embeddedness in social groups (Szulanski 1996). However, there are difficulties in exploiting this knowledge because it is dependent on someone else having shared interpretive schemes that enable the understanding and acceptance of the knowledge (Schwenk 1988). Accordingly, the transfer of the tacit knowledge is dependent on the development of some level of shared interpretive schemes allowing a group to understand and apply another group's knowledge in their own setting (Senge 1990, Weick 1995), and in that way create a community of practice (Brown and Duguid 1991, 2001). In communities of practice the transfer and application of knowledge is very much dependent on the situatedness and context of practice (Pavitt 1984), which causes organizational challenges in a project context where groups are temporally and spatially differentiated, and task focused (see e.g. Bresnen *et al.* 2004). Thus, the organizational challenge lies in working out the organizing of social practices and the alignment of them (Brown and Duguid 2001).

Accordingly, how can we understand affordances BIM provide for organizing a social practices these would facilitate knowledge and expertise sharing? Some authors has labelled BIM as a boundary object (see e.g. Gal *et al.*, 2008; Whyte and Lobo, 2010; Neff *et al.*, 2010). Boundary objects are “*objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them. Boundary objects are objects which are plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites.*” (Star and Griesemer, 1989: 393). Boundary objects act as ‘anchors or bridges, however temporary’ across different groups with different goals, objectives, and purposes (ibid:414). Thus, BIM as a boundary object provides a mechanism for a reciprocal knowledge sharing among professional groups (Whyte and Lobo, 2010). However, several scholars have argued that boundary objects are most effective for collaboration and coordination when they are actual objects – tangible and concrete, but still able to maintain multiple, epistemic definitions so as to be accepted and usable by the groups they are trying to bridge (Carlile 2002; Bechky 2003). They help people work across knowledge boundaries through assisting with the processes of ‘transferring, translating, and transforming’ (Carlile 2004). Neff *et al.* (2010:569) argue that boundary objects are useful when they can produce interpretive flexibility across heterogeneous knowledge boundaries, but BIM and the practices around BIM are not currently producing the socio-technical conditions for this flexibility. Deeply embedded disciplinary thinking is not easily overcome by digital representations of knowledge and that collaboration may be hindered through the exposure of previously implicit distinctions among the team members’ skills and organizational status (ibid). However, in the case referred, the issue is if BIM fail to play the role as a boundary object, or if the deeply embedded disciplinary thinking not allowed BIM to take the role as a boundary object?

In the literature on CSCW, the view on BIM as a boundary object, is classified in the so called repository model, belonging to the first generation of research in CSCW, where management of information is concerned with information as an externalized artifact, or object, although information has to be understood within a social context (Ackerman *et al.*, 2013). The second generation of research has been more people

centric and labelled expert sharing, meaning the capability to get the work done or to solve a problem based on discussions among knowledgeable actors and less significantly supported by a priori externalizations. Emphasis was on finding an appropriate person, and sharing tacit knowledge, including that contextual knowledge that might be required to understand information is critical (ibid). Technologies should support expertise sharing by finding people and locate expertise. Taking this two generations of research into consideration, it can be claimed that BIM could be an object for study when it comes both to repository models, as well as expertise sharing.

METHOD AND CASE DESCRIPTION

In order to achieve the aim of the paper a case study of a construction project has been analyzed. The case is the fifth wing that is an enlargement of one of the university buildings at Jönköping University, Sweden. The building is a five story split level house with a total area of 3000m², containing offices and lecture halls. It was built during 2003 and 2004. The production cost was about 55 million SEK or 5.9 million Euro. The type of contract used was general contract. Both the construction manager and the structural engineer agreed that this project went well and there were no major problems in the project. The structure of the building is prefabricated concrete and the structural engineers used ordinary 2D technique (AutoCAD) in the design of the building.

The case study was conducted in two major phases. In the first phase design errors were detected and categorized. In the second phase the building was modeled by using Tekla-structures (www.tekla.com) in order to be able to investigate if a product-model based technique could be a mean for reducing design errors.

In the first phase data was collected by three sources: drawings, construction deficiency reports, and informal interviews. The drawings were studied to get an understanding of the project and to get a geometrical description and the material of the structure. The type of contract, general contract, made construction deficiency reports available. By studying the construction deficiency reports, the design errors causing some of the deficiency reports could be identified. A number of informal interviews with the construction manager, who was the author of most of the construction deficiency reports, and the structural engineer were also conducted. The purpose of these interviews was to gain a better understanding of some of the deficiencies.

Based on the information gathered, the next step performed was to analyze the construction deficiencies in the following steps:

Design error? Yes/No

If yes:

Participants involved?

Are errors situated where two or more elements meet? (Yes/No)

It was noticed early in the case study that most of the defects reported in the construction deficiency reports were situated where two or more elements met. To confirm this finding it was investigated for each defect if it was situated where two or more elements met.

The design errors were in turn categorized according to which participants that were involved in the design errors. The design errors where the structural engineer was

involved (SE-errors) were investigated further. The reason for choosing design errors related to structural engineering was that one of the authors has a background in structural engineering, which was an advantage in the further investigation of the data.

In the second phase each SE-error was further investigated with help of the developed Tekla model of the building in order to answer the following questions:

Could SE-error be avoided using product-model based CAD-system? Yes/No

Could SE-error be avoided in the next project using feedback? Yes/No

However, the following results should not be interpreted as SE-errors per default are avoided if a product-model based CAD-system and feedback are used in the next project. Instead, the results should be interpreted as option for avoiding SE-errors if a product-model based CAD-system and feedback is used. However, already now it can be realized that options are more or less easy to take advantage of. For example, in this stage it can be assumed it is rather easy to prevent clashes in filed installations by taking advantage of automated clash controls, compared to error prevention that require interactions and expertise exchange among designers. Nevertheless, how options can be explored is discussed in the discussion section.

RESULTS

In total, 185 construction deficiency reports were studied and categorized. 57% (106) of these construction deficiencies were categorized as design errors while 43% were caused by other reasons. The involvement of the different participants in these design errors were:

Architect	19%
Structural engineer	30%
HVAC engineer	68%
Electrical engineer	37%

The HVAC engineer was the designer involved in most of the design errors, 68% (72) and the structural engineer was involved in 30% (32) of the design errors. We will focus on these design errors and they are from now on called SE-errors.

24 (75%) of the 32 SE-errors involved other participants

26 (82%) of the 32 SE-errors were situated where two or more elements met

Thus the very majority of SE-related design errors involves other participants, or situations when two or more elements meet, or both. Below three examples of design errors are presented and these could have been avoided by the use of BIM as a means for visualization and clash detection, and feedback.

First, a partition wall should contain HVAC-installations. These installations have to be transferred through the hollow core to the lower floor. Due to the placement of the partition wall a hole through the hollow core would result in cutting the strand and in turn reduce the resistance of the hollow core (Figure 1). This problem was found on site when the wall had been half built and the HVAC-installations should be put in place. It was decided necessary to move the wall, causing a great amount of extra work and cost. This error could have been avoided by visualization of the design solution.

Second, the combining of the pile foundation and the spread foundation resulted in a very thick concrete section that implied a longer drying time of the concrete (Figure

2). Even if heating hoses was embedded in the concrete the drying time became longer than expected, resulting in a delay of laying a plastic carpet. This could have been avoided if feed-back had been available, informing that a plastic film could have been placed between the pile foundation and the spread foundation. See also figure 4.

Third, the architect had designed the attachment of in-fill walls in the same mode in the whole building, but the SE-had designed two different solution at different floors, where one of the solutions were directly in-appropriate (Figure 3).

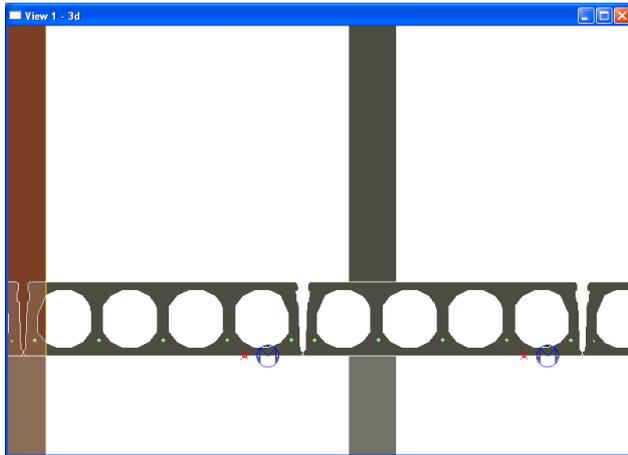


Figure 1: A faulty placement of a partition wall could have been avoided if BIM had been used, thanks to better visualization possibilities.

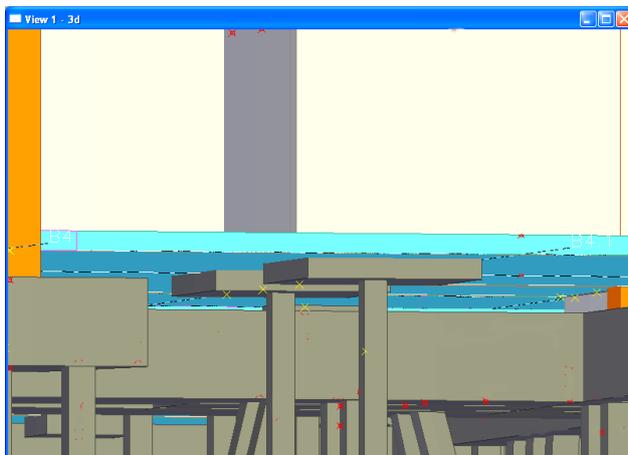


Figure 2: The combining of the pile foundation and the spread foundation.

15 (47%) of the 32 SE-errors were categorized as “*Could be avoided using product-model based CAD-system*” That is, they could probably have been avoided if a product-model based CAD-system had been used in the design process. 8 of these 15 errors also involved the HVAC engineer. For example was a solution designed for the heating system along the outer walls that implied that the tubes should go through the concrete beam.

12 (38%) of the 32 SE-errors were categorized in the category “*Could be avoided in the next project using feedback*”. Of these 12 SE-errors, as many as 11 (92%) were situated where two or more element met.

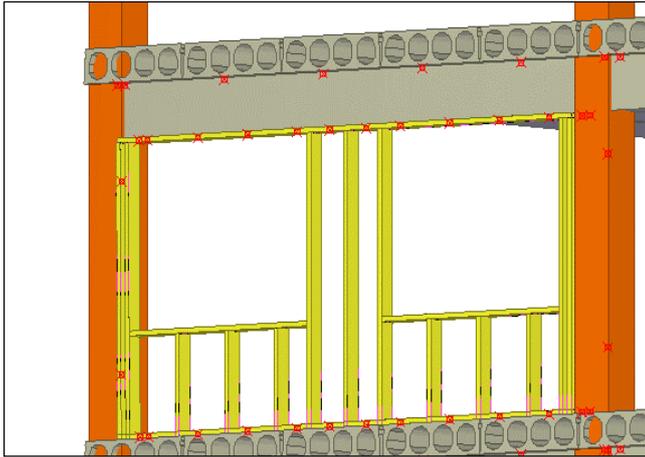


Figure 3: In-appropriate attachment of in-fill walls.

If the two techniques, both product-model based CAD-system and feedback, were successfully used, 20 (63%) of the 32 SE-errors could have been avoided.

Finally we want to show an example of how the feedback information can be made available to the structural engineer, using product-model-based CAD-systems. We then designed a prototype to show how this information could be made available by using a product model in the way that the construction deficiency reports were linked to the elements involved. The construction deficiency reports were created using Microsoft Word. These reports were translated to HTML documents. Having this, the construction deficiency reports could in the prototype be connected to the elements by giving the URL to the HTML document. In the prototype the document is situated in a subdirectory of the project file but it could be placed in a database. The product model is then transferred to the structural engineer, or a common web-based product model could be used. The structural engineer can then browse the elements and study the construction deficiency report together with the elements involved (Figure 4).



Figure 4: The structural engineer can now browse the elements and investigate the construction deficiency report and the elements involved.

DISCUSSION

The aim of the paper has been to analyse BIM's role in facilitating knowledge and expertise sharing in order to prevent design errors. Based on the case study it is confirmed that BIM can serve a mean for preventing design errors by facilitating knowledge and expertise sharing. By drawing on the idea of BIM as boundary object, BIM serve a means for preventing design errors by facilitating knowledge and expertise sharing across different boundaries. By paying attention to the kinds of

boundaries crossed, challenges in the organizing of knowledge and expertise sharing can be detected. By drawing on three examples from the case study it can be claimed that three modes of error preventions can be identified.

The first mode, intrusion over of disciplinary boundaries, that encompass the traditional clash detections, is where two or more element meet and where more disciplines are involved (see for example figure 1 and 4). Either by automated clash detections, or visual inspection BIM provides actors with information that the actual design solution cannot be implemented. This kind of problems is solved by a discussion among actors who had become more knowledgeable due to the visual representation and in the next step can agree upon a revised design solution. This mode of preventing design errors can be claimed to be rather uncomplicated, because BIM makes the intrusion over disciplinary boundaries rather visible and the organizing of solving the error is made by communication among the disciplines involved in order find a revised design solution.

