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**ARCOM Declaration:**

The papers in these proceedings were double-blind 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 32nd Annual Association of Researchers in Construction Management (ARCOM) conference, and to Manchester – a city known for its many firsts, from the pivotal role it played in the industrial revolution, to the birth of the Suffragettes and Trade Union movements, to the modern day discovery of Graphene. In a similar vein, the 32nd Annual ARCOM Conference celebrates a few firsts as well. We are experimenting for the first time with a themed conference. The bee has been adopted as a motif for Manchester to symbolise industry and acknowledge the contributions of the working class. It is therefore fitting that the theme for the Manchester conference should revolve around the worker, and to question how construction work and the worker are evolving amidst social and technological change.

Not surprisingly, the theme of the worker has attracted a large number of contributions that examine health, safety and wellbeing in the industry, resulting in occupying five sessions (or just over 10% of the sessions) in the conference. Two other thematic areas that have seen quite a number of contributions include building information modelling (BIM) and low energy/sustainable construction, with many authors examining how developments in the digital world and growing environmental consciousness are having implications for construction work. It is also promising to see more theoretically-informed, engaged scholarship where authors are concerned not only with the principles of construction management, but also what these mean for everyday, mundane practices in organising construction work all over the world.

Although ARCOM is principally a British association, our annual conference continues to have global reach. We are delighted to be welcoming delegates from over 40 countries in this year's conference. This is especially encouraging since ARCOM 2016 is the first conference to be run shortly after the Brexit vote. The vote has certainly been a momentous event in Britain in 2016, and raised a number of pertinent points and questions that are relevant to the discussion of construction work and the worker. For instance, the vote brought to the fore tensions that have been brewing between the global and the local. Matters of concern such as control by supra-national institutional bodies, immigration, rising inequalities, unemployment and under-employment, and the power of Big Business were highlighted during and after the EU Referendum.

These matters are also of concern for the construction industry, an industry sector that lies at the very nexus of global cooperation (and coordination of supply and demand of goods, services and people) on the one hand, and local production and community engagement on the other. So, how will construction companies and workers negotiate the tensions between the global and the local in a post-Brexit world? The vote is also seen by some as being anti-establishment and anti-expertise. For academic researchers, this raises the question as to how we make our expertise matter for all. We will thus be running a Plenary Discussion session to identify the 'Radical Questions' that our community could be (ought to be) asking moving forward in a post-Brexit world.

ARCOM has existed over thirty years with a mission to raise capacity and capability in the field of construction management research. Papers presented at ARCOM conferences often end up in high-quality journals within and outside the field. We will again be inviting a selection of authors of some of the best papers accepted for presentation in this year's conference to extend their papers for publication in

Construction Management and Economics. For the first time, we will also host a ‘Meet the Editors’ session at the conference, with representations from the ASCE Journal of Management in Engineering, Building Research and Information, Construction Management and Economics, and Structural Survey. Moreover, we are extending the time allocated for discussion of each paper so that every author gets a 20-minute slot for their paper at the conference. Building on the success of the online programme piloted in the Lincoln conference in 2015, we also encourage delegates to read the papers before the conference so that better discussions and engagement can be facilitated. To this end, presenters of each session have been sent papers of the other authors in the session so that they, together with the sessional chairs, can lead more engaging discussion and debate.

We have also lined up an exciting programme of keynote and plenary sessions. Our first keynote will be delivered by Stefan Gottlieb of the Danish Building Research Institute. Stefan will mobilise Foucault’s ideas of governmentality to examine the transformation of the Danish building industry. His keynote will also be discussed by Linda Clarke, University of Westminster and CLR Europe. The second keynote is by Dylan Tutt from the University of Reading who will draw on his ethnographic work to question the continuities between the on-site and off-site world of workers. His keynote will be discussed by Edmundo Werna from the International Labour Organization (ILO). The Langford Lecture will be delivered by Tom Bartley, an Engineering Doctorate candidate from the University of Bristol who will explore what technological advancement in the BIM space means for workers. We are also delighted to run a Social Value spotlight on the Wednesday, following the Langford Lecture in Lincoln.

Finally, the ARCOM Conference would not function properly without the kind support of many people. We would, first of all, like to thank our generous sponsors, including the CIOB, and publishers (Emerald, Routledge Taylor and Francis, and Wiley) who have each sponsored best paper awards, as well as The University of Manchester for subsidising the cost of hiring the venue for the parallel sessions. We are also grateful for the voluntary support of 107 peer-reviewers drawn from the ARCOM and Scientific Committees, many of whom provided excellent, constructive feedback on a total of 360 abstracts received in January 2016. The input from our reviewers are instrumental in maintaining the quality of the ARCOM conference experience. We eventually accepted 128 papers for presentation in this year’s conference. Last, but not the least, I also wish to show my sincere appreciation to a number of key individuals for their support and help over the past year, including Ani Raidén, Emmanuel Aboagye-Nimo, Simon Smith, Fred Sherratt, Cath O’Connell, Jenny O’Mara, Jorja Bradbury, all the folk across the three venues (Manchester Town Hall, People’s History Museum, and the National Football Museum), and of course, our ever-patient conference secretary, Chris Neilson.

We hope you enjoy the conference as much as we did putting the programme together.

Paul W Chan  
ARCOM 2016 Conference Chair  
August 2016

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# KEYNOTE



# GOVERNMENTALITIES OF CONSTRUCTION: FROM MORTAR TO MODULAR SYSTEMS AND MARKETS

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In this paper, we apply Foucault's concept of governmentality in a dual analysis of the formation and transformation of the construction sector and the construction worker. The governmentality concept is well-suited for such an analysis as it directs attention to the ways in which control is exercised over a specific area of institutional life through the shaping of individuals' conduct. We argue that construction, as a coherent sector, first was rendered governable in the 1940s in order to achieve national modernisation. It is shown how the political measures that were based on the exercise of disciplinary power also impacted the formation of identities constituting the construction worker as a normalised subject. We then illustrate how construction since the mid-1990s has been shaped by two contrasting governmentalities framing the sector as respectively a resource area, with emphasis on innovation and capacity building, and as an economic entity, where deregulation and the establishment of free markets are the governmental objectives. With this shift in governmentalities, we argue that new identity formations have taken place in that the construction worker has been rearticulated as a calculative subject with responsibilities for own conduct and the development sector as a whole.

Keywords: governmentality, reform, sector development, subjectivity

## INTRODUCTION

Societies and construction sectors all over Europe are facing major challenges coming years. In Denmark, the population concentrates in cities where there is a housing shortage while the surplus of housing in the country is growing. The built environment is aging, and the need for renewal increases. An increasing proportion of the existing buildings does not meet the technical and use requirements we impose with regard to energy consumption, indoor air quality and accessibility. Furthermore, the increasing internationalisation and the free market for construction products and labour are challenging the balance between, on the one hand, competition, innovation and cost reductions and, on the other hand, considerations to local building customs and the quality of the built solutions. The ever increasing proliferation of new and untested materials and solutions are thus placing the sector's professional actors in a position where they have to be able to ascertain that products and solutions being delivered and used conform to health and safety requirements under conditions of deregulation.

In an effort to address the challenges faced by the construction sector, the Danish government, as governments across other Western societies, from time to time has

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released a series of industrial strategies and actions plans describing the current state of affairs and highlighting changes necessary in order to bring construction back on the track, into the 21st century, or however the different aspirations are formulated. In Denmark, the construction political strategy "The road to a strengthened construction industry in Denmark" (Regeringen, 2014) is the most recent example, whereas its UK counterpart is Construction 2025 (HM Government, 2013).