In the second mode, knowledge sharing across time- and space boundaries, concerns design errors these occurs due to lack of knowledge of what for example happens when two elements meet (see for example figure 2). This mode of knowledge sharing is somewhat more complex than the first mode. The knowledge is explicit, but the organising of knowledge sharing over time and space is somewhat more challenging, because roles and responsibilities are more blurred. This is a classical knowledge management problem. Knowledge about a potential problem and solution of the problem is somewhere inside or outside the organization, but there is no match making between to knowledge and the actor in need of the specific knowledge. Challenges in the organizing of the knowledge sharing is first who should document the knowledge and where should it would be transferred? Second, who is responsible for attaching the information to the right elements, if the knowledge concerns measure to be taken when two or more elements meet, as in the case with the plastic film? Third, who is responsible for making the information in the model available in the next project?

In the third mode, expertise sharing across professional boundaries, concerns design errors these are related to forms and functions, and requires the involvement of actors from more disciplines. This mode of error prevention draws on BIM's visualizing capabilities. But in the first mode actors from a similar community of practice can immediately make sense of a visualized clash between two elements and the further consequences without any further communication. In this, mode, however, one involved actor make sense of a visualized design solution that s/he not finds appropriate (see for example figure 3). With help of the model and communication with other actors involved, the actor who finds a design solution inappropriate can explain wha s/he finds the solution inappropriate. Regardless if actors concerned can make sense of the problem, or find it crucial, thanks to the visualization they contribute to a revised design solution. The organizing of this mode of error prevention can be more, or less complex. The less complex organizing is that design errors are detected in regular design meeting and finding an acceptable revised design solution can be more or less complex. An alternative way to avoid design errors from the outset, is to transform the organizing of design from a sequential organizing of design activities, to a more integrated and concurrent design process where these errors not appear. However, this solution is more complex from the perspective of organizing the design and construction process. A more integrated and concurrent

design process would probably require a changed procurement process that is outside to scope of this paper, but a topic for future research.

CONCLUSIONS

Based on the case study it is confirmed that BIM can serve a mean for preventing design errors by facilitating knowledge and expertise sharing, across discipline, time and space, and professional boundaries. Depending the kind of boundary knowledge and expertise should be shared across, different challenges emerge in organizing the knowledge and expertise sharing.

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LEVERAGING COLLABORATION THROUGH THE USE OF BUILDING INFORMATION MODELS

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Building information models are a major new means of design information communication and therefore they are of primary importance for successful design collaboration. However, in addition to communicating the design information, models are used in many different situations for different purposes by different stakeholders at different stages in construction projects. The developing model is a result of the different situations encountered in its production through the interaction of stakeholders. Consequently, it is important to evaluate different uses of models by different stakeholders collectively in order to understand the implications of these differences on models and therefore on design collaboration. The paper investigates this through two educational building projects and establishes the origins of these differences to identify how particular situations affect the developing model. Findings suggest that a successful collective use of models requires structure and planning but these plans need to be adapted to the situations in order to enable collaboration.

Keywords: BIM, collaboration, design management, modelling.

INTRODUCTION

Design in the construction industry requires different players with different backgrounds and foci to work together. Consequently, efficient interdisciplinary design collaboration is regarded as a critical success factor for construction projects (van Leeuwen 2003). In such practice, communication between different players of the developing project becomes critical, as each player needs to integrate their different sets of skills and knowledge (Sebastian 2011). The literature on collaboration in construction industry shows how a delicate balance between technological, organizational and people issues needs to be reached to collaborate successfully (e.g. Shelbourn *et al.* 2007). The primary condition to achieve successful collaboration is the establishment of the right social and organizational foundation (Homayouni *et al.* 2010). Technology, whether paper drawings or Building Information Models, needs to support this by facilitating transparent and reliable communications and this is an important determinant for collaboration in construction projects (e.g. Dossick & Neff 2011).

Among the technological solutions proposed to facilitate communication and therefore to support collaboration, Building Information Modelling (BIM) has become a significant topic for the UK construction industry. BIM can be defined as the process of development and use of a digital model of the facility intended to be built. The resulting product of BIM, the Building Information Model (model), has the ambition

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of being the central hub for all information about the facility from its inception onward. This information needs to take on many forms in its many roles through the life cycle of the facility. The conceptualization and use of the model as the central hub for all information require all stakeholders of the project to add to and use the building information depository through a collaborative effort (BIM Industry Working Group 2011; UK Cabinet Office 2012). Consequently, there is strong emphasis on inter-disciplinary design information sharing and collaboration in BIM related policies (e.g. BIM Industry Working Group 2011, BSI 2013) and in BIM related research (e.g. Arayici *et al.* 2011; Shafiq *et al.* 2013). Although it has been argued that the factors influencing successful inter-organizational collaboration and BIM practice are largely the same (Homayouni *et al.* 2010), how model based communication should operate in practice in order to enable the collaboration needs to be further explored.

In exploring this, the research assumes that the model is a major means of design information communication in BIM enabled projects and aims to establish how the communication of design, through collective use and sharing of models, needs to operate in order to leverage design collaboration. Through observations and interviews in two projects, the research enquires into how different disciplines decide their modelling approach, how they use other disciplines' models for their own purposes and what kind of modelling and other type of arrangements are taking place to maintain satisfactory design communication based on models. From this it establishes how models are not only used for sharing design information and design collaboration but also actively used for other fundamental functions such as information generation, storage, analysis, representation, control etc. during design development. The advantages and disadvantages (i.e. implications) of certain modelling approaches from design communication point of view are determined but more importantly the origins of these modelling approaches are revealed. It is concluded that different situations in which models are used have impacts on the modelling process and therefore on the resulting models and in order to be successful, planning and management are required to address these situations.

METHODOLOGY

This research takes a critical realist position (Ackroyd & Fleetwood 2000; Mingers 2008) as being the most suitable for the practical task of exploring the use of a same artefact (i.e. model) in different situations where different purposes are dominant. Critical realism sees the physical world and technology as real but recognises that human views and actions of those are socially constructed. The selected approach presumes that, ontologically, models exist independently (i.e. independent from its users) and they have the power of affecting the practice (i.e. the situations) in which they take place with their users. At the same time, it allows the research to capture how different uses of the models in different situations are differently constructed by users and in turn caused changes in the reality (i.e. materiality) of the model.

As part of a larger research project, data were collected from two design-build educational building construction projects. The client, the architect and M&E subcontractor were the same for both projects however M&E consultants were different. The enquiry used semi-structured interviews and observations of the projects to provide robust data so that a wide critical analysis of both ideas and practice could be undertaken. The first author regularly attended the design coordination and clash detection meetings of the second project but only audio recordings of clash detection meetings were used for first project. Insight was gained into in-discipline uses of the models through the semi-structured interviews. The

observations in the design coordination and clash detection meetings were used to determine how models were used as design checking artefacts and what kind of modelling and other arrangements were required to satisfy the different uses of the model. The themes under which findings are listed emerged from the analysis of the observational data and previous interviews with projects' stakeholders. These themes were validated during the interviews and in cases when a particular reason for a modelling approach did not fit in an existing theme, a new theme was created. Through this the research gained an insight into how models were affected by different situations (i.e. different uses) that they were exposed to, in order to explore the implications of this on design collaboration.

COLLABORATION AND BIM

Collaborative design, in itself, is a disputed concept that is used interchangeably for different scopes of interaction in design process (Kvan 2000). Kvan (2000) citing Mattessich and Monsey (1992) described cooperation, coordination and collaboration as a spectrum where determinant of authority, risks for interacting parties, and sameness of missions differed. He argued that although there is strong emphasis in the literature on collaborative design, most of the times construction teams only cooperate and compromise. He stated that these are exactly what they should do because collaboration is time consuming and requires relation building. Consequently, he suggested loosely coupled information systems rather than closely coupled ones.

The point made by Kvan (2000) regarding the relation between the scope of social interaction and its relation to the type of information technology (i.e loosely coupled vs. closely coupled) is supported in a more recent study. Homayouni *et al.* (2010) argued that successful inter-organizational collaboration and successful inter-organizational implementation of BIM have shared "*theoretical categories*". These are listed as: fostering integrated teams; implementing tools and strategies to encourage clear communication across the team; and developing transparent technology use. Importance of people issues in BIM enabled projects are also argued by others (e.g. Arayici *et al.* 2011; Olatunji 2011) and it has been stated that in inter-organizational settings, technology adoption process requires mutual adjustment to achieve successful inter-organizational collaboration (Taylor 2007). Similarly, BIM related policies also state that the conceptualization and use of the model as the central hub for all information require all stakeholders of the project to add to and use the model through a collaborative effort (e.g. BIM Industry Working Group 2011) and suggest closely coupled systems such as Common Data Environment (BSI 2013) for technically enabling this. Consequently, the BIM discourse often includes arguments for interdisciplinary communication and collaboration (Homayouni *et al.* 2010).

However, it has been reported that the level of collaboration in BIM enabled projects are lower than expected and/or not in line with the opportunities provided by current BIM software (e.g. Shafiq *et al.* 2013). Problems and concerns regarding collaboration in BIM practice have been studied both from technology-centred perspective focusing on functional requirements of the technology (e.g. Isikdag & Underwood 2010) and more comprehensive perspectives considering the developing relations between people, technology and processes for collaboration (e.g. Dossick & Neff 2011). The former category of studies focus on system design and aim to identify system requirements to technically enable closely coupled systems. The latter category aims to determine how organizational settings, in which dynamic relations between people and technology emerge, need to be managed to benefit from BIM.

Related to the concepts of loosely and tightly coupled systems are the ideas of Suchman (2007) on plans and situated action. Suchman discuss what makes artefacts “*interactive*” in order to explain the meaning people attach to computers in practice. Theoretically, this suggests that computers have intent “*as demonstrated precisely in this ability to behave in an accountably rational and intelligible way*” (Suchman 2007: 43). This intent is embedded in plans (both inscribed in the software and presented in the management of the task) and the actor’s problem is to find a path from an initial state to a desired end state using the plans. In complex dynamic situations involving people the plans are inadequate and adaption is required in practice which becomes the point of situated action. This can cause problems for other members of a team if one member's adaption provides another's dynamic context as it deviates from the plan. The consequence as Gherardi (2012: 14) states is “*The concept of performance, in fact, makes it possible to regard work as an activity which follows a script, but whose interpretation is situated. It is an individual and collective activity that may consequently vary according to the participants involved in it, or those who are prepared to be involved*”.

MODELLING APPROACHES IN PRACTICE

As well as plans and situations the research analysis used a number of themes which emerged from the data itself. Central to this analysis is the expected (i.e. planned) “*BIM way of working*” which is structured (i.e. scripted) and technology driven. However, there are inadequacies in this that require “*pragmatic adjustments*” and the “*contractual requirements*” influence modelling approaches which respond to the situatedness of the activity. Further, the practicalities of developing a design through collective developing of a model require “*different levels of detail*” resulting from the collective and dynamic nature of design development. The ability to check design and coordination using clash detection is a significant part of BIM way of working but the practicalities of this need to be considered both technically and as a collaboration tool.

BIM way of working

In both of the projects, the same BIM platform was used by different disciplines which included an online document management tool to store and exchange design documents. The presence of different packages of the same platform allowed software interoperability. However, it was observed that there was a strong commitment to standardization of the way the model was created particularly through using naming conventions, work set contents and agreements on model contents. This allowed different parties to interrogate the model for their own design development purposes and also for managing clashes. These conventions were partly articulated in BIM Execution Plan (e.g. naming conventions). It was acknowledged by all the parties that creating and following a consistent structure for object development was the key to benefiting from the linked models and to produce the healthy development of design in BIM environment. However this alone was not sufficient due to the complexity of both modelling and design development such that regular on-going discussions were needed to keep the model consistent for all the parties.

The design teams stuck to in-built tools provided by the BIM software as much as possible to avoid the potential problems that might occur because of stepping outside the structured BIM way of working. Therefore, generic objects were only created when existing tools were not able to satisfy the design purposes at particular instances. For example, although they created an object family for furniture, the architects chose to model fitted furniture under a generic objects family. The reason for this was that

they wanted the fitted furniture (e.g. reception desk) to be always visible even when they turned off the loose furniture. It took considerable discussion in both projects to decide what to include and what not to include under "*Generic Objects Family*" but a consensus was achieved and fewer conversations were required after this.

The BIM software has an embedded logic and understanding this logic was important in order to document the design correctly. For example, the editor didn't schedule the wall heights and did not show them correctly at some instances. When the wall intersected with a roof or ceiling, the editor automatically cropped it but when the object was considered in the designer view, it still showed the "*unconnected height*" which was the height before the automatic crop.

The BIM environment allows the creation of extensive connections between objects and the opportunity of assigning many attributes to the objects. However this requires approaching similar objects with consistency and planning in advance in order to know how these attributes would be used. For example, if rooms are defined as spaces, M&E discipline can use the model to conduct ventilation analyses. Similarly most of the objects can be scheduled automatically if defined consistently in the model. However counting on these automated functions brings its own risks because if there is a problem, it becomes really hard to find where it was generated from. Additionally, the designers need to understand the ways that measurements are performed by software to ensure that what was scheduled is actually what was designed. Curtain walls, for instance were problematic in this sense. The in-built curtain wall tool of the software, takes it as an opening in the wall however curtain walls' fixing elements span beyond the visible opening in the model, thus, causing potential misunderstandings about the size of the curtain wall in schedules.

A useful feature for designers in BIM environment is that objects are created once and then developed over time. This makes it necessary to assign ownership to each object in order to ensure that they are adequately handled during the design development. This ownership of objects requires more coordination as objects are used by other members of the team. Similarly in BIM environments, different members use different views and the disciplines need to decide from which plane they should cut the model to obtain the view they want for it to be useful to them. Although there is the flexibility to create almost any views, the fact is that not everything is detailed in the model means that extra time is required to enrich the views with annotations.

Pragmatic adjustments to BIM way of working

The BIM way of working is determined by the functionalities of the software however the software does not work universally and so practical pragmatic adjustment need to be made. An example of stepping outside of the "*BIM way of working*" was about the in-built change tracking features of the software. Designers found the in-built change tracking features complicated to use. Therefore, to compensate, they decided to issue a cover letter every time they issued a new model where they detailed which parts of model were developed. Additionally, the auto-joint feature of the software did not satisfy the architects in some instances. For example in column-curtain wall joints, this feature extended the wall layers onto the column which was not what was wanted. After long discussions, the architects decided to black out these joints to force people on site to refer to 2D drawings where they could correctly document the joint.

In a similar way, the functionalities of the software were used for pragmatic reasons. For example, architects did not want to connect the walls to the slabs because slab objects were owned by structural engineer. They wanted to be able to turn off the

structural elements and still have the walls visible. Although they acknowledged that this is against the logic of parametric design based on the fact that they fixed the heights of levels quite early in the design, they did not think the parametric feature was of value against other purposes. Furthermore, they created red 3D marker objects visible in all views to identify important coordination issues. As these markers were objects in the model, they also could schedule them to see all the pending coordination issues. Similarly, they created placeholder objects to specify objects that they don't own but they needed in order to coordinate their own designs. These placeholder objects were simple representation of the real object and were replaced by fully designed ones when the real owner of the object developed the design to the point that this object was needed. For example, radiators are created as placeholders (i.e. as empty boxes) by the architect to coordinate the room layout but later replaced by radiator objects by M&E designer.

Contractual issues

Contracts are important determinants for how the design is documented. The same views and drawings as pre-BIM practice are still created because the contractual documents in the background are based on 2D drawings. Therefore, as stated by all the interviewees *"it is still mainly based on 2D drawings but coordinated through 3D"*. There is a general disclaimer on the model which says that any information that exists in the model but not in 2D drawings should be checked with the owner of the object. As stated by an architect *"there are things that just don't work with a BIM way of working"*. Similarly, it was explained that the model as a design output can cause arguments between designers and clients. Although the scope and content of the model can be specified, it is impossible to specify every single detail about modelling and the client may end up arguing that the model is not developed appropriately. Therefore, 2D drawings were seen as being helpful to ensure that the design does its job properly and satisfies everyone.

Level of development of design and level of detail of the model

In the projects studied, the initial conceptual design used sketching software, and 2D drawings. The BIM model was created at RIBA Stage C. At Stages C and D mainly generic objects were used. At Stages E and F these generic objects are swapped out with custom ones (i.e. with the objects under custom families). This allowed the model to be flexible so that it could be changed quickly during design development. For example at Stage C, the design team only wanted to see that there was a door in a particular place but they were not interested in any particular property of that door apart from its location and approximate size.

Another issue about the level of detail of the model appeared in clash detection exercises. In many instances for the sake of efficient use of time, objects were deliberately left clashed with each other because of the fixed operation of the modelling software. For example the screed was left to clash with structural columns because everyone knew that the screed will only run up to the columns in reality. Another explanation given for this was that these clashes don't appear in most of the views, especially if they were set to medium or coarse level of details. However, although there were deliberate modelling decisions that do not reflect the reality, all the construction details were correctly included in the generated 2D detailed drawings and the annotations added on them.

The level of detail was also important when the coordination views were created. There was an ongoing discussion between the different disciplines sharing models

with each other as each wanted to see different aspects and not see others. It was stated by all the interviewees that when a model was received from another discipline, it was very confusing to have it in the level of detail that the sender used. Therefore, agreements on what and how they want to see were made between the parties.

Design workflow

It was observed that the designers needed the design information stored in the models to develop their own design. Therefore the design workflow was connected with the model development. Individual disciplines use other disciplines' models as input to develop their own models and designs. When there was problem with the synchronization of the model development between the parties, 2D CAD drawings of other disciplines were used to coordinate in-discipline design to maintain the design development.

It was observed that it was impossible for individuals to make decisions only looking at the model because of the iterative and ever developing nature of the design. Therefore conversations were vital no matter how good the models were. These conversations were combined with 2D drawings which were complementary to the model. 2D drawings with their annotations and revision numbers told a necessary story and retained the message about the design intent. Similarly, because of the ever developing nature of design, the model was always incomplete in different ways for different disciplines. At any point in time, the model was only a snapshot of work in progress and designers didn't know what the final design would be. The iterative nature of design required jumping back and forward through different iterations. This caused problems in model based design communication. In one of the projects for example, an electric switch owned by M&E discipline was orphaned when architect deleted a wall which required communication outside of model environment.

Clash detection

In the clash detection exercises, only clashes between highest level object families were checked instead of setting more detailed rules. More detailed rules created an exponential increase in the number of clashes which were already felt to be excessive. Here again, the importance of object naming and structuring conventions was observed. These conventions allowed the designers to manually filter the clashes and to differentiate clashes created due to modelling issues rather than more important design clashes. For example, inset lights clashing with ceilings were never checked because the designers knew that these clashes were due to modelling issues; the lights were not embedded in the ceilings in the model because it was time consuming and such connections slowed down the model. Finally, clash detection exercises and any other model checks were always accompanied by a walk through the model. In many instances, designers detected design or modelling problems during these visual inspections rather than through clash detection exercises.

DISCUSSION

Use of the model as the central hub for all information requires all stakeholders of the project to add to and use the building information depository through a collaborative effort to ensure data integrity (BIM Industry Working Group 2011; UK Cabinet Office 2012). Consequently, there is need for an additional dimension of collaboration (i.e. in addition to design collaboration) in BIM enabled projects which arise from the collective use of the model. Although there is no explicit differentiation in literature between these two dimensions of collaboration (design collaboration and data collaboration), these are implied in BIM related policies (e.g. BIM Industry Working

Group 2011; BSI 2013) and in BIM related research (e.g. Shafiq *et al.* 2013). In order to understand better how design collaboration and data collaboration need to operate, the findings were analysed against the concepts of plans and situated actions. This will also be related to the establishment of closely or loose coupled systems. Clearly a work world dominated by plans is closely coupled and so experiences problems when its context changes such as in design development. It is generally promoted that the structured and accurate nature of the BIM model allows everything to be established through plans. This is challenged below.

What is described as "*BIM way of working*" in the previous section and the accompanying documents such as BIM Execution Plan and the agreements materialized in them (e.g. naming conventions) can be seen as plans. Collective development and use of models and their storage in a shared platform requires consistency. Project level BIM planning and structure informed by the plans inscribed in the technology by developers are required to establish this consistency. As a result, two types of plans can be articulated in BIM practice. First the plans inscribed in technology by developers and second the plans developed by the construction project team for consistency in order to enable collective development and use of models. The first type of plans allows technology to function properly. This can adapt to different construction projects only to the extent that the software offers a level of adaptation capability through the use of the embedded tools and functions. The second type of plans is created by the construction project team and gives legitimacy and accountability to model as a communicator of design information.

There are problems arising even with the first type of plan involving the data collaboration itself. Object-oriented design software (i.e. BIM software) and its associated rules and procedures have an embedded structure and scripts such as in-built tools, families, functions and data structure which fix and constrain the possibilities of design. However, the purpose of the software is to enable the development of a unique design artefact represented in the model, therefore, its users require the freedom to use different combinations of software features to accomplish the design. The modelling approaches in the case studies showed how the pre-developed rules and plans for the design and the model needed to be adapted to the different situations they encountered in order to accommodate the uncontrollable and unpredictable contingencies arising from these situations.

This adaptation takes place in and through the situated action. In any particular situations involving construction project design, it is argued that models are only a part of the purposeful situated actions. The models themselves are part of the situated action and so are in flux and influenced by the surrounding social and material elements; in addition they are interpreted in the unfolding situations. Therefore, the models are used and affected in different ways in different situations as was shown in the findings by the pragmatic adjustments to BIM way of working, the effects of contractual issues on modelling, the need for different levels of detail in different situations, the iterative and unfinished nature of ongoing design and the need to employ various inspection methods to detect clashes.

The collaborative construction project design work, itself, is run through social arrangements in which different meanings are attached to design by different designers and are negotiated and reconciled along the design development. Models, as a major means of design information communication, act as legitimate and accountable mediators of this negotiation and reconciliation process using the design

information they represent. However, other means of communication such as phone calls, e-mails and meetings are needed between different stakeholders in order to sustain the social arrangements between the stakeholders and to reconfirm the accountability and legitimacy of the model as a trustable design information communicator. If communication through models replaces other means of communication justified by extensive planning, then models risk dictating or locking meanings rather than nesting them for negotiation and reconciliation. Therefore, models and accompanying plans should be positioned in design practice in a way that leaves enough space and facilitates meaning negotiation and reconciliation. This means that the way models are seen and the plans that are created should acknowledge and allow adaptations to different situations for successful collaboration.

Consequently, it can be argued that, on one hand model based inter-disciplinary design work requires close coupling and extensive planning to keep the software working and a consistent shared model for everyone. On the other hand inter-disciplinary design work is an iterative and evolving process that requires loosely coupled situations and flexibility to develop. Design is developed as result of various purposeful situated actions along the process and the design artefacts should afford unfolding and evolving nature of design work (Ewenstein & Whyte 2009). We argue that the tension between these two should be acknowledged and managed. This means that, in BIM enabled projects, management needs to accommodate loosely coupled situations in order to enable successful design collaboration.

CONCLUSION

In BIM enabled projects, the model, as a major mean of communication is an important factor that can improve collaboration. However in practice, modelling software is not ideal and the data is needed in different ways by different disciplines. Therefore, it is vital to achieve a harmony between uses of models as design development artefacts and uses of models as design communication artefacts. We argue that the models can only perform well as design communication tools if they also perform well as design development tools and the models which are successful in design communication are able to leverage collaboration in construction projects.

In this paper, it has been shown that there is a tension between plan driven, closely coupled model based design and the loosely coupled situations where design development is performed. Thus future work in BIM needs to explore how this tension should be managed. Although we observed some instances where users of the model "*hacked*" the software and improvised their own uses to make the model suit their needs, we argue that there are bigger potential opportunities that can be realized for better collaboration. We argue that once project particularities and requirements for design development and communication are established, BIM needs to be tailored according to the needs and particularities of the project and the software needs to enable this.

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DETERMINANTS OF BUILDING INFORMATION MODELLING (BIM) ACCEPTANCE FOR SUPPLIER INTEGRATION: A CONCEPTUAL MODEL

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Building Information Modelling (BIM) is expected to promote efficiency in project delivery through collaboration and integration within a highly diverse and fragmented construction industry. Yet, uncertainty concerns relating to the technical, human and inter-organisational contexts of the usage of technology for Supply Chain (SC) integration remain. This affects willingness and preparedness of SC to participate in such electronic data exchanges due to perceptions of greater risk compared to traditional paper-centric communications across the SC. It remains unclear, what model best explains acceptability of BIM within the SC. A conceptual model to aid investigation of influencing factors affecting acceptance and use of BIM in the SC context is presented. The model is proposed to aid examination of the inter-relationship between the determinants of acceptance and the readiness of the SC as well as its impact on achieving the highest maturity of BIM adoption i.e. a fully integrated SC. The key constructs from the Unified Theory of Acceptance and Use of Technology (UTAUT) model are extended through consideration of the relational and transactional context of integration in the development of a SC specific BIM acceptance model. Through this proposed model, it is argued that the SC firms' disposition towards BIM is a key determinant of technology usage and implementation success hence the need for the study of determinants of acceptance. Directions for empirical validation of the model are presented with a review of potential benefits of understanding the determinants of acceptance on the readiness of the SC.

Keywords: BIM, supply chain, integration, implementation, technology acceptance.