Much has been said, also sometimes rightfully harsh, about the nature and scope of such government strategy documents for the construction sector. In a comment on the Construction 2025 industrial strategy for construction, Green (2013) thus argues that only a minority of construction professionals sees the need for a coherent government strategy and the report in essence doesn't really have a lot to say. Also Dainty *et al.*, (2015) question the role and functioning of reform agendas, arguing that there is a distinct lack of continuity and learning from policy cycle to another, and that it is ironic that "...the development and diffusion of post-war reform policies has changed as little as the content of the research agendas themselves" (Dainty *et al.*, 2015, 4), which i.a. can be attributed to a lack of contextual sensitivity (Ferne *et al.*, 2006).

Whilst it undoubtedly can be seen as a shortcoming that such reports only display a vague contextual and historical sensitivity, and that it often is difficult to see the link between overall aspirations and proposed actions, we will nevertheless contend that construction policy and policy making is not located within an institutional vacuum. Rather, construction policy should be seen as intertwined with and reflecting a broader transformation of government as such, and following this, the effects of various reform initiatives could fruitfully be understood in terms of how institutions become transformed in the image of a new governmentality, rather than in cost-benefit terms.

Drawing on Foucault's (2007) concept of governmentality, we explore how the Danish construction sector, historically has been rendered a governable entity through different governmentalities or regimes of power and control that is not only grounded in sovereign authority, but also in alternative configurations of state and power, or governmentalities, in the form of discipline, biopower and liberal government. In doing so, we focus on how construction has been appropriated as an object of knowledge and try to unravel the ensemble of institutions, administrative measures, laws, technologies and practices that have become mobilised and interlinked in each of these different governmentalities. In other words, we attempt to relate articulations of construction and construction reform, no matter how seemingly alike they are, to changing modes of governance in order to illustrate how societal or supranational considerations are linked to and changing not only the face of construction and its policy landscape, but also sectorial institutions and consequently transforming conceptions of professionalism and identities (cf. Hughes and Hughes, 2013).

## **GOVERNMENTALTY AS A LENS FOR STUDYING REFORM**

Gouvernementalité or governmentality is a concept formulated by Foucault in the fourth lecture of his 1978-course on 'Security, Territory, Population.' In this lecture, Foucault sets out to discuss the so-called problem of government that arose in the sixteenth century as a result of the intersection of two movements or processes namely religious dispersion and state centralisation. These movements presented new problems in different aspects ranging from the problem of the government of (i) oneself (morality), (ii) the family (economy); and (iii) the state (politics). Government, in Foucault's reading, thus denotes something more than the present day interpretation where it belongs to politics and the state alone. Rather, government in the sense of 'to govern' covers a very wide semantic

domain referring to "a process of exchange between one individual and another" or to "the control one may exercise over oneself and others" (Foucault, 2007, 122). In this context, governmentality can be seen as "a strategic field of power relations [...] within which the types of conduct, or 'conduct of conduct,' that characterize 'government' are established" (Senellart, 2007, 389). Foucault (1977, 194) argues that governmentality can be understood as an ensemble "consisting of discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions" that allows for a specific exercise of power over many areas of social life. As an analytical approach, the study of governmentality is thus the study of the historical constitution of different forms of governance that are not only limited to the state are exercised on all levels society (Oels, 2005). The concept not only draws attention to the ways in which institutions of the state become transformed, but also "to the moulding and mobilising of individual subjectivity and individuals' capacity to govern themselves" (Patterson and Stripple, 2010, 346).

### Studying construction sector governmentalities

Governmentality analyses aim to study the techniques and procedures through which a phenomenon (e.g. construction) is rendered visible as a stable and governable object and associated with particular political rationalities (Miller and Rose 1991). Drawing on Dean (2003), Oels (2005) presents an analytical framework (Table 1) for the study of governmentality by focusing the analysis of programmes being "interventions that seek to transform an existing regime of practices by using new technologies and procedures, which give rise to a different field of visibility, different forms of knowledge and which presuppose a different kind of identity" (Oels, 2005, 189).

Table 1: Analytical framework for the study of governmentality (Adapted from Oels, 2005)

	Questions	Examples (Discipline)
Fields of visibility	What is illuminated, what obscured? What problems are to be solved?	Individual bodies
Forms of knowledge	Which forms of thought arise from and inform the activity of governing	Polizeiwissenschaft (science of politics), morality, economy, politics
Technical aspects	By what instruments, procedures and technologies is rule accomplished?	Hierarchical observation, panopticism, normation (control and surveillance)
Formation of identities	What forms of self are presupposed by practices of government? Which transformations are sought?	Docile bodies, normalised (normated) subjects

In the following analysis we use these categories as a guideline for identifying the changing governmentalities of Danish construction. The first analytical category concerns the particular visibility, i.e. representation of construction, which is created by a given governmentality, and the political rationalities associated with that visibility. The second category concerns the different epistemic technologies and procedures employed to develop and maintain that visibility. The third category concerns the instruments and techniques by which rule is carried out according to a particular political rationality. The fourth category addresses the production of new subjectivities pertaining to e.g. the engineer or the construction worker.

As a backdrop for the analysis of Danish construction governmentalities we furthermore draw on four governmentalities originally laid out by Foucault (2007; 2008): sovereignty, discipline, biopower and liberal and advanced liberal government. Sovereignty is an exercise of power that has territory as the object of governance, law and legislation as its main governmental technologies, and thus exists as a codifying technology that lays down

sanctions to be respected by legal subjects. Discipline, in contrast, intervenes in the existence of its object of governance, being individual bodies that are moulded to function according to a prescriptive norm in order to prevent the unwanted to occur. Biopower works to facilitate the self-regulation of a population by means of various social technologies that instead of trying to prevent or dispose certain outcomes let things, desirable or not, take place (Raffnsøe *et al.*, 2014). Finally, in advanced liberal government, the market is the organising principle for all types of social organisation (Oels, 2005). The idea is that "...markets have strong disciplinary effects on the subject made to compete in them. These subjects model themselves on the 'calculating' and 'responsible' individual who needs to increase his/her competitiveness in a constant strive to self-optimization" (Oels, 2005, 191-192). This is accomplished by means of technologies of performance and agency that work on multiple social areas and introduce an evaluative dimension into social life.

## **CONSTRUCTION GOVERNMENTALITIES**

In this analysis we focus on changing governmentalities in Danish construction (see Table 2 for a summary). We start by focusing on how construction first was rendered governable in the 1940s in order to achieve national modernisation. We then go on to illustrate how construction since the mid-1990s has been shaped by two other governmentalities framing the sector in a market-based view. Along this, we discuss how these governmentalities not only change the policy landscape but also function as technologies of subjectivation and impact the identities of the construction worker.