INTRODUCTION

Fragmentation within a loosely coupled construction industry has contributed to poor communication and resultant process inefficiencies which often leads to poor performance (Mohamed, 2003). A more vertically integrated Supply Chain (SC) working in network-like structures has been advocated to improve information availability and flow efficiency (Dainty *et al.*, 2001). This step is regarded as paramount in delivering real time decision making for better collaboration and coordination of processes. Building Information Modelling (BIM) is regarded as an opportunity for achieving such integration through centralised digital inter-organisational communications in virtual 3-D environments (Eastman *et al.*, 2008; BIS, 2011). Despite reported benefits of BIM, the extent of its use remains low with

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some lack of clarity pertaining to its role in achieving SC integration (Robson *et al.*, 2014). Generally, it is unclear what factors account for BIM acceptance. However, according to Jacobsson and Linderoth (2012, p.339) ‘for the industry to take advantage of ICT’s transformative capacity, more fine-grained knowledge would be needed regarding perceptions of ICT impacts’. Such an understanding includes knowledge of the determinants of users’ acceptance which has become a key measure of implementation success for technological innovation (Venkatesh *et al.*, 2003). A typical factor contributing to the acceptance or rejection of a technology includes end-user perceptions about likely consequence of use (Davies and Harty, 2013). In the SC context, this includes whether or not BIM fits the social relational and transactional context of operations (Adriaanse *et al.*, 2010). Despite this acknowledgement, these issues have not been adequately incorporated and explored within BIM acceptance studies (Lee *et al.*, 2012; Davies and Harty, 2013). A conceptual model is proposed to guide future research on understanding the implementation of BIM in the SC integration context thereof. We argue that research from a user acceptance perspective can broaden the theoretical understanding of the role of user disposition in the success of using BIM to achieve digitally mediated interaction of the SC firms. The practical contribution of this paper is to showcase how user acceptance modelling can be used to assess critical areas affecting readiness. It is envisaged that operationalization of this model will aid prediction of acceptability rates across various disciplines and BIM maturities in the SC. This will further aid prioritisation of key drivers and challenges for managerial focus during implementation.

BIM AND CONSTRUCTION SUPPLY CHAIN INTEGRATION

Building Information Modelling (BIM) is expected to bridge communications gaps which have contributed to lack of collaboration and process inefficiencies associated with current fragmented structures (Vrijhoef, 2011). BIM has been described as an embodiment of policies, processes and technologies towards generation and management of project data in digital format throughout a building's life-cycle (Eastman *et al.*, 2008). The benefits of such a system include real time information availability and access for early decision taking, reduction in lead-time and accountability (Vrijhoef, 2011). UK Government’s construction strategy expects some level of implementation of BIM on all government projects by 2016 in a road map towards universal adoption of BIM across the industry (BIS, 2011). It is expected that the highest maturity of BIM will be a fully integrated SC where a single parametric environment will be the basis of communication between each project participant during the entire lifecycle (BIS, 2011). However, the establishment of a system to facilitate such inter-organisational communication presents a challenging task due to its sheer scale and the need for congruence in the interest of participants within such a commercially driven environment (Adriaanse *et al.*, 2010). Implementation is therefore still challenged by technological complexities of BIM as well as human, organisational and commercial context of its usage (Gu and London, 2010). For instance, it has been reported that higher perceptions of risks exist as a result of the openness of a centralised system, which may expose valuable intellectual property (Singh *et al.*, 2011). These affect the willingness of users to adopt BIM (Mahamadu *et al.*, 2013). Information scientists have described this phenomenon as the psychological representation of a complex interaction of individual perceptions about consequences and attitudes towards use (Venkatesh *et al.*, 2003; Lee *et al.*, 2012). This eventually determines level or extent of use, generally described as user acceptance (Davis, 1989). Related theories and models have proliferated and have been

successfully used in explaining or predicting implementation success through assessment of factors that contribute to user disposition towards these technologies (Venkatesh *et al.*, 2003; Davies and Harty, 2013).

THE ACCEPTANCE OF BIM FOR SUPPLY CHAIN INTEGRATION

Most of the initiatives associated with implementing integration have failed as a result of non-acceptance due to a lack of fit between these initiatives and existing work practices or industry cultures (Briscoe and Dainty, 2005). Lack of trust and risk adversity particularly between clients and main contractors (focal suppliers) have reportedly derailed prescribed mechanisms for integration including procurement methods, lean techniques and even information technology use (Dainty *et al.*, 2001). According to Briscoe and Dainty (2005 p.323), the relative failures of such 'formulaic prescriptions' for integration is because they are more effectively achieved at the social-relational level. Mohamed (2003) however posited that ICT usage would actually improve such relationship building through the provision of opportunities for collaboration as well as its potency in improving inter-organisational trust. Such assertions need to be validated in the BIM context particularly in view of contrasting evidence, that, lack of trust and risk adversity may rather hamper implementation of such centralised forms of communications (Adriaanse *et al.*, 2010). Linderoth (2010) describes BIM as an artefact that shapes the roles and relationships across organisational networks based on actor-network theory. In assessing the potential impact of BIM, it was concluded that the consequences of deployment is determined by a combination of actors' (SC firms) interpretations of the patterns of action induced or inscribed by the artefact (BIM). Such patterns include risk, or perceptions of significant changes to the status-quo (Lowry, 2002; Linderoth, 2010). These naturally create resistance and aggravates unwillingness to use BIM (Lee *et al.*, 2012). They further highlight the importance of identifying the interplay between drivers and inhibitors including perceptions of risk associated with adoption of BIM for integration.

U.K Government's primary expectation of BIM use by firms in the SC includes the attainment of a fully integrated SC (BIS, 2011). The extent and effect of BIM usage has been described as a reflection of its acceptance (Lee *et al.*, 2012). BIM usage within the SC is, however, still low with evidence pointing to incomplete acceptance and making the envisaged full integration illusory (Khosrowshahi, 2012; Robson *et al.*, 2014). With this growing recognition, it is imperative to assess the real impact of user disposition towards BIM use in the SC context and to further understand the determinants of its acceptance.

MODELLING SUPPLY CHAIN ACCEPTANCE OF BIM

Technology Acceptance Models (see Davis, 1989; Venkatesh *et al.*, 2003) have provided a basis for investigating the role and impact of perception and behavioural disposition towards technology usage based on psychological theories. They provide theoretical linkages among beliefs, motivation, attitude, intention, and action (Venkatesh *et al.*, 2003). A generic feature of these models is the hypothesis that actual system use is determined by users' behavioural intention to use, which is in turn influenced by users' attitudes towards use (Davis, 1989; Venkatesh *et al.*, 2003). It helps in predicting the likelihood and rate of adoption of an innovation and has been applied and validated in various contexts of IT usage (Lee *et al.*, 2012). According to Davies and Harty (2013), beliefs and expectations of the consequences of ICT use

predict subsequent and extent of usage within BIM environment. Professionals are therefore increasingly interested in understanding the determinants of acceptance and ensuring new technological solutions designed are implemented so as to minimize resistance (Lee *et al.*, 2013).

The Unified Theory of Acceptance and Use of Technology (UTAUT) is adopted in this study as a result of its prior usage in inter-organisational context due to additional constructs that consider the socio-organisational context of ICT usage (Venkatesh *et al.*, 2003; Adriaanse *et al.*, 2010). The primary constructs of the UTAUT model are theorised as the key determinants of user acceptance, namely: *Performance Expectancy*: perception of the degree to which using a technology will help attain performance in work tasks; *Effort Expectancy*: the degree of ease associated with the use of the technology; *Social Influence*: perception of importance associated with usage within social context of organisations or influence of peers; and *Facilitating Conditions*: perceptions about the prevalent environmental and organisational conditions that facilitate ease of use and support (Venkatesh *et al.*, 2003). In view of transactional risk concerns often associated with SC relationships, *Security Expectancy* as an extended construct of UTAUT represents the degree to which an individual believes that security, relational or transactional risk impedes or support use of BIM. This construct is on the basis of successful extension of UTAUT in previous studies where information security is often regarded as very important such as research in online banking acceptance (Luo *et al.*, 2010).

The core UTAUT constructs have been found to be affected by antecedent factors which provide stimulus for users' cognitive responses to new technology (Venkatesh *et al.*, 2003). These factors can be categorised based on the characteristics and capability of the technology (BIM), the organisational context (SC) of usage as well as wider environmental influences such as industry and conditions provided by Government (Sargent *et al.*, 2012; Davies and Harty, 2013).

Similar assertions led to development of Technology-Organisational-Environmental (TOE) framework which has previously been used in information studies to categorise implementation factors (Tornatzky and Fleischer, 1990). This framework has however been used extensively without recourse to technology acceptance (Oliveira and Martins, 2011). Building on the UTAUT model, the TOE framework is incorporated to assess antecedent factors that influence the core constructs. TOE framework has been advocated to allow appropriate consideration of all organisational level factors (Tornatzky and Fleischer, 1990). This is proposed to further alleviate the individual-user bias in previous application of UTAUT model in research (Oliveira and Martins, 2011). The consideration of external variables on the core constructs does not only contribute to theory development, but also improves understanding of technology acceptance (Sargent *et al.*, 2012). As such, external variables provide a better context and understanding of what influences the core UTAUT constructs (Venkatesh *et al.*, 2003). Therefore as opposed to previous studies which have often focussed on the impact of core constructs on acceptance, this model proposes direct incorporation and measurement of the influence of these antecedent factors on acceptance. Identified antecedent factors (determinants) to UTAUT constructs relating to BIM are presented in Table 1 and elaborated in the subsequent sections. Further exploration based on this framework is however required to aid completeness and comprehensiveness in the list of antecedent factors which can be later prioritised through empirical measurement within BIM enabled construction projects.

Table 1: Relationship between Determinants and Core UTAUT Model Constructs

Technological Determinants	Organisational Determinants	Environmental Determinants
Integration Capability (PE); Interoperability (EE); Cost (EE); Security and Privacy (SE, EE); Scalability and Information Risk (SE, EE); Standards (EE, FC)	Executive Support (FC); Inter-Organisational Trust (SE, SI); Legality and Data Ownership (SE, SI); Competence and Capacity (EE, FC)	Industry Support and Guidance (FC); Legislation (FC); Competitive Pressure (SI, PE); Image (SI); Vendor Support and Training (FC); Procurement (FC; EE)
UTAUT constructs: Performance Expectancy(PE); Effort Expectancy (EE); Social Influence (SI); Security Expectancy (SE); Facilitating Conditions (FC)		

Technological Determinants of Acceptance

Rogers (1995) describes five attributes related to a technology which influences implementation: relative advantage it provides; compatibility with existing task and systems; complexity, observability of its benefits and the ability to try it before deployment. This is similarly conceptualised within the proposed model to include variables with direct effect on Effort, Performance and Security Expectancy. BIM characteristics that are likely to affect or influence these perceptions generally relate to current state of development, technological challenges and its ability to deliver specific SC related performance expectations (Sargent *et al.*, 2012).

From the review of literature, these have been identified to include *interoperability* which refers to the compatibility and data exchange related challenges associated with the high levels of heterogeneity in software and IT systems used across the SC (Aranda-Mena and Wakefield, 2006). Several case studies of BIM have highlighted high levels of cost and technical effort in remedying interoperability making it a key determinant of implementation success (Sargent *et al.*, 2012). *Cost* of implementation or acquisition has also been a major factor affecting BIM implementation decisions (Lee *et al.*, 2012). With the high numbers of small firms within the SC and a perception of high cost of implementation, it is unclear whether the anticipated benefits will outweigh perceptions of associated high cost (Robson *et al.*, 2014). *Integration capability* refers to the ability of BIM to deliver key objectives of integration within the SC. Related benefits of BIM with regards SC integration include delivering information, flow efficiency and effectiveness, transparency, visibility and collaboration (Dainty *et al.*, 2001; Hu, 2008; Mohamed, 2003). Other critical issues in relation to this element is early involvement, coordination and control of supply (Vrijhoef, 2011). *Security and privacy* concerns are critical in the SC because issues such as intellectual property theft and accidental data losses remain a critical concern in digital collaborative environments (Smith *et al.*, 2007). There however remains a lack of understanding of the role of the characteristics of technology on these risks or perceived risk as this is critical for designing measures to foretell them in the deployment of BIM (Mahamadu *et al.*, 2013). *Scalability and information risks* refer to the ability and capacity of individual SC systems to handle ever increasing volume and complexity of BIM based data. This is primarily caused by high levels of attached data including product or operational data from SC (Eastman *et al.*, 2008). The scale and transitional requirements of data across the lifecycle of facilities therefore poses significant risk which may require additional effort by SC to become BIM compliant or to manage related data quality issues that may emanate from this (Singh *et al.*, 2011). *Standards* are developed to ensure streamlined and consistent approach to managing BIM systems and data exchange

(Eastman, *et al.*, 2008). The Industry Foundation Classes (IFC) (by the International Alliance of Interoperability) and International Organization for Standardization's (ISO) specification (ISO/PAS 16739) have proliferated recently largely for the purpose of achieving a unified approach to describing data structures and rules for encoding project information (Howard and Björk, 2008; Singh, *et al.*, 2011). Widely fragmented state of development across the various disciplines also makes adoptability and universality challenging (Howard and Björk, 2008). The importance of current approaches and the extent to which this affects implementation of BIM is however not clearly known.