### **From mortar to modular systems**

From the 1940s a radical new governmentality was introduced as the basis for the governance of Danish construction. This new governmentality was formulated as response to the industrialisation of the Danish society that had led to an urbanisation and the emergence of the 'working class' as a new societal force that could potentially threaten societal stability. The political significance of the working class grew increasingly strong as workers became organised in unions. In order to ensure stability it was seen as an imperative that workers' organisations were not persuaded by the socialist and fascist ideals of radical societal reconfiguration, which had otherwise been strongly promoted in the 1920s and 1930s. In particular the quality of built environment was recognised as key concern for winning over the workers in favour of a social-capitalist societal order, since workers hitherto had been crowded together in low-quality unhealthy buildings in the cities during the early years of industrialisation. It was in response to this situation that a new governmentality was formulated in the 1940s, framing construction as an instrument for societal modernisation and a safeguard against the threat of socialist and fascist imaginaries. This was an entirely new role prescribed to construction, since the governance of buildings and the built environment previously had focused on physically and symbolically demonstrating the power of the king, the military and the church, thus being an instrument of nation-building (cf. Van Wezemael *et al.*, 2011). However, to achieve the biopolitical ambition of governing the population through the provision of better living conditions for the working class, construction became institutionalised as a national sector. This sectoralisation entailed that construction was institutionalised as discrete object of national regulation anchored in a housing ministry, and as a discrete object of scientific knowledge production anchored in a national building research institute.

This powerful politico-epistemic configuration gave rise to a new governmentality in the intersection between scientific knowledge and industrialised factory production.

According to this visibility, the traditional organisation principles of construction activities based on tradition, guilds and tacit knowledge was seen as irrational and anachronistic (Gottlieb, 2010). On this basis, a very different organisational configuration was successively developed over the next decades, partly financed by the Marshall Plan provided to support the redevelopment of Europe after WW2.

A fundamental element of this reorganisation involved the introduction of new 'rational' building materials and techniques. The traditional use of timber and bricks was partly replaced by pre-manufactured reinforced concrete elements, allowing much of the production move away from the often chaotic construction site and into more controlled factory settings. This in turn gave rise to an entirely new organisational configuration of construction and a new regulatory regime. Planning became increasingly more important, and was permeated by 'scientific' and calculative procedures and tools.

New types of scientific and calculative planning was thus required (i) for the design and production of concrete components, (ii) in the design of the construction site and the use mechanical equipment such as cranes; and (iii) in order to optimise the assemblage processes on the construction site. Equipped with authoritative knowledge, the planning engineer emerged as critical figure within this new construction governmentality. The rationalisation of construction also required a new regulatory regime. Local building codes were replaced by national building codes in order to develop a national market for standardised products, and a modular grid was enforced as a regulatory norm in order to ensure the compatibility between pre-fabricated components. This entire reconfiguration left little room for the traditional skilled craftsman, and within the new governmentality the knowledgeable craftsman was replaced by 'the assemblage worker' disciplined through the surveillance techniques of the regulatory regime and the planning engineer (Jensen *et al.*, 2011).

### **Market logics: From biopower to advanced liberal government**

Following the continuous growth periods in the 1950s and 1960s where the state played an active and interventionist role in the socio-economic and political development of the welfare society and the Danish construction industry, the mid-1970s marked a turn towards more than 20 years of frequent economic and social crises that radically altered the existing policy landscape (Bang *et al.*, 2001). Jensen (2012) thus argues that the sectorial development strategy for construction completely disintegrated in the 1970s as a consequence of a collapse in the publicly subsidised large-scale market for housing construction that hitherto had been the impetus of the sector development efforts. In conjunction with the ratification of the Maastricht Treaty and the opening of the Eastern European markets after the collapse of the Soviet Union, the early 1990s saw the emergence of new field of visibility for Danish construction. In contrast to the post-war period where the construction sector had been framed as an instrument of national modernisation, the new visibility framed the industry as an industrial cluster challenged by the imperative of market-based value creation. The political rationality contained herein sought to (i) improve the productivity of the sector as such; and (ii) position construction as a cornerstone in the general enterprise policy-reorientation towards an expansive economy fuelled by international competitiveness (F.R.I, 1990). This reorientation, we argue, implicated two different governmentalities based on liberalism and advanced liberal government as well as the development of a new field of visibility where the production of market values was promoted as the point of departure for the development efforts.

The *raison d'être* of the early efforts to bring construction back on the development agenda was rooted in a perceived economic/structural problematisation. In 1990, the Danish Building Development Council (BUR, 1990) released a report on the resource consumption and distribution in house building that documented a marked decline in productivity over a 20 year period. This report marked a turn towards a new governmentality for two reasons. First, it introduced the idea of construction as a market, framing the sector as a so-called resource area (Jensen, 2012), with emphasis on innovation and capacity building. The main argument shared by government and industry alike was that the subpar performance of the construction industry compared to other industries could be attributed to a 'market failure' that had led to a lock-in situation (EfS, 2001), i.e. a condition where the production and distribution of goods or services by the market is inefficient leading to inferior results for the society as a whole. In order to break the lock-in situation it became imperative to formulate a new enterprise political strategy for the construction sector. The strategy was based on the understanding that there was a strong need for public intervention in order to force the necessary changes through – most notably in the form of equipping the professional actors with the required competences to enter into new modes of collaboration, which was seen as one of the central cornerstones in the development efforts (EfS, 1993).

Second, the report introduced industrial economics and productivity analyses as forms of knowledge in the governance of construction. In doing so, it gave rise to proto-ideas relating to the formation of new subjectivities and identities. In contrast to the identity formation of the post-war years that was influenced by centralised scientific and calculative planning, the aim of the new governmentality was to cultivate responsible subjects with the capacity and freedom to contribute to market-based value creation. This was achieved through the use of technologies of performance and agency that are hallmarks of advanced liberal government (Oels, 2005).

According to Dean (2006) technologies of agency and performance can be understood as two strategies geared at the production of the 'calculating individual' being a subject that has been "shaped, guided and moulded into one capable of responsibly exercising that freedom" (Dean, 2006, 262) that liberal government presuppose. Technologies of agency include quasi-contracts, formation of partnerships and various instruments of voice and representation. In a government perspective, technologies of agency can be seen as top-down instruments that aim at establishing subjects with the capacity "to keep the agreements of a contract, to speak out for themselves and to enter into partnerships" (Oels, 2005, 192). As such technologies of agency establish institutional spaces for responsible self-conduct. Looking into the actual instruments, procedures and technologies through which the enterprise political strategy for construction actualised, it is clear to see this governmentality at play. In addition to the so-called "liberal solution" (F.R.I, 1990, 21) that was believed to stimulate an economic-structural rationalisation of the construction industry, the ambition was to invest heavily in a joint development program that would put innovation, capacity building and competences high on the agenda. In the course of the following ten years a large number of initiatives were launched, two of which is highlighted below.

If the degree of strategic codification and formalisation in an indicator of success, one of the most prominent results of the political efforts were the Project Productivity and Project New Forms of Collaboration programs that were instrumental in the uptake and development relational contracting in Denmark, including partnering and various types of partnerships. When we argue that this is a highly representative example of an advanced

liberal government technology it should be understood in context of the specific Danish actualisation.

Thus, since the establishment of the phase-model that can be seen as a strategic codification or ideal representation of the rationalisation efforts in the 1960s, coordination in construction projects has been based on contractually defined relations involving high degrees of surveillance in order to ensure correspondence between plan and action (Clegg *et al.*, 2002). With partnering, however, the industry began to experiment with less formalised and rigid plans, contracts and modes of collaboration. Our main argument here is that these new forms of collaboration can be seen technologies of agency that create 'deliberative spaces' at the same time as it is an example of a so-called 'new contractualism' that establishes individuals and companies as entrepreneurs of themselves (Oels, 2005, 192) being responsible for their own conduct as well as for the realisation of the project and the governmental objective as such (Gottlieb and Jensen, 2012).

The turn to a new contractualism led to a reticulation of the roles of the various actors in general, and the contractors and craftsmen in particular. Thus, in order for these actors to be able to occupy by the new deliberate space they had to be empowered subjects rather than normalised subjects acting in accordance to a disciplinary matrix as was the governmental ideal in the 1950s and 1960s. The so-called BygLOK initiative (Leadership, Organization and Competence in Construction) was a development program established under the general LOK program. The goal of the program was to "show a way to change the old-fashioned norms and traditions in the participating firms and on their construction sites" (Elsborg *et al.*, 2004, 2). This was sought accomplished in particular by focussing on the development of personal and collective competences in order to enable the creation of value for the customer while respecting the wellbeing of the worker. This is, in other words, in stark contrast to the immediate post-war approach with its focus on creating value for the society by means of functional differentiation and elimination of the skilled worker.

Concurrently, another development took place that can be interpreted as a response to a perceived 'state failure.' Despite 10 years of heavy public investments in the construction sector, in 2000 the so-called Task Force Report (By- og Boligministeriet, 2000) nevertheless problematized the lack of development and argued for a re-orientation of the political efforts. In doing so, the Task Force proposed 28 initiatives, some of which were in continuation of the initiatives throughout the 1990s, and others all new. When we, however, link the reform efforts of the 2000s to a government or 'state failure' perspective, the reason is twofold. First, in 2001, with the election of a liberal-conservative cabinet government, the Ministry of Housing was abolished. The following year, also the Danish Building Development Council that had played a crucial role the early 1990 was abolished as a consequence of a larger so-called reconstruction of a series of quasi-governmental councils and committees that also saw the repeal of several councils, funds and support schemes within the construction and housing area. Second, the most prominent outcome of the Task Force report the following years was the establishment of BEC (The Benchmark Centre for the Danish Construction Sector). The benchmark centre had the relationship between the market and the consumer in focus. Instead of a belief in an omniscient state with the foresight and ability to expediently provide the diagnosis and means necessary to solve a societal need, the benchmark centre was moulded in the liberal view that the voluntary exchanges between consumers and producers are sufficient in producing the right solutions - provided that the necessary transparency and knowledge on the performance of companies, products and prices exist (cf. Rasmussen, 2013). This was an objective best left for the industry to fulfil.

Rather than relying on state coercion and prescriptive norms operationalised by standardised materials, practices and procedures technologies of performance were the means through which the transformation was sought accomplished. Our contention is that this turn towards technologies of performance in the 2000s mirrors a development that is a feature of the transformation of the societal governmentality in general. The development in the 1990s can be seen as a strategic intervention that was instrumental in opening the established terrain or field of construction, creating the opportunities for establishing new institutional spaces. In this context technologies of performance are calculative devices that aim at making actors in new institutional spaces self-governing and hold them accountable for their own conduct.

Table 2: *Governmentalities of construction*

	Mortar	Modular systems	Markets
Governmentality	Sovereignty	Discipline and bio-power	Advanced liberal government
Emergence	-1940	1940-	1990-
Objective of government	Territory, nation building	Governing the working class through national modernisation	Competition, innovation, productivity
Fields of visibility	The building (as symbolic structure)	The sector (as societal instrument)	Market failure and state failure
Technical aspects	Policing of trade, guilds, apprenticeship	Prescriptive norms operationalised by regulation, building codes, modular grids and planning techniques	Technologies of agency: Life-long learning, relational contracting. Technologies of performance: best practice, benchmarking,
Forms of knowledge	Tacit embodied knowledge, templates, rules of thumb	Scientific knowledge, optimisation, factory ideal	Competition state
Formation of identities	Juridical subjects constituted by guild statutes	Normalised subjects: Planning engineers and unknowledgeable craftsmen	The empowered subject and the calculating individual.

Observing the current developments it is apparent how the government relies on these technologies of performance. As mentioned in the introduction, most recently the Danish construction industry is facing a hitherto unprecedented de-regulation wave. The nation building code is undergoing a change from prescriptive requirements to performance-based requirements. At the same time, the de-regulation leads to a marketisation of functions that hitherto have been a public affair. At the present moment the Danish parliament is debating a bill to dispense with the mandatory public processing of applications for building permits and instead introduce a market-based certification scheme. Also national standards and norms are being abandoned in favour of international standards in order to reduce trade and entry barriers and increase innovation and competition. In 2014, a general education reform in Denmark took place. The reform resulted in a series of new requirements concerning the quality of education and training in construction. This self-proclaimed paradigm shift led to that entry requirements were placed on all programs, and a focus on development of academic competencies was introduced in order to ensure that the construction worker is able to "...live up to the requirements and expectations of the future labour market" (Kunov, 2014). Surely, in a governmentality that favours constant self-optimisation, the future belongs to the individual that is capable of adapting to future futures.

## CONCLUSIONS

In this paper we have demonstrated the relevance of applying Foucault's concept of governmentality in an analysis of construction reform and development. We have shown that this theoretical perspective is able to shed light on the specificities that render a given phenomenon governable, and in doing so illustrate that even though the seemingly same issues and discourse seems to be continuously repeated, these are embedded in larger regimes of power. Also, the governmentality approach has drawn attention to how regimes of power shape subjectivities and has as such provided a way to bridge the dichotomy between macro-level changes and micro-level practices.

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# **BUILDING INFORMATION MODELLING**



# BIM IMPLEMENTATION AND PROJECT COORDINATION IN DESIGN-BUILD PROCUREMENT

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Various procurement methods have been proposed as being more appropriate for implementing BIM. Simultaneously, BIM implementation affects the project coordination. Whereas many approaches to BIM implementation have considered integrated procurement, not all are applicable to various local markets. Particularly in the Netherlands, BIM implementation is characterized by 'ground-up' and self-regulated initiatives. This paper aims to explore and identify the relationship between design-build procurement and the emerging coordination structures from BIM. Exploratory case study research has been undertaken. The findings included two main coordination structures: centralized and decentralized. These two structures subsequently carry implications for various construction firms and their respective business models, as well as BIM implementation in general.

Keywords: Building Information Modelling, coordination, management, procurement

## INTRODUCTION

The supply chain of the Architecture, Engineering and Construction (AEC) sector is highly fragmented. A building is usually designed by numerous domain experts with different disciplinary inputs and afterwards, a builder is engaged to execute this design on site. Winch (2002) defines the AEC project team as a temporary project network, a coalition of small firms and specialties that are assembled for a project-specific goal. Poor performance in AEC is attributed to this temporary network. The design process is clearly separated from construction and the project information generated and shared across phases is often unreliable and difficult to access due to lack of team and process integration. The overall management of design and construction is achieved via the emergent function of the project manager. Forgues and Lejeune (2015) argue that traditional project management is ineffective, as the project manager has little control over the various actors' tasks' interdependences. Despite the many years of criticism over this separation of design and construction, and many national initiatives proposed, e.g. Egan's Report in the United Kingdom (UK), fragmentation and poor project coordination continue to be a challenge that hampers productivity in AEC.

In the past decade, Building Information Modeling (BIM) has been considered a solution to fragmentation, poor project coordination and information management problems (Eastman *et al.*, 2008). The promise is that BIM and its associated processes and

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technologies, facilitate simultaneous work by multiple design disciplines. It provides a platform for integrated information exchange through model federation. BIM challenges the traditional configuration of the supply chain. BIM requires new roles and new workflows. On one hand, many BIM-specialized companies emerge. Some offer all-inclusive BIM-related services to AEC firms and on projects. The services sometimes encapsulate the traditional project management services as well as technology and information management-related services. On the other hand, various in-house roles pertinent to BIM have emerged within existing firms. New project organization, project coordination structures and processes, distribution of responsibilities, tasks and risk allocations emerge, due to advancements in BIM.