Organisational Determinants of Acceptance

This aspect of technology acceptance is most critical in dealing with the inter-organisational context of the SC. According to the TOE framework, related factors in this dimension often border on the transactional and social relational aspects of technology usage (Tornatzky and Fleischer, 1990). IT usage is underpinned by a web of social actions motivated by business objectives (Venkatesh *et al.*, 2003). Thus, the structure, power and control dynamics, socio-cultural and transaction cost context of relationships and their relative influence on collaborative information exchange needs further investigation (Davies and Harty, 2013). This therefore considers factors related to prevailing organisational conditions that affect BIM usage for inter-organisational communications within a commercially driven environment.

The widely reported determinants include *executive (focal supplier) support* which refers to the decision by leadership within an organisation to commit resources for BIM implementation. This is often based on top management willingness which might be influenced by perceptions of risk (Sargent, *et al.*, 2012). This, in the SC context may be focal firms such as main contractors or first tier suppliers (Vrijhoef, 2011). Sargent *et al.*, (2012) found such executive commitment as having direct impact on BIM acceptance. *Trust* has more recently been recognised as a key influencer of SC performance (Briscoe and Dainty, 2005). According to social exchange theory, inter-organisational trust influences the ability of partners to adjust for uncertainties within exchange relationships including the use of integrative technologies (Wei, *et al.*, 2012) such as BIM. Extensions of UTAUT have generally incorporated measurement of the impact of trust particularly where transactional or inter-organisational related risk exist (Luo *et al.*, 2010). This is particularly important in view of ambiguity and legal constraints concerning ownership of data in these open BIM environments (Gu and London, 2010). *Competence and capacity* is regarded as a vital influencer of BIM implementation and acceptance by SC (Robson *et al.*, 2014). Such capacity and competence include the human, financial and technical resource needed to deliver BIM (Eastman *et al.*, 2008). It however remains unclear which level of competence or capacity will be required for each participant. *Legal risks* perceptions often moderate the actions of project actors, particularly where multi-party interactions are mediated by IT (Hassan *et al.*, 2004). However, the conceptual ambiguity in the definitions of the BIM process and the relative misperceptions in practice however create significant legal uncertainties (Eastman *et al.*, 2008; Gu and London, 2010). It is reported that current contracts have not adequately catered for the uncertainties and risks associated with digitally mediated integration (McAdam, 2010). Further, it is unclear how these influence BIM acceptance and usage.

Environmental Determinants of Acceptance

This represents the arena in which a firm conducts its business (industry, competitors, and governmental). Such industry level factors or prevailing conditions influence actions of technology adopters (Tornatzky and Fleischer, 1990). These external factors include technology vendor related issues which significantly affect the usability of technology (Oliveira and Martins, 2011).

Competitive pressure is a key determinant in the use of BIM within the SC context because of the general commercial nature of relationships within that environment (Khosrowshahi, 2012). Apart from coercive powers that influence strategy (e.g., rewards and threats), it has been found that the desire to remain in business could affect BIM acceptance (Adriaanse, *et al.*, 2010). *Image*: If organisations believe they can receive industry rewards by using BIM, they will develop more positive attitudes and intentions towards the use of BIM (Lee *et al.*, 2012). Such rewards include recognition as being innovators or having technological ability which may serve as extrinsic motivation to alleviate some of the challenges and risks (Adriaanse *et al.*, 2010). *Vendor support and training* including up-skilling affects the ability to adapt (Lee, *et al.*, 2013). Similarly, the provision of after-sales support by vendors of BIM systems, may serve as an appropriate facilitating condition for its continued usage (Xu, *et al.*, 2014). *Industry leadership and support* including governmental intervention is believed to be a key driver of enabling environment. If U.K government targets of universal adoption will be met, SC firms will require adequate industry support, capacity building or even promotion (Robson, *et al.*, 2014). Available guidance and protocols or other incentives that may reduce effort required to implement BIM is therefore needed (BIS, 2011). The real impact of such support on SC integration through BIM is yet to be ascertained. *Procurement* is used in establishing the basic governance framework for SC relations including their integration (Vrijhoef, 2011; Dainty, *et al.*, 2001). While some particular forms have been advocated for integration, it is unclear what their contribution will be in facilitating BIM based integration and implementation (McAdam, 2010). In view of the challenges in achieving integration through procurement in the past, it is imperative to ascertain its role in successful BIM based integration.

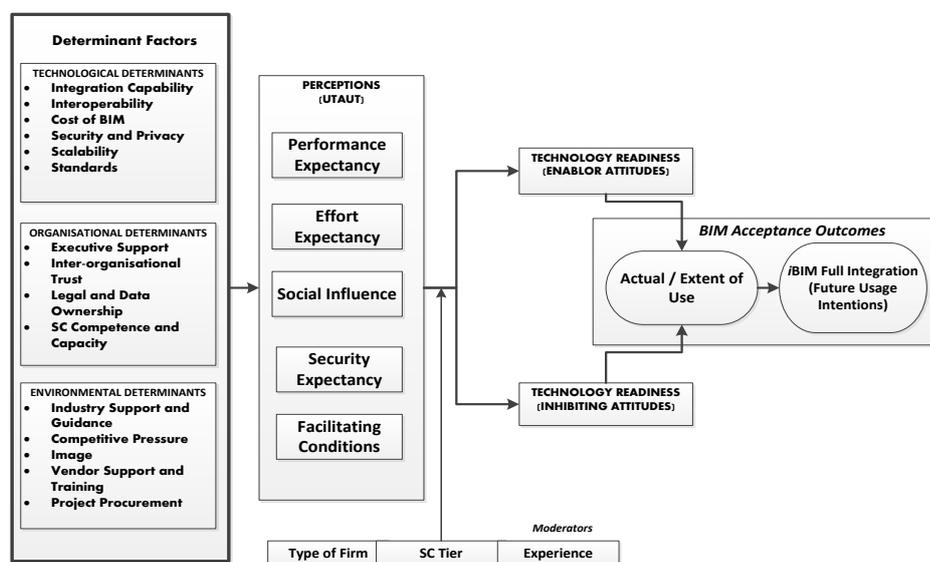
Incorporating Technology Readiness (TR) in Assessing BIM Usage Intentions

Building on the proposed concept of UTAUT-TOE modelling of acceptance, TR measures proposed by Parasuraman (2000) is regarded as appropriate for assessing the synergistic effects of acceptance determinants on the extent and intentions to use BIM for SC integration. Devolder *et al.* (2008) advocated that acceptance research must integrate user traits that reflect their preparedness to use a new technology. This is referred to by Parasuraman (2000) as technology readiness (TR) representing the complex interactions between conflicting positive (enablers) and negative (inhibitors) feelings about such technology usage. TR enablers include attitudes associated with optimism while inhibitors relate to constructs that measure feeling of insecurity (Parasuraman, 2000). TR is regarded as a suitable measure of user intentions which represent a user's affective response to new technology (Devolder *et al.*, 2008). Its incorporation therefore provides a platform for more holistic readiness assessment where the cognitive dimensions (perceptions of consequence) play a key role in assessing readiness (affective response). This is in contrast to the current limitation of readiness assessment which have focussed on resource-centred capability and maturity modelling of readiness (see Haron, 2013).

Contextual participant attributes is also acknowledged as a determinant of variation in acceptance studies (Venkatesh *et al.*, 2003). SC firm’s professions, size, experience and role within the SC (ie Tier of the supplier they participate in) is therefore regarded as important in assessing peculiarity of acceptance from the varied perspectives of the SC. Such attributes therefore need to be incorporated as moderators in the modelling of BIM acceptance.

Drawing from the foregoing discussion, Figure 1 is represented to show the relationships between the key themes of BIM acceptance for SC integration. The integrated model adapted from UTAUT model (Luo *et al.*, 2010; Venkatesh *et al.*, 2003) and TOE frameworks (Tornatzky and Fleischer, 1990) for identifying and categorising determinants of acceptance. TR is incorporated to assess aggregated contribution of determinants on user disposition towards use.

Figure 1: An integrated Acceptance model for BIM in Construction SC



CONCLUSION

BIM has become a prerequisite in delivering integrated construction SC practice. Adoption is, however, still slow due to a plethora of implementation challenges. A theoretical model to aid further investigation of such challenges is proposed with a focus on the role and influence of user perceptions about the consequence of implementation. The relationships between the key determinants of acceptance is established from the literature and are forwarded as critical criteria for assessing implementation success, in view of its likely impact on willingness and preparedness of the SC to use BIM. TOE framework is incorporated into UTAUT to provide a wide arm for exploring stimulus for SC acceptance of BIM based on a categorisation that reflects growing recognition of the socio-technical complexities of the SC. From this model it is demonstrated that user acceptance plays a major role in understanding BIM implementation within the SC context. A conceptual model of influencing factors affecting acceptance and associated usage behaviours of BIM in the SC context is thus demonstrated to guide future research. It is recommended that future research adopts this model as a framework for the exploration of determinants particularly to assess their suitability in the construction SC context as well as for empirical validation.

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CHALLENGES TO BUILDING INFORMATION MODELLING IMPLEMENTATION IN UK: DESIGNERS' PERSPECTIVES

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Building information modelling (BIM) has been proposed as a technology enabled process for the realisation of the performance ambitions of the construction industry through integrated management of information in virtual 3-D formats. Significant challenges however exist which undermine its implementation within the construction industry. The identification of these challenges is an imperative precondition for successful implementation of BIM given the associated risk. The design phase has particularly been cited as a significant beneficiary of process improvement and efficiency gains expected from the deployment of BIM. Despite the critical role of the design phase to project delivery and consequently BIM usage, few studies have sought to interrogate the challenges faced by designers. A qualitative approach was adopted through semi-structured interviews to solicit perspectives of UK design firms on the implementation challenges being faced. Findings reveal a categorisation of challenges as design-specific, team-orientated, project-related, technology related (BIM specific), industry-wide challenges and cost. This categorisation is used as a basis for identifying critical challenges which include: design process lag and loss of time; lack of understanding by clients regarding requirements for the BIM model; lack of learning feedback from projects on which BIM has been used; and lack of supply chain integration. Variation in the challenges across different maturity levels of firms is also confirmed in this study, particularly in relation to cost of implementation. Awareness of these challenges provides opportunities for identifying effective solutions for their mitigation.

Keywords: BIM, designers, qualitative research.

INTRODUCTION

For the past two (2) decades, effective and efficient delivery have been a major challenge within the construction industry, with fragmentation being one of the key contributors to the under-performance in the delivery process (Latham, 1994; Egan, 1998; Cabinet Office, 2011). Some of the cited performance issues include: lack of cost and time certainty in the delivery process; quality of finished product; adversarial culture; unmanageably delegated risks and rewards (Latham, 1994; Egan, 1998). Lack of integration within a loosely coupled project delivery process prevents effective communication and collaboration towards aligning the interests of project participants and streamlining project delivery into a single well-co-ordinated process

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(Egan, 1998). Such a process, underpinned by effective information and knowledge sharing which is enabled by the application of information and communication technology (ICT), is being promoted as one of the key catalyst towards improvement within the construction industry (Arayici *et al.*, 2012a). More recently a new process related to innovation underpinned by virtual 3-D communications has emerged promising to revolutionise the extent of integration and collaboration within the project delivery process (Eastman *et al.*, 2011; Arayici *et al.*, 2012a). This innovation referred to as building information modelling (BIM), is defined as a "*process involving the structured sharing and coordination of digital information about a building throughout the lifecycle*" (Eastman *et al.*, 2011).

In the UK, the Government construction strategy (Cabinet Office, 2011) has given greater impetus to BIM adoption with the expectation of realising a host of benefits. Full realisation of benefits however relies on an industry-wide adoption of BIM which however appears to be fraught with several challenges. This study looks into the challenges to BIM usage from the perspective of designers. In the sections that follow, a background literature review on BIM covering developments on BIM, its benefits and implementation challenges is presented. Subsequently the research method adopted for this study, and the resulting findings and conclusions are presented.

LITERATURE REVIEW

BIM is regarded as a collaborative technology that achieves the levels of integration envisaged as being capable of eliminating most of the communication related delivery challenges of the industry (Eastman *et al.*, 2011). Although it has been in existence for decades (van Nederveen and Tolman, 1992), it has only been popularly used in recent years (Eastman *et al.*, 2011). In the UK, BIM is more widely discussed due to the Government's construction strategy to implement BIM level 2 on all government projects by 2016 in a road map towards universal adoption of BIM across the industry (Cabinet Office, 2011). Government's expectation includes the delivery of efficiency, improved carbon performance and up to 20% cost reduction on public projects through systematic adoption of BIM (Cabinet Office, 2011). It is expected that the achievement of these targets will be delivered via the benefits associated with BIM. The realisation of these benefits is however being undermined by several socio-technical issues. The following sections discuss these issues together with the benefits of BIM.

BIM Benefits

The benefits of implementing BIM in a construction project are copious. They include: early collaborative decision-making; increased design clarity; strong link between design and costs; early virtual prototyping; improved visualisations and simulations; reduced waste; decreased errors in documents; reduced costs; better construction outcomes; higher predictability of performance; and real-time data sharing between all disciplines from cradle to grave (Suermann, 2009; Azhar, 2011; Bryde *et al.*, 2013). Beyond these are also specific benefits to the various project participants. Clients are expected to benefit from better requirement capturing due to enhanced communication with the design team (Eastman *et al.*, 2011; Arayici *et al.*, 2012b). Designers are also expected to achieve increased clarity in design intent, easy testing of design options, and easy distribution of design documentation across the teams (Arayici *et al.*, 2011; Azhar, 2011). Benefits to contractors include access to better quality information for estimation and bidding; early involvement to contribute to constructability and effective scheduling; and clash free construction due to ability

to simulate before actual construction (Suermann, 2009; Sebastian, 2010). Some benefits attributed to facilities management include enhanced quality of as-built and handing-over information, and easier integration into computer aided facilities management (CAFM) systems for maintenance and post occupancy assessments (Azhar, 2011; Arayici *et al.*, 2012b). Despite the touted and sometimes demonstrated benefits from case studies, there are fundamental socio-technical issues which continue to decelerate the industry's wider adoption and implementation of BIM (Bernstein and Pittman, 2005; Arayici *et al.*, 2012a).

BIM Challenges

Many of the challenges contributing to slow adoption of BIM have widely been reported from various viewpoints. According to Newton and Chileshe (2012, pp.3-12), the most highly-ranked challenges, based on a survey in the Australian construction industry are: 'lack of understanding about BIM', 'education and training costs', 'start-up costs' and 'changing the way firms do business'. The high expectation of information sharing requires organisational interoperability. This is often regarded as a contributory factor to legal challenges and possible disputes emanating from ambiguity about data ownership, copyright and data protection (Azhar, 2011). Some other reported challenges include: overcoming the endemic resistance to change; adaptation to traditional and existing processes and task workflows; and awareness and clear understanding of the responsibilities of different actors in a typical project organisation (Eastman *et al.*, 2011; Arayici *et al.*, 2011; 2012a). Authority and control over information involving diverse parties has been cited as a key challenge (Davies and Harty, 2013). There is also some uncertainty as to who to bare the associated costs of implementation (Azhar, 2011). Some of the challenges have also been attributed to relatively low capacity, capability and extent of development of BIM related technologies. This includes lack of information technology (IT) resources and network capability to run BIM applications competently (Eastman *et al.*, 2011; Singh *et al.*, 2011). Lack of interoperability due to a lack of standardised approaches to sharing data across diverse proprietary information systems and software is seen as a major challenge (Eastman *et al.*, 2011; Gu and London, 2010). The general unavailability of vendor-neutral data formats and standards, as well as issues regarding accessibility and security of data are challenges yet to be appropriately addressed (Singh *et al.*, 2011; Mahamadu *et al.*, 2013). According to Fischer and Kunz (2006) the lack of awareness or promotion through standardised guidelines and implementation support impedes successful adoption. BIM specific requirements are yet to be adequately embedded within current state of procurement and legal structures in order to alleviate some of the above-mentioned challenges (McAdam, 2010).

The above discussion demonstrates that BIM implementation challenges have been a subject of considerable attention. However, in the main, studies which have reported on BIM implementation challenges have not done so with an in-depth focus on a specific profession/project participant. Despite the emergence of discipline/profession-specific studies in relation to BIM implementation (e.g. BCIS, 2011), few of such studies have focused on an in-depth analysis of challenges.

Towards interrogating profession-specific challenges of BIM implementation

Whereas the benefits of BIM to various construction professions/project participants have been widely reported (see Sebastian, 2010; Bryde *et al.*, 2013), similar profession/project participant focus on the challenges has not gain much research attention. A few of the studies which have explored profession-specific challenges

include works by Williams (2013) and BCIS (2011) which provide some insights from the perspective of facilities managers, quantity surveyors and building surveyors. The need for profession/project participant-specific studies has been highlighted by several industry BIM surveys (within and outside UK) which indicate significantly varied levels of BIM awareness and perceptions of BIM challenges across various professions (see McGraw-Hill Construction, 2010; NBS, 2012). Other studies have also highlighted the role of contextual profession-specific attributes such as industrial norms and environmental settings within which each profession operates as determinants of their perceptions about BIM (Jacobsson and Linderoth, 2010; Davies and Harty, 2013). Such professional dispositions and perceptions invariably affect adoptability as a result of variations in readiness, capability, and maturity of these professions (Jacobsson and Linderoth, 2010; Davies and Harty, 2013).

In summary, the foregoing discussion points to the need for further studies to explore profession-specific challenges to BIM implementation. Given that the various professions/project participants will have to engage with BIM within their respective functions/roles (albeit in a collaborative manner), it is crucial to identify any challenges these professions/project participants may be encountering.

The need to explore challenges being faced by designers

In exploring profession/project participant-specific issues regarding BIM implementation, it is worth interrogating the challenges being experienced by designers. It is well established that the most important project decisions are often made during the design stage which has significant impacts on the subsequent stages of a project (Uher and Loosemore, 2004). For instance, it is estimated that approximately 70% to 80% of a project's lifecycle costs are determined during the design phase (Mileham *et al.*, 1992). Also decisions made during the design phase have a significant impact on other project outcomes such as health and safety (Manu *et al.*, 2012; 2014). Undoubtedly, design decisions are thus crucial in project delivery. The profound significance of decisions by designers makes any efforts towards facilitating BIM implementation by designers very vital, hence the need for in-depth exploration of designer challenges to BIM implementation. This research therefore aimed at investigating the challenges faced by designers (i.e. design firms) in the implementation of BIM within the UK construction industry.

METHODOLOGY

The research aim of exploring the challenges to BIM implementation for a specific context (i.e. designers) requires exploration of personal opinions, experiences and knowledge within the domain. Qualitative research is capable of providing the opportunity to discover any peculiarities to designers from their opinions, impressions and experiences through in-depth examination of issues (Hartman *et al.*, 2009).

Adriaanse (2007) cited methodological issues (i.e. over-reliance on quantitative and positivist perspectives) as a cause of limited explanatory powers of current knowledge on adoption of IT within the construction industry. In view of the 'novelty' of BIM, it is recommended that more qualitative approaches are deployed to explore context to greater depths (Hartman *et al.*, 2009). More recently, studies employing qualitative approaches are beginning to emerge (e.g. Adriaanse, 2007; Harty, 2012). Such qualitative studies are better positioned to aid inductive development of theory and conceptual propositions on adoption which is vital in view of the 'novelty' of BIM (Hartman *et al.*, 2009). For this study, qualitative interviews (semi-structured) were used to collect data from design firms. The interviews were designed to probe their

perceptions, attitudes and experiences relating to challenges faced in implementing BIM. To obtain the participation of design firms (i.e. architectural and engineering), invitations were sent to 60 design firms operating within the London region of UK. Out of these, the participation of 10 firms was obtained. The profile of the firms and the interviewees within them are shown in Table 1. The interviews were audio-recorded and subsequently transcribed and cross-checked to correct any errors. The transcripts were read and re-read iteratively and coded with the aid of QSR NVivo 10 leading to the generation of themes.

Table 1: Profile of design firms

<i>Firms</i>	<i>Type of Design Firm</i>	<i>Size of Firm (by no. of employees)*</i>	<i>Approximate Years of BIM usage experience</i>	<i>Role of Interviewee with Firm</i>
A	Engineering Design	Large	7 years	Structural CAD technician
B	Architectural and Engineering Design	Large	7 years	Digital Design Representative
C	Transport Systems	Large	None	Project engineer
D	Architectural	Large	9 years	Applications Administrator and BIM Manager
E	Architectural	Small	1 year	Architect
F	Engineering Services, Facilities and Energy Management	Large	12 years	Engineering and Energy Director
G	Architectural	Large	None	CAD and Design Manager
H	Architectural	Large	2 years	BIM Manager
I	Architectural and Interior Design	Medium	0.5 years	BIM Manager and Design Team Lead
J	Architectural	Small	1 year	Architect

*Firm size: micro < 10, small < 50 employees, medium < 250 employees, and large \geq 250 employees (European Commission, 2005).

As shown by Table 1 above, the firms include architectural and engineering design firms. The firms vary in size and they also have varying years of experience of BIM usage. These variations enriched the data in terms of providing the opportunity to explore differences in the perceptions or experiences of BIM challenges.

FINDINGS AND DISCUSSION

The analysis resulted in the categorisation of challenges in key thematic areas. It was emergent that the challenges could be classified as: Design-specific, inference to challenges faced by the designers that are very specific to design tasks and suitability of BIM for undertaking them; Team-oriented (i.e. challenges faced by the designers in relation to teamwork, collaboration and cooperation with other project participants); Project-related (i.e. challenges related to temporal organisation rhetoric of the construction industry as well as barriers related to the delivery of individual projects rather than business within the firms); Industry-related (i.e. challenges related to barriers imposed by wider industry conditions including frameworks for supporting BIM implementation); BIM specific (i.e. challenges related to the inherent characteristics of BIM technologies including software and infrastructure issues); and lastly challenges pertaining to the Cost of adopting BIM. The emerging issues are discussed in these thematic areas. The discussion is also interspersed with sample

quotations from the interviews to demonstrate grounding of the findings in the interviewees' own words.

Design-specific challenges

A critical challenge highlighted by participants was that *"people are used to working in much simpler ways where lines are just lines and they aren't 3D objects"* [Firm D - Applications Administrator and BIM Manager]. It was also commented that BIM is *"a massive system overhaul where you have to completely change the work and all the processes"* [Firm A-Structural CAD technician]. This challenge is also mentioned in literature as changing the way firms do business (Newton and Chileshe, 2012) and adaptation to new process (Arayici *et al.*, 2011). Tailored training to accommodate the necessary process redesign was viewed as a key issue similarly reported by Newton and Chileshe (2012). Another design-specific challenge is the loss of time and lag in the design process resulting from setting up of the BIM model and passing it between different team members. Commenting on this, an interviewee for instance mentioned that, *"The initial creation of the model - that is very different. You need a lot more time to build up the model with a lot more information upfront, time to go away and do the modelling. Whereas before you would draw up the CAD drawings as the information was fed through"* [Firm A - Structural CAD technician].

Team-orientated challenges

These challenges include: a lack of understanding by clients regarding their requirements for the BIM model, problems with facilities management, and supply chain congruence on the manner in which to engage with BIM. Examples of interviewee comments reflecting these are:

"It is a problem when certain companies use BIM only commercially in the business development angle rather than from a process and system development angle." [Firm F - Engineering and Energy Director].

"The clients need to be further educated on BIM so that they know what to expect but currently they don't understand enough" [Firm D – Applications Administrator and BIM manager]

Within literature, similar issues that prevent the ability of actors across the entire delivery process to effectively integrate have been highlighted (Gu and London, 2010; Harty, 2012; Newton and Chileshe, 2012). For instance, Azhar (2011) mentioned that facilities managers usually have limited involvement in the early phases of projects, despite the advent of BIM. This is indicative of structural and industrial norms which may still be impeding effective collaboration in spite of the integrative communication capabilities of BIM. Additionally, uncertainty by clients has also been noted in literature (Cabinet Office, 2011). Another challenge is the lack of integration from the supply chain as some manufacturers are not convinced that investing in BIM in the UK will be a worthwhile investment. In view of this it was mentioned that, *"Another challenge is supply chain integration whereby a big problem is with major international manufacturers where the UK is a fairly small proportion of their business, therefore for them to invest in UK-centric BIM would not add value to them."* [Firm F - Engineering and Energy Director].

Project-related challenges

The project-related challenges that surfaced from the interviews are insurance and uncertainty of chosen route to implement BIM through existing project procurement

strategies. A comment relating to this is: *"Intellectual property, who owns the risks and responsibilities, can be difficult to determine due to the level of sharing on BIM. We find ourselves outside our level of insurance at times just because the insurance hasn't adapted to the new ways by which people are having to work."* [Firm I - BIM Manager and Design Team Leader]. Azhar (2011) also highlight that BIM creates further risks and liabilities due to indistinct responsibilities of every project member where errors will be difficult to determine and prove.

Industry-related challenges

It was expressed that project deliverables (i.e. drawings) need to be modified from a contractual perspective and that there is lack of clear guidelines and standards for implementing BIM. The latter challenge is even more pronounced among large multinational firms where due to different requirements in different countries, it is difficult for them to standardise their work. Whilst it was mentioned that existing guidelines and standards require further clarity, it was also acknowledged that they have some usefulness. Another challenge is the lack of adequate learning feedback from projects on which BIM has been used. It was felt that such feedback is important in improving the understanding of BIM amongst project participants and that it is also important in informing investment decision regarding BIM. A selection of the interviewee comments relating to the industry-related challenges are:

"One of the larger issues for the industry is that the requirements are changing but the deliverables haven't changed from a contractual perspective. Until 2D deliverables are gone or at least refined, we are going to have a lot of problems. Until the system changes, the deliverables change, and it is contractually obligated to use BIM, there will be a challenge." [Firm D - Applications Administrator and BIM Manager]

"Due to the lack of learning feedback, we are struggling to understand" [Firm F – Engineering and Energy Director]

"With a large company like ours where firms are worldwide, it is difficult to standardise work as they all have different requirements in different countries" [Firm D - Applications Administrator and BIM Manager]

The Government has provided significant leadership and promotion of BIM through frameworks and guidance (Cabinet Office, 2011; NBS, 2012). It has however been reported that some of these remain inconsistent or have not been effectively synergised within existing procurement practices and related documentation (McAdam, 2010). The implementation challenges have similarly been attributed to lack of case studies to serve as benchmarks and knowledge base for training and implementation guidance (Gu and London, 2010).