The AEC sector needs more insights into emerging structures from BIM. Will BIM lead to the demise of the traditional project network or will the traditional project network align with the features of BIM and re-invent their workflow and interactions? This paper aims to present and discuss lessons-learned from BIM implementation in two cases in the Netherlands. It would examine and compare the project coordination structures that emerged from BIM implementation in Design-Build projects, and the actors' roles. It will also attempt to shed light on the impact that the various structures had on the cases, i.e. challenges and outcomes. The findings would inform and assist AEC firms to improve their BIM adoption processes to reap its acclaimed benefits.

## **THEORETICAL FRAMEWORK**

### **The concept of BIM**

Eastman *et al.*, (2008) define Building Information Modelling (BIM) as ‘a verb or adjective phrase to describe tools, processes, and technologies that are facilitated by digital, machine-readable, documentation about a building, its performance, its planning, its construction, and later its operation.’ The adoption of those tools, processes and technologies is a 'building information model'. With BIM a building can be represented in a digital, computable and intelligent 3D form, where all information pertinent to realization can be stored. The input from the various design disciplines, contractor, suppliers and subcontractors can be sought early in the design process; and potential problems, e.g. clashes and constructability issues, can be resolved digitally.

The design stages can be overlaid by the BIM Level of Development (LOD). LOD describes the dimensional, spatial, quantitative, qualitative, and other data included in a design model (AIA, 2013). The LOD can help designers define and manage information richness of the design over the design stages. Thus, BIM could eliminate waste in project delivery if applied appropriately (Eastman *et al.*, 2008). BIM is seen as a radical innovation that will change how building information is represented, manipulated, and shared (Eastman *et al.*, 2008). The changes in the sharing of building information would further induce changes in project organization and coordination. However, the maturity of BIM tools, technologies, processes, knowledge and skills could play a significant role in the success of BIM implementation. On its way to maturity, BIM implementation would continue to stimulate new coordination structures and would carry implications for project collaboration, procurement and how production in AEC is organised in general.

### **Project procurement and BIM implementation**

Procurement can be defined as ‘the organisational structure adopted by the client for the management of the design and construction of a building project’ (Masterman 1992). Uher and Davenport (2009) describe it as ‘the process by which the client seeks to satisfy his [or her] building requirement, characterised by a particular organisational form,

distribution of responsibility, tasks and risk allocation'. Turner (1997) identified two essential decisions in procurement (1) the organisation for the overall project management, and (2) the organisation for design and construction.

The organisation for the overall management of project involves client's decisions for either using an in-house project manager or an external project management or a combination of the two. The role of the project manager is to oversee the organisation of the different work parts, define project scope, plan and control project deliverables, (Forgues and Lejeune 2015). The organisation for design and construction involves decisions about how those two would be brought together, either in a fragmented or integrated way. It also entails the allocation of design responsibility and the timing of the contractor's involvement – either early in the design or after design for the purpose of construction only. This has given rise to various procurement methods before BIM.

Turner (1997) classify the procurement routes into (1) design-led (2) designer-led, and (3) management-led. Other procurement routes have also emerged to address the need for creating value and increasing performance, namely the Public Private Partnerships (PPP), alliancing, and Integrated Project Delivery (IPD). The use of project partnering has also been developed. It is a management approach that two or more organisation can use to achieve predefined mutual business objectives including agreement on method of resolving problems and continuous improvement (Lahdenperä 2012).

Generally, the procurement structure supports the coordination activities, by creating a setting that fosters concurrent interactions among team members, throughout the project. From life cycle BIM perspective, Holzer (2015) conducted an analysis of the opportunities and challenges of BIM under procurement methods applied in Australia and deduced that IPD is the closest fit, contractually speaking, for full BIM implementation. The potential opportunities for BIM use and its challenges in Design and Build procurement include: it facilitates increased transparency in setting up and tender pricing, models can be set up with construction in mind, it increases the potential for interfacing information between consultants and trade contractors, and it requires a contractor who understand BIM (Holzer, 2015). Loke (2012) argued that the Design-Bid-Build (DBB) procurement is not an arena for realizing the full benefit of BIM, whereas isolated actors may reap some productivity benefit.

The collaborative benefits of BIM could be leveraged through the use of Integrated Project Delivery (IPD). Unlike DBB procurement that encourages project team to work in disciplinary silos (Loke, 2012) IPD is a contractual agreement between a minimum of the owner, design professional and builder, where risk and reward are shared and stakeholder success is dependent on project success thereby encouraging collaboration and some elements of partnering relationships (Lahdenperä 2012). It involves mutual benefits and reward, early involvement of key project actors, and early definition of project goals. Thus, IPD could facilitate interaction among project actors in a BIM-based project. For the AIA (2007) the use of BIM and IPD is called 'Virtual Design and Construction' (VDC). VDC has been pioneered by the Centre for Integrated Facility Engineering (CIFE) at Stanford University and supports the description, explanation, evaluation, prediction, alternative formulation, negotiation and decisions about a project's scope, organization and schedule with virtual methods (Khanzode *et al.*, 2006).

Despite the significance of IPD to BIM, it is unrealistic to implement IPD, entirely and globally (Holzer 2015), due to transaction cost issues, market maturity, client experience, and contextual differences across projects. Holzer (2015) observed that the excitement about the combination of IPD and BIM is fading because IPD in its pure form does not

suit current market dynamics. Whereas the most procurement methods do not support smooth flow of BIM process, practitioners are now turning to exploring the role that BIM can play within existing procurement routes. Sebastian (2011) presented two hospital project cases in the Netherlands where the clients opted for traditional DBB procurement while at the same time developed clear vision for BIM to achieve specific project ambitions. The implication is that new coordination structures emerge within the existing project procurement methods. This study would contribute to the discourse on BIM and its implementation in practice by exploring the BIM implementation process in two Dutch Design-Build (DB) projects and it would highlight the project coordination structures that emerged from BIM.

### **Project coordination structure and BIM implementation**

Project coordination structure is regarded as the pattern of decision-making and communication among a set of actors (Malone and Smith 1988). Underlying abstract decision-making patterns characterize every project procurement method and are needed for managing the tasks dependencies. Dabbish *et al.*, (2010) distinguish between formal and informal coordination. For early organisational theorists, formal coordination is needed where uncertainties are low, e.g. where tasks are clear and based on routine and involving 'a priori definition of organizational structures and processes for managing dependencies including supervision, rules, routines, standardization, scheduling, pre-planning, and division of labour into minimally dependent units' (March and Simon 1958). Informal coordination is interpersonal coordination, better suited for managing highly interdependent and complex tasks where actors interact directly to exchange task information and negotiate task dependences (Malone and Crowston 1994). In the context of product development in organisations, Olson *et al.*, (1995) classified formal coordination structure into seven structures ranging from the most mechanistic, e.g. bureaucracy, to the most organic and participative structure, e.g. design centres. These are characterised by varying degrees of complexity (simple to complex), distribution of authority (centralised to decentralised), formalization (formal to less formal), and autonomy (low to high).

Such structures are also characterised by features that affect decision-making/conflict resolution (hierarchical to participative) and information flow (formal to informal). Martin *et al.*, (2014) concluded in their study that the better structure for communication is the decentralised because it reduces communication resistance in teams. According to Olson, Walker Jr and Ruekert (1995), in decentralised organisation, rules and operating procedures are less formalized and less rigidly enforced, and individual units tend to have more autonomy to develop their own methods and make their own decisions. The success of a BIM-based project may exhibit a different response between centralised and decentralised coordination structure.