BIM-specific (technology) challenges

There were challenges faced by the designers that are specifically related to the BIM technology itself as evident by comments such as, *"There is still anxiety generally for people to use it."* [Firm J - Architect]. Such anxiety is related to the complexity and lack of understanding surrounding BIM (see Newton and Chileshe, 2012). It is also reported in the literature that adopting a new integrated technology in general is a challenge due to coordination and interoperability of different software packages (see Bernstein and Pittman, 2005) and the lack of designers who are competent and conversant with BIM (Harty, 2012). The issue of interoperability was again highlighted in the interviews as shown by the quote below.

"There are a lot of different disciplines that use different bits of software. Historically, architects tend to use Microstation, a Bentley product; structures tend to use Autodesk Revit or AutoCAD, so there are rival companies. The barrier is getting the completely two different bits of software to talk to each other effectively." [Firm A - Structural CAD technician].

BIM cost challenge

The cost of implementing BIM as a firm was considered to include: software cost; hardware cost; training cost; hiring new employees with BIM competence; and hiring an external BIM consultant. Whilst some of these costs (e.g. software cost) are easy to quantify in monetary terms, costs relating to the process of up-skilling employees is more difficult to estimate. In particular, it is difficult to quantify the cost relating to the reduction in employees' productivity as they learn to become conversant with BIM. Also, whilst cost of implementing BIM appeared to be a main concern for the small firms, cost did not seem a prioritised challenge to the large firms. Below are sample quotes regarding the cost of BIM implementation.

"We did have to upgrade some of the older computers with enough power to run all the CAD programs, graphics and BIM." [Firm H - BIM Manager]

"The cost that can't be easily quantified is the drop in the employee's productivity while they get up to speed in learning the software... The cost of the learning curve is difficult to quantify." [Firm I - BIM Manager and Design Team Leader]

The costs of implementing BIM are also accentuated in literature as a challenge by Azhar (2011).

CONCLUSIONS

Previous studies on BIM have, in the main, not accorded much attention to in-depth exploration of challenges being faced by specific industry professional groups/project participants. Contributing to these studies, this research has explored BIM adoption and implementation challenges particularly from the perspective of designers. Key challenges identified include: cost of deployment especially in the case of small design firms; changes to existing ways/processes of designing; process lag and loss of time due to the creation of the BIM model and passing it between other project participants; lack of understanding by clients; lack of learning feedback; issues of interoperability; lack of supply chain integration; and lack of clear guidelines and standards. Whilst some of these challenge share similarity with other challenges reported in previous studies, the specific profession (i.e. designers) focus given by this study provides further opportunity for exploring and identifying tailored solutions to address the challenges being faced by this professional group.

Furthermore, in view of the criticality of the cost of BIM implementation, especially to small design firms, the existence of thorough cost-benefit assessments to evidence return on investment (in the short and long term) would be useful to facilitate decision-making.

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INTERACTIVE VISUALISATION OF HEAT LOSS AND GAIN FOR EARLY-STAGE ENERGY APPRAISAL OF THE BUILT ENVIRONMENT

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Integration of Building Information Modelling (BIM) within the scope of commercial operations of Small to Medium Enterprises (SMEs) is becoming more important as the deadline for the 2016 UK government guidelines for collaborative information sharing approaches. Until recently, open source and more affordable BIM software tools were almost non-existent. Instead potential users of BIM tools invested time and money in expensive and complex BIM software solutions. Energy appraisal modelling and visualisation is now becoming possible to implement using BIM methodology. However, even top end BIM software tools do not necessarily meet the requirements of SMEs as they are either too complex, too expensive or lack the necessary features for energy appraisal and visualisation. A custom 3D software tool was developed for an SME specialising in low carbon housing, with the aim of influencing early design choices maximising energy efficiency. The software tool is designed to be a quick calculation tool that uses BIM principals for visualisation and limited data exchange. The software tool, based on computation models from the Passive House Planning Package (PHPP), appropriate for early energy appraisal, is able to compute both numerically and visually the estimated energy usage and solar gain for early stage building designs (corresponding to the Level of Detail (LOD) 100 BIM maturity levels specification). We will describe the design and development process of the software tool, software validation and testing results. We conclude that the software tool can offer a beneficial alternative or used in addition with more complex and expensive 3D BIM tools and features a less steep learning curve.

Keywords: BIM, games technology, stakeholder engagement, energy appraisal.

INTRODUCTION

Building Information Modelling (BIM) is now prevalent within the architectural, civil engineering and construction management professions. The BIM standard is set to become a standard within these industries by 2016 in the UK. At the moment, a significant drawback for small to medium enterprises (SMEs) is investing time and money in purchasing and learning to use high end BIM software packages. As previous research has suggested (Friese *et al* 2008), games based technology has the potential to provide an affordable and flexible alternative when it comes to developing low-cost, fully interactive, robust and flexible software (Isaacs *et al* 2010). BIM can

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also be applied at the early design stage of a building project in order to facilitate sustainability assessment and stakeholder engagement, thus reducing the additional costs of doing this later in the project (Hope and Alwan 2013). We applied games technology to develop a custom interactive 3D modelling and visualisation tool, based on PHPP calculations directed by the needs of two SMEs and with additional input from an academic. The software tool is based in terms of its visualisation and computational functionality on BIM principals, but is limited in terms of its focus only to early stage energy appraisal. 3D PHPP is not a pure BIM software tool, but rather an accessible visual and numerical computation tool that extends the PHPP calculations to include interactive visualisation components. Early stage energy appraisal was deemed important by the clients as it could potentially decrease the carbon footprint of buildings using the Passive House standard by 50% to 65% (Joosten *et al* 2005). Based from initial discussion with the clients it was decided that the primary requirement should focus on early design stage energy appraisal.

SUPPORTING LITERATURE

Interactive visualisation of early stage energy appraisal is a distinct lacking feature of the PHPP software package. While PHPP is able to approximate the numerical results of energy indicators for building designs, the visualisation of such indicators and their associated components is lacking. Previous research aimed at providing involved stakeholders with clear and concise data about energy performance of building designs has been discussed by (Charalambides and Wright 2013). Software such as Autodesk Ecotect is able to tie the numerical data with an interactive 3D visualisation, but requires extensive parameter input and recalculation if any changes to the 3D building envelope are made. An add-on for the Google Sketchup software to visualise PHPP scenarios (Malzer and Edwards 2013), has been released in December 2013 - but at present only a commercial version of the software is available. Interactive visualisation and modelling have been proved to be one of the key requirements for utilizing BIM concepts and putting them in practice (Baker and Garret 2011). (Whyte *et al* 2000) highlighted the benefits of interactive 3D visualisation for CAD applications. The fact that it was published over 14 years ago shows the recognition of importance for interactive 3D visualisation by the CAD community before BIM became a mainstream and standard. The paper also describes the potential benefits of a collaborative data sharing approach within the virtual environment. The concept of collaborative design is also mentioned by (Whyte *et al* 2000) as one of the key strengths of interactive visualisation. (Plume *et al* 2007) describes how the use of the IFC file format for collaborative data exchange was tested within an educational context. The paper describes the benefits as well as the disadvantages of using the IFC file format within a collaborative educational environment. This paper describes the benefits as well as the disadvantages of using the IFC file format within a collaborative educational environment. This is important as the paper describes user group tests that were carried out in 2004 and 2005, where students collaborated and exchanged building model data using the IFC file format. This is especially important as BIM methodologies are for example being integrated into the academic curriculum worldwide and the need to present and assess building designs at various BIM stages is crucial in order to communicate with the involved stakeholders (Glick *et al* 2012). Using BIM methodology for early stage sustainable building designs has the advantage of providing transparent involvement for all engaged stakeholders and providing a framework for collaboration (Bryde *et al* 2013). In terms of visualisation,

3D PHPP focuses on the ‘envelope’ or schematic visualisation model of the building – showing only the shell of the building and the key exterior structural support. In this paper we use the Level of Detail (LOD) 100 BIM maturity level terminology to describe conceptual building geometry (BSI 2013). The use of BIM visualisation in order to visualise energy appraisal within the building design constraints of a given standard such as the Passive House Standard can cut down costs at the initial stages and increase building performance through out its life cycle (Morrissey *et al* 2005).

METHODOLOGY OVERVIEW

Games based technology used for development

Having access to a simple, robust and reliable tool for the computation and visualisation of early stage energy appraisal (3D PHPP) was the core requirement for this project set by the SMEs and academics involved with the project. Specifically the requirements of 3D PHPP were to implement heat loss and gain calculations as in PHPP, with the additional benefit of interactive visualisation, navigation and ease of use. Given our previous research and development in the games technology for sustainability assessment and visualisation, this approach was adopted to meet the clients requirements. The 3D PHPP software tool was developed using Unity 3D. Unity 3D is a leading games engine (Lee 2013) and allows for rapid application development of games prototypes. The need to incorporate BIM software principals exposed the need to handle different file formats for importing and exporting geometry and associated building information data. This required the use of a file system and it was decided to create 3D PHPP as an extension to the Unity 3D editor. This would allow the software tool to make use of the existing file system functionality tied to the Unity 3D editor, as well as to allow use of the Unity 3D

“prefab” objects library - which can be thought of as similar to a BIM server component library, thus enabling easy sharing of building models created within Unity (see Figure 1). We additionally implemented the feature of being able to import LOD 100 geometry from IFC files into 3D PHPP. This enables users to create their building designs using their preferred BIM software and export the LOD 100 geometry into 3D PHPP for energy appraisal testing. This makes the design of 3D PHPP conform to the core BIM concept of accessible and collaborative data sharing.

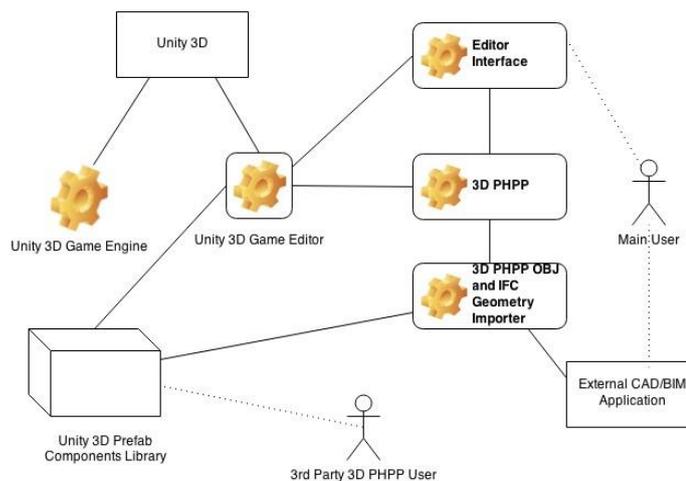


Figure 1: Relationship diagram showing the integration of the 3D PHPP tool with the Unity 3D editor, the Unity 3D Game Engine and the Unity 3D Prefab Components library.

Another important reason for creating the 3D PHPP software tool as an extension to the Unity 3D editor is that it allows 3D PHPP to use most of the existing editor

features, such as real-time interactive object selection and manipulation, different camera projection models for viewing the scene in different ways - as well as both standard and non-standard camera control schemes. Most of these editor features align with 3D editor features found in commercial CAD software packages (Autodesk 2003). The version of Unity 3D that was used to develop the 3D PHPP is free for academic and non-commercial use (and even limited commercial use), and allows potential users to use 3D PHPP for free (provided they have access to the free version of Unity 3D). The current version of the 3D PHPP is tied to the Unity 3D editor and is designed to work on modern Microsoft Windows computers. Unity 3D is also able to run Mac OSX, Linux, Web browser and Android platforms, and this provides an interesting opportunity for future versions of the 3D PHPP software tool to be developed to run on these platforms.

CASE STUDY

3D PHPP was used to assess the effect of building location and orientation on energy appraisal of building designs for a site in Dundee that is currently being developed (see Figure 2). The default concept building model we used is 100 square meters and the height expected to be no more than two storeys in line with the existing buildings. A recommended minimum building floor space for Passive Houses is 70 square meters (Mead and Brylewski 2013). A default model of what would be an open plan office space with a south facing glazed façade (see Figure 3) was selected for 3D PHPP testing.

Research and development

The initial challenge faced during the design of the 3D PHPP prototype was concerned with abstracting the “core” Passive House energy appraisal calculations relevant for early design-stage energy appraisal.



Figure 2: The location of the proposed building development on the Dundee Waterfront.