Project design in AEC is highly dynamic with complex interdependent tasks often targeting new solutions and involving frequent changes. Using design artefacts, such as models and web platforms, to connect the actors and integrate design work is then crucial. It can facilitate information exchange and help the actors to understand each other's view, negotiate and resolve conflicts in an ongoing basis. The advent of BIM in a common data environment (CDE) (level 3 BIM in the UK) is making consistent information exchange possible. These new developments challenge the role of the traditional project manager. Koskela and Howell (2002) argue that the traditional project management tools only optimise efficiency at task levels; they do not address task interdependences. BIM is set to address the gap in task interdependencies, as it entails a shift from fragmented

workflow to concurrent engineering and engages the various firms in dynamic and frequent interactions. Thus, in the BIM era, a project manager would need both the skills of the traditional project manager and additionally BIM-related technical skills for the technical coordination of the design.

Certainly, BIM has also led the emergence of new roles, e.g. BIM manager, BIM coordinator. In BIM projects, the use of the traditional project manager together with the BIM manager can result in conflict and duplications (Forgues and Lejeune 2015). The project manager is typically responsible for managing project scope and deliverables, whereas the BIM manager is responsible for the BIM models and the information exchange for the models. The paradox is that the BIM manager is more familiar with the status of the BIM, and thus project schedule. Forgues and Lejeune (2015) suggested that to transform the traditional project network into a BIM workflow, an ‘organisation architect’ is needed to guide the translation of a project vision to a flexible, integrated platform by devising the right combination of BIM processes, capabilities and technologies. Based on the above theorisations, it would be useful to explore the emerging coordination structures arising from BIM as well as disturbances in the traditional project phases and roles dictated by BIM implementation.

## **METHODOLOGY**

Two BIM-based projects were analysed as to their BIM implementation and namely the, (a) BIM management structure, i.e. distribution of roles, responsibilities and tasks, (b) BIM-related activities and processes. Two cases in the Netherlands were analysed, cases A and B. The Dutch AEC was selected for the study, given that BIM adoption in this market presents a balanced mix between policy-driven BIM roadmaps and emerging BIM practices (Kassem, Succar and Dawood 2015). Whereas BIM policies are not very advanced in the Netherlands, the construction firms are quite proactive in BIM adoption using various strategies. The two cases were antithetical, because although both had DB procurement method, opposite approaches were used for managing and coordinating the BIM process. Case A used a specialist BIM consulting company, while case B involved BIM functions undertaken by in-house BIM-knowledgeable employees from the various firms involved. Case A was studied during early 2013 and case B during late 2015.

The study used exploratory case study. The cases exploration involved interviews with the project actors, analysis of project documents, and live observations of BIM clash and design sessions. The interviews were semi-structured, addressed to various actors, e.g. contractor, client, engineers and the BIM consultancy firm (only in case A). The first questions were about the firms’ BIM adoption history, challenges and outcome. The next questions were about BIM implementation at a project level, e.g. motivation for BIM, BIM workflow, contractual strategies, BIM roles and responsibilities and technical challenges from BIM. The case description as to type, scale, location and dates, and the responses to questions about BIM adoption, motivation and strategy are shown as text using thematic analysis, whereas the responses to questions about BIM implementation activities and roles are presented in tables, to aid the case analysis.

## **CASES ANALYSIS**

### **Case description**

Case A (2013) is a housing project of 40 rental apartments with five apartments per floor for single and two-person households, using industrialized building systems. The client is a housing association in partnership with a property developer. For the project, BIM was not a contractual requirement. The use of BIM was part of the contractor’s tender

proposal to the client with the goal of using BIM to achieve ‘a better building delivered at the lowest possible cost’. It was envisioned that BIM and VDC methodology will be used for reducing design errors and clashes and deliver the project faster (time), cheaper (cost) and better (quality).

In case B (2015) whereas, the client did not require BIM, the contractor and his partners decided to adopt BIM to increase project quality. It involved a housing tower with 12 stories and 83 housing units of two to four bedroom apartments, to buy or rent. BIM was used because the project had technical challenges in the site logistics. It was a tower in a small plot, adjacent to a shopping centre, whose operation could not be disturbed. This project also used industrialized building systems and dry construction, which is very common in the Netherlands. The Architect stated that they did not dare to do this project in a non-BIM way. The motives for using BIM in case B was also strategic, because the contractor and their partners wished to deliver “as-built” drawings and potentially master the use of BIM for their future projects.

### Project procurement structure

Figure 1 illustrates the project procurement structures of the two cases. In case A, the project delivery method was DB procurement. The designers were engaged by the owners to define the scope of the project whereby the design was developed from conceptual design (Level of Development (LOD100) to schematic design (LOD200). Based on the LOD200, the project was tendered for, then the contractor was selected and thereafter the architect was novated to the contractor. The contractor thereafter engaged the BIM managers while the designers worked under the BIM manager’s leadership. Various suppliers and subcontractors were also selected by the BIM managers (with contractors input) on the basis of their experience with BIM.

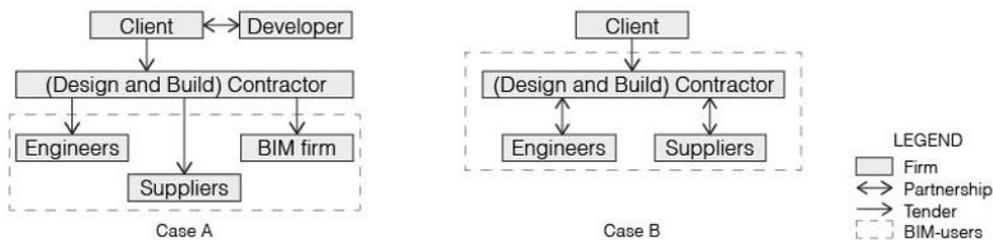


Figure 1. Project procurement structures of cases A and B.

The procurement of case B was simpler than that of case A. The client hired the contractor to deliver the design and construction and gave them complete power over the next decisions. The contractor had long-term partnerships with the Architects and the Structural engineer (Str. Eng.), who were responsible for the architectural and structural design respectively. Also the contractor had long-term partnerships, or ‘chain contracts’, with a MEP firm and some sub-contractors and suppliers. Other suppliers were selected from a list of ‘preferred partners’ of the contractor.

Most firms involved in case B adopted BIM as a means to control the information flows in the project and to increase project quality. The adoption of BIM was triggered from either internal or external reasons. On one hand, for the architect, the structural engineer and the contractor, BIM adoption was a natural decision to improve their businesses. For example, the architects were already designing in 3D before BIM. The structural engineering firm was also using 3D since 2007 and fairly rigorously made the transition to BIM. For the contractor the information sharing with their partners would become more efficient because of BIM. On the other hand, the concrete sub-contractor, the steel

supplier and the MEP engineering firm adopted BIM to comply with ‘customer demand’ and because ‘this was requested from the market’.

### Case analysis: BIM implementation and coordination

#### *Overall management structure*

In case A, after the project award to the contractor, the BIM consulting firm i.e. BIM managers, was hired by the contractor. The BIM managers were responsible for not only the overall management of the project, as project managers, but also for the generation of the BIM models based on models produced by the designers and several subcontractors, as coordinators. To ensure the success of BIM implementation, an initial project workshop was conducted i.e. a BIM “kick-off” meeting. The purpose was to ensure that all the parties understood the project and agreed to the way of working and BIM use. All parties had to sign the BIM execution document as a part of their contract. The BIM process was supported by BIM protocols and management plan from the early stage of the workshop and the project.

In case B, BIM was applied from various roles within the involved firms. The architect, structural engineer and MEP firms had at least one BIM-savvy engineer, alongside the project engineer. The main project management function was held by the contractor. A “kick-off” session and a BIM protocol took place from the start, to coordinate the BIM scope. The BIM process was supported also from frequent collocations. The architect was the BIM coordinator until the pre-construction phase. Thereafter, a site engineer from the contractor’s firm became the BIM coordinator. Figure 2 illustrates these two BIM coordination structures.

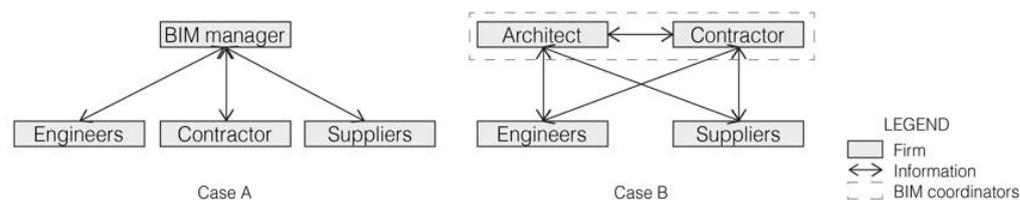


Figure 2. BIM coordination structure of cases A and B.

#### Processes and activities

In case A, BIM was used from Definitive Design, with LOD200 until the Construction Preparation phase with LOD400. BIM was used for the following activities: design coordination, clash detection, design visualization, quantities take-off, cost estimation, preparation of working (shop) drawings and information exchange. The project schedule was prepared in different software and was not linked to BIM tools. The BIM manager was responsible for modelling, cost calculation and clash detection. The federated model formed a basis for the subcontractors. There were a lot of formal and informal coordination activities with the various subcontractors to produce jointly a working model for construction. Interestingly some of the suppliers were co-located in the same office building with the BIM managers. According the BIM managers, this greatly influenced the team collaboration. A project website hosted on the servers of the BIM managers was used as a Common Data Environment (CDE) to share project information using Industry Foundation Classes (IFC).

In case B, BIM was used from the Initiation phase, i.e. LOD100 until the Hand-over (as-built BIM). It was used for design exploration, visualization, design coordination, cost estimation, clash detection, quantity take-off, information exchange and site resource management. Similar to case A, the information exchange took place in a CDE, where all

parties uploaded their IFC files. Afterwards, the various references models were federated to perform clash detections as described in Berlo *et al.*, (2012). The contractor used preliminary input from the architectural and structural models to perform the budget estimation, and early informal discussions with some preferred suppliers. The suppliers were involved early in the process after the LOD300 phase and provided preliminary input.

#### *Outcomes of the cases*

Case A was delivered ahead of schedule. The client was satisfied with the quality. All parties had better understanding of the BIM process but challenges included time pressure because of the contractual obligations and late completion of tasks by some parties. The contractor's expectations were too high because it was their first BIM project, which also put work and time pressure on the other parties. The BIM managers had to work overtime for the BIM management function. Case B is an ongoing project and so far no time delays have been reported. Time pressure was reported by various project actors, but according to them it was not due to the BIM implementation, but rather due to the strategic decisions of the contractor's commercial managers. However, some coordination issues surfaced regarding the role of the BIM coordinator. In the beginning, the architect performed this function, but later, after request from the partners, a site engineer was trained to become a BIM coordinator, so as to combine technical expertise from the site to technical BIM expertise. Also, frequent collocations of the partners increased the understanding and knowledge about BIM process.

## **DISCUSSION AND IMPLICATIONS**

In Case A, BIM coordination and project management were highly centralized. The BIM managers were responsible for BIM modelling and coordination, project and cost management. They also exerted control over the MEP, sub-contractors' and suppliers' models. The BIM managers send their staff to support the other BIM users whenever issues arose. Surprisingly, whereas the control was centralised, the decision-making was not strictly hierarchical. This was possible because the CDE ensured participative structure and a quasi-concurrent workflow. Most of the interactions were between the BIM managers and the suppliers and subcontractors, and were facilitated by the CDE. There were also a lot of informal interactions. The BIM managers performed an 'integrating manager' role (Olson, Walker Jr and Ruckert 1995). They also exerted informal influence from their central position (see Figure 2). The CDE was critical for the interaction of the BIM users. Case A also shows that the designer's and contractor's roles were less visible due to the power of the BIM management firm.

Whereas Case B was also DB procurement, had opposite BIM coordination structure, because of the multiple partnering relations among the firms. The contractor executed the project management activities. All engineers and suppliers were then responsible for their BIM input to the federated model. The paradox in case B was that although the project management was centralized, BIM coordination was decentralized. Both the contractor and the architect were BIM coordinators and this lead to a decentralized BIM structure (see Figure 2), concurring with the participative, consensual, horizontal and informal coordination structures from Olson *et al.*, (1995). The engineers and suppliers were empowered to apply BIM and exert distributed control via their input. Given that not all actors had the same BIM capabilities, frequent collocations, informal communication and shared learning took place.

Case A carries implications for business models in AEC firms. The BIM management firm was originally cost managers that reinvented into a firm that provided all-round BIM

services and information management, together with cost and project management services. Their services might be attractive to clients looking for cheap, good and fast projects, especially in repetitive and less complex buildings. This could lead to mergers, rise of consortiums, and acquisitions of firms that previously provided auxiliary services. From case B, the analysis indicates that the contractors would become information managers. Also, in case B, there was an increase in the engineers' and supplier's empowerment and responsibilities to provide their services using BIM standards and agreements. This could be a sign that the future AEC business models AEC would offer integrated BIM and discipline-related services. Accordingly, it would be interesting to explore the clients' preferred approach for reducing the risks of BIM adoption, i.e. choosing between specialized or integrated BIM and engineering firms.

## CONCLUSIONS

Due to the increasing adoption of BIM, the various firms would gain experience from BIM-projects and become increasingly aware of its benefits. The two cases with DB procurement presented two contradictory routes to BIM implementation. The cases used either specialized BIM consulting firms or solutions within their firms, e.g. hiring BIM-savvy engineers or training their in-house personnel, to reduce the cost of outsourcing BIM implementation. This produced two models of BIM coordination: centralized and decentralized. There are lessons to be learned from both cases, given that the centralized and inclusive approach towards BIM, from the BIM consulting company, sets high-quality standards that challenge the ad-hoc or decentralized BIM approaches. The engagement of organizations in both 'centralized and 'decentralized BIM coordination could potentially contribute to effective diffusion and development of BIM knowledge and higher BIM maturity among AEC professionals.

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# USING THE ARUP BIM MATURITY MEASURE TO DEMONSTRATE BIM IMPLEMENTATION IN PRACTICE

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Building Information Modelling Assessment Methods (BIM-AMs) are performance measurement systems that evaluate BIM across organisations, projects, individuals and teams. They focus priorities and help companies communicate their strategies both internally within their own businesses, and externally to other stakeholders. Currently, there are sixteen known assessments and each has its unique take on performance measurement. Amongst these models is the recently released BIM Maturity Measure (BIM-MM) which integrates critical elements of BIM including the BIM Champion, Common Data Environment and Employers Information Requirements. In this study BIM-MM is applied to 213 projects, in association with Arup, a global firm of consulting engineers. The aim of this substantial test is not only to investigate the implementation of BIM-MM in practice but more significantly to shed light on how BIM is being used in practice. In particular, the emphasis is on the relationship between the BIM Champion and the rest of the evaluated measures. Observations show that the overall scores of all projects is higher when the BIM Champion has a greater level of involvement in projects. BIM-AMs are of vital importance for policy-makers, professionals and researchers since they illustrate a broad snapshot of BIM adoption between and across organisations and countries. They are critical to the future directions of BIM agenda.