The functions listed below were selected for the initial early-stage energy appraisal after consultation with the clients involved in the project – one of which routinely uses PHPP. Additionally, we made use of the official Passive House Planning Package documentation (Passive House Institute 2014):

- Heat Loss for component (Q-value)
- Overall heat loss for the building (Q-value)

- Treated Floor Area (TFA)
- Insulation value for component (U-Value)
- Insulation value for building (U-value)
- Estimated energy consumption for building (kWh/m²)

The heat usage or heat loss, referred to as the Q-value component, is calculated using the standard formula (Weisstein 2012):

$$Q = U * A * \Delta T$$

Equation 1: The heat usage formula.

After we implemented and verified the material property calculations (Equation 1), the next major functionality component that was added to the current version of the 3D PHPP has the ability to dynamically calculate basic energy appraisal values based on custom environmental, parametric and spatial properties associated with each building model component. The inside and outside temperature difference is defined as

ΔT and the total surface area A in Equation 1 is calculated for each polygon face of the building envelope geometry. Additionally, these values can be recorded and summed for the whole building. As the user modifies the scale of the component, the total surface area value gets automatically updated. This parametric form of control is one of the main current strengths of 3D PHPP – as users can translate, rotate and scale the selected component, the spatial values tied to component get directly updated in any associated numerical calculation models.

The client was interested to see how the rotation and positioning of the building in Figure 3 would affect the solar gain of the glazed façade. The glazing value component of the façade featured in the current building model takes into account the standard glazing material components (thickness, thermal conductivity, U-value), but also includes an additional solar radiance gain calculation component that is calculated using the following custom formula:

$$S_g = (\vec{u} \cdot \vec{v}) * 1.362 * TSA$$

Equation 2: Approximated solar gain equation.

Where S_g is the solar gain variable that is calculated as the dot product between the directional coordinates of the global light (vector u), and the current rotational coordinates of the selected glazing components reference frame (vector v). This dot product value is then multiplied by a constant of 1.362, which is the approximation of the solar constant variable, calculated in kWh per meter square units (Kopp 2011). This result is then multiplied by the total surface area of the selected model glazing component – which can be dynamically updated by the user in real-time. This provides the user with the advantage of being able to edit the glazing component of the building model in real-time 3D, while simultaneously assessing the energy performance impact.

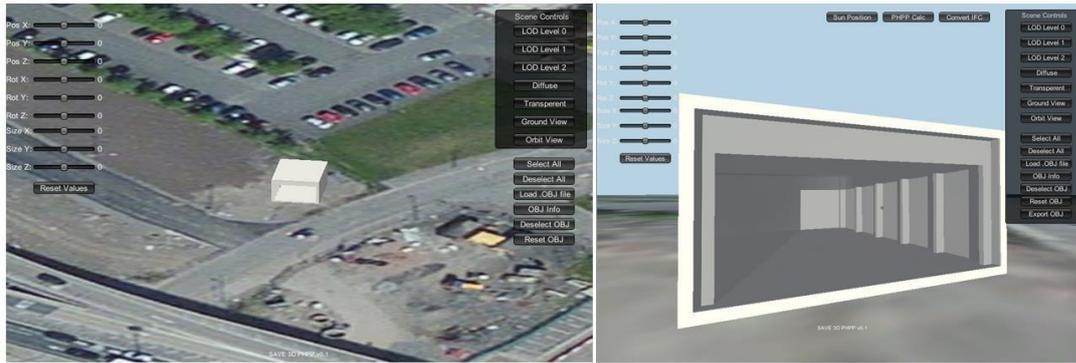


Figure 3: The site visualisation (left) of the default model and the glazing component of the front building (right).

RESULTS

Testing: Verification of implementation of heat loss and gain calculations using Ecotect

A verification test was carried out for the direct solar gain computation using Autodesk Ecotect, and the 3D PHPP software tool. The building model that we used for this test was the LOD 100 conceptual model described above (see Figure 3). The results obtained from 3D PHPP closely match the results produced by Ecotect. In the test scenario, we obtained the direct solar gain for the building model for the day of 1st June 2014 at 12:30 in the afternoon. The 3D PHPP software tool is able to approximate the azimuth and altitude of the sun if the user can provide the time, date, and latitude and longitude information for the geo-spatial properties of the building. In addition to the geo-spatial location of the model, we also used the following default testing properties in Table 1 for the floor, wall, roof and window thermal insulation properties, as well as the outside and inside temperature.

Table 1: Material and temperature properties used for testing (Stojanovic et al 2013).

BIM Level 1 Object	Thickness (meters)	Thermal Conductivity	Ventilation Factor	R-values	Inside Temperature (Celsius)	Outside Temperature (Celsius)
Back wall	0.022	0.04	1.8	10.0	22.0	18.0
Left wall	0.022	0.04	1.8	10.0	22.0	18.0
Right wall	0.022	0.04	1.8	10.0	22.0	18.0
Roof	0.015	0.03	1.8	13.0	22.0	18.0
Front Glazing	0.009	0.05	1.8	1.25	22.0	18.0
Floor	0.0019	0.035	1.8	13.0	22.0	18.0

Table 2 shows the results for the direct solar gain we obtained using our 3D PHPP software tool and we then compare them to the results we obtained using Autodesk Ecotect. Figure 4 shows the direct solar gain value obtained in Ecotect for the hours between 12:00 and 13:00 for 1st June 2014 is between 596 W/m² and 585 W/m². Our summed approximated solar gain result that we obtained and recorded in Table 2 from 3D PHPP, for 12:30 on the same day, is 575.437 W/m². Additionally, we also

calculated the daily net energy difference for the LOD 100 version of the building envelope using our 3D PHPP software.

Table 2: Approximated direct solar gain values computed in 3D PHPP.

Component Name	Approximated Direct Solar Gain
Back wall	42.58
Floor	0.00
Right Wall	13.11
Left Wall	178.60
Roof	131.40
Front Glazing	210.00
Summed Approximated Solar Gain:	575.43

In 3D PHPP, the net energy difference is calculated by finding the difference between the heat loss value and the direct solar gain value. Table 3 shows the results of the summed component net energy values. The positive net energy indicates the approximated potential amount of energy gain per day. This result is dictated by the current seasonal factors and the material properties used in the calculation.

Table 3: Daily approximated net energy value for the BIM Level 3 building test model.

Component Name	Net Energy Value (kWh/m ²)
Back wall	0.0178
Floor	0.0058
Right wall	0.0580
Left wall	0.0580
Roof	0.1964
Front Glazing	0.0280
Summed Components Net Energy Value:	0.3643

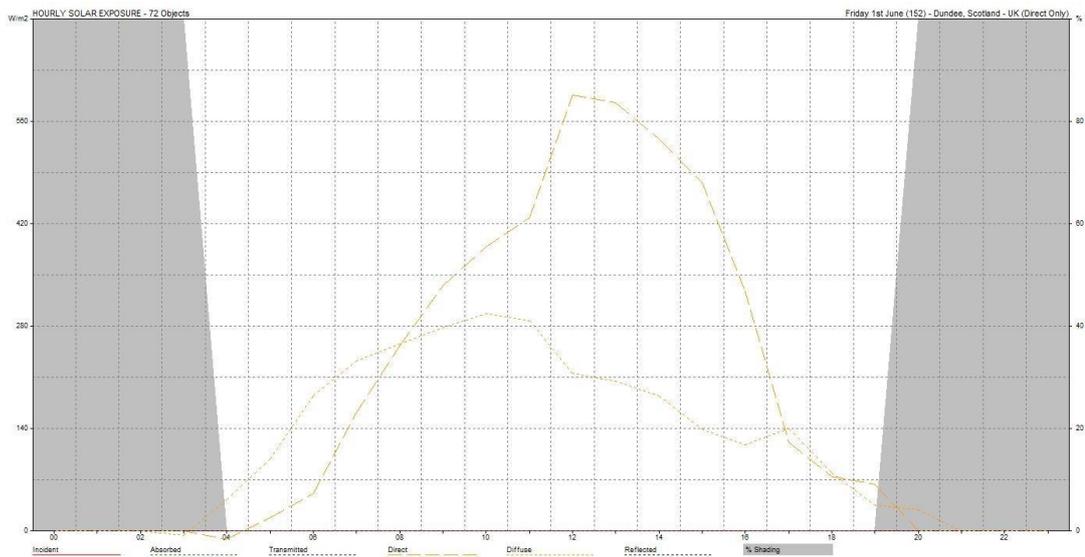


Figure 4: Daily approximated direct solar gain computed in Autodesk Ecotect. The bolder dashed line shows the peak direct solar gain at 596 W/m².

Testing: Interactive visualisation, navigation and ease of use

With the calculation of heat loss and gain verified, a testing session was conducted at Fife College aimed at evaluating the interactive visualisation, navigation and ease of

use of 3D PHPP prototype (see Figure 5). The testing session was conducted with a small group of individuals comprised of BIM professionals, academics and sustainable architecture students. The group of students were working on a project assessing the energy performance of early designs of new building development proposals for the Dundee Waterfront area (see Figure 2). The students were interested in having access to a tool that would allow them to quickly and rapidly prototype the different geo-spatial properties and energy performance of the design. This also provided us with the opportunity to see how the 3D PHPP prototype would work with more complex building models (instead of the default warehouse model used for internal testing as described in the case study). The testing session lasted four hours and was used to fulfil the two main requirements of software usability and functionality.

Usability

During the testing session it was noted by the participants that the user interface for the 3D PHPP software tool is more games orientated than the traditional CAD software tools. It was suggested that for the next phase of the project a new keyboard based camera control system for inspecting the 3D scene that is closer to a CAD-like control scheme should be implemented. It was also suggested that the main tools for component manipulation should have better categorisation. An undo feature was suggested for the next version of the software, as well as more precise 3D object selection (as the user is able unintentionally select more than one component at the same time).

Functionality

The first potential improvement that was suggested was for the concept stage of the design process, it would be good to come in from a whole building perspective (e.g. volume mass model) and then progressively be able to explore options at general arrangement (e.g. roof, floor and wall) levels. For example, this could be used to discuss with a client what effect reducing or increasing glazed areas and/or changing orientation was likely to have on the heating or cooling load. It was noted that 3D PHPP is more of a quick computation tool than a complete BIM software tool, and such it is most beneficial when used alongside standard BIM software tools such as Autodesk Revit. At the time of the testing, the current version of the 3D PHPP software tool only featured energy appraisal computation on a per component basis, rather than a whole building analysis. It was suggested that for the next version of the software, a whole building energy appraisal computation be implemented. We agreed that it would be beneficial to observe the file transfer process into 3D PHPP, ideally from a range of source files. During the testing session, the users noted there was difficulty importing complex 3D building envelopes as IFC files from Autodesk Revit, as once imported, the 3D building envelopes had to be manually set up in within the Unity 3D editor. Users noted that it was quite straightforward to import Wavefront Object model components using the default building model. There was confusion as to what constitutes LOD 100 and LOD 200 BIM concept geometry and how such levels of detail can be transferred from Autodesk Revit to the 3D PHPP software tool. It was agreed that the complexity of the model to be transferred should be limited to the compact “*volume mass*” level of detail. One of the participants during the testing session noted that the 3D PHPP software tool is able to compute the net energy values on a per component basis much faster than Autodesk Revit. The clients also felt that the 3D PHPP software tool was lacking true support for IFC models, as at present only

the geometry can be extracted and imported by 3D PHPP. Parsing and interpretation of additional attributes associated with a given IFC file are omitted.

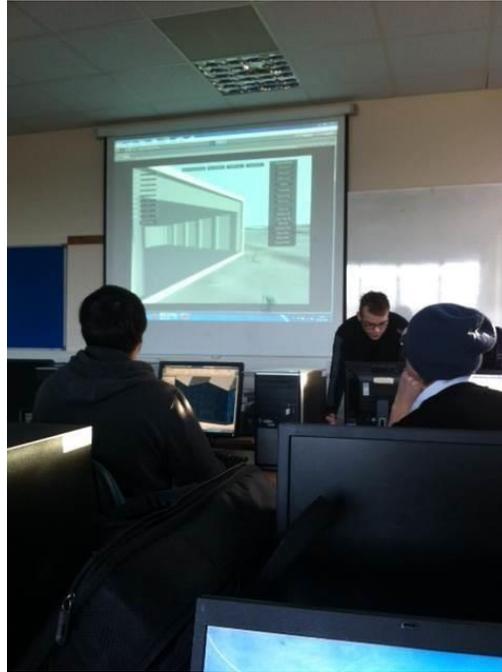


Figure 5: The testing session in progress at Fife College.

CONCLUSIONS

Despite these criticisms and suggestions for potential improvements, the clients involved in the project felt that the 3D PHPP software tool prototype met the original specification requirements within the limited development time frame. We do not make a claim that 3D PHPP can replace standard BIM tools – but rather that it can be used beneficially in conjunction with standard BIM tools in order to quickly calculate energy appraisal values for concept building models. 3D PHPP also has no official affiliation with the Passive House Institute, and was developed on publicly available information and specification documents for the Passive House Planning Package. The end result of the 3D PHPP prototype was the creation of a games based interactive 3D software tool that was easy to use and conforms strongly to BIM principals. With further refinement based on the results of the testing, 3D PHPP can potentially benefit SMEs involved in low carbon building design and construction.

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