Keywords: BIM, assessment methods, BIM Maturity Measure, BIM champion

## INTRODUCTION

In the last decade, the development of Building Information Modelling Assessment Methods (BIM-AMs) has been the subject of significant research (BRE, 2015; Giel, 2014; Kam, 2015; Succar *et al.*, 2012). This development has led to sixteen Assessment Methods (AMs) introduced by both academics and practitioners. Each AM provides a unique perspective on BIM performance, with different sets of measures and different assessment focus. The first AM was the National BIM Standard Capability Maturity Model (NBIMS-CMM), developed in the U.S. by the National Institute of Building Sciences (NIBS, 2007). NBIMS-CMM consists of eleven critical BIM measures, including business process, delivery method, data richness and information accuracy. It focuses only on information management and has been therefore criticised for not reflecting the diverse facets of BIM. Critics have also questioned its usefulness and usability due to its structural limitations (Succar, 2010).

So profound and powerful these critics were and resulted in the introduction of new models that tried to build on NBIM-CMM and provide more optimised models.

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The emergence of new BIM-AMs was seeking better ways of measuring BIM. Frameworks such as the BIM Maturity Matrix (Succar, 2010), the Virtual Design and Construction (VDC) Scorecard (Kam, 2015) and the BIM Maturity Measure (BIM-MM) (Arup, 2014), have been designed to improve previous models. They have supplemented past measures with diverse areas of measurement that represent much broader dimensions of BIM e.g. policies, technologies and processes. Individually and collectively, coexisting AMs have contributed to the growing body of literature that examines BIM use. Despite this growth, the research field of BIM-AMs as a whole is still facing fundamental challenges. Until recently, there has been a lack of knowledge surrounding the ‘implementation’ of many assessments in practice. This is essential to shift the field of BIM-AMs from its theoretical basis into an effective and practical context, a challenge documented previously by Neely *et al.*, (2000) who write extensively on performance measurement:

The process of designing a measurement system is intellectually challenging, fulfilling and immensely valuable to those managers who participate fully in it [However,] the real challenges for managers come once they have developed their robust measurement system, for then they must implement the measures.

This gap in literature is addressed here by implementing the Arup BIM-MM on a substantial dataset of 213 projects. The study considers the BIM-MM as an analytical framework and questions its ability to specify how BIM is being implemented across projects. Arup released the BIM-MM in December 2014 to assess and compare the maturity of BIM implementation within projects. It draws on the Organisational BIM Assessment Profile (CIC, 2013) under the Creative Commons 3.0 licence (Arup, 2014). This testing is important for professionals to review their progress over time, for academics to address the current challenges and opportunities of AMs and for policy-makers to create an overall picture of BIM implementation on a national scale.

## **LITERATURE REVIEW: BIM-AMS**

Initial development of BIM evaluation systems is originally rooted in the software engineering Capability Maturity Model (CMM) which informed the first BIM-AM, the NBIMS-CMM (NIBS, 2007). Since then, multiple conflicting models have emerged shaped by both external and internal influences. Externally, AMs have been informed by the broader performance measurement systems in different fields, including business management, quality management and building environmental AMs. Internally, more recent BIM-AMs have built upon previous ones to avoid shortcomings. Together, these influences have impacted on the evolution of BIM-AMs in regards to the design process, type and range of measures and the ways results are communicated.

The significance and need for BIM-AMs has been highlighted by various scholars. A study by Succar *et al.*, (2012) introduced three core advantages of BIM performance metrics. Such metrics enable teams and organisations to benchmark their own successes and (or) failures, evaluate their own BIM competencies and compare their progress against different companies in the Architecture Engineering and Construction (AEC) industry. Similarly, researchers in the ‘Computer Integrated Construction (CIC) research programme’ (2013), note that assessments help companies; internally to identify their current status, and externally to determine where they stand within the business market. Despite these advantages, there is still a shortage of literature which examines AMs in practice.

Most studies on BIM-AMs have focused on introducing and promoting new models, rather than implementing them in the architecture, engineering and construction industry.

In the reviewed literature, publications of Case Study Projects (CSPs) is only available on seven AMs. For instance, the ‘BIM Proficiency Matrix’ (Indiana University Architect's Office, 2009) and the ‘Organisational BIM Assessment Profile’ (CIC, 2013) have contributed significantly to the field of BIM performance measurement, but no available publications document their implementation in practice. Table 1 presents all existing assessments according to their chronological order and reports the number of available CSPs.

*Table 1 Availability of case study projects across the existing BIM-AMs*

BIM-AM	Year developed	Origin	No of CSPs	Reference
NBIMS-CMM	2007	U.S.	11	(McCuen et al., 2012)
BIM Excellence	2009	Australia	-	(Change Agents AEC, 2013)
BIM Proficiency Matrix	2009	U.S.	-	(Indiana University Architect's Office, 2009)
BIM Maturity Matrix	2009	Australia	-	
BIM Quickscan	2009	The Netherlands	130	(Berlo et al., 2012)
VICO BIM Score	2011	Global company	-	
Characterisation Framework	2011	U.S.	40	(Gao, 2011)
CPIx BIM Assessment Form	2011	UK	-	
Organisational BIM Assessment Profile	2012	U.S.	-	
VDC Scorecard/bimSCORE	2012	U.S.	130	(Kam, 2015)
Owner's BIMCAT	2013	U.S.	2	(Giel, 2014)
BIM-MM	2014	UK	213	(Arup, 2014)
Goal-driven method for evaluation of BIM project	2014	South Korea	2	(Lee & Won, 2014)
The TOPC evaluation criteria	2014	Australia	-	
BIM Level 2 BRE certification	2015	UK	-	

As seen in Table 1 there are sixteen models developed in different countries. The advantages and disadvantages of these models vary greatly. For instance, the BIM-MM is currently the only UK-based AM that evaluates the BIM maturity of ‘projects’. It seeks greater linkages between substantial measures that reflect the broader perspectives of BIM, rather than focusing on one area, as in the NBIMS-CMM. It is a self-assessment and freely available for wider industry use, whilst in the BRE certifications a third-party is required to complete the assessment, which incurs a fee. Furthermore, BIM-MM is user-friendly and short to complete which attracts more interest compared to models that are detailed and complex. However, in order to optimise the BIM-MM, it should be implemented in practice which would maximise its effectiveness and suggest future directions of model to evolve.

## RESEARCH METHODS

A comprehensive study is reported in this paper which documents the implementation of BIM-MM on 213 CSPs at Arup. The purpose of this AM is to enable comparison between projects, demystify BIM and to improve its capabilities across design and engineering disciplines (Arup, 2014). BIM-MM consists of eight parts: project, structural, mechanical, electrical, public health, facades, geotechnics and lighting. To complete the assessment participants have to specify one out of six possible maturity levels for each of the evaluated measures. These levels are 0 Non-Existent, 1 Initial, 2 Managed, 3 Defined, 4 Measured and 5 Optimising.

Once project assessment is completed (the first part of the BIM-MM) an overall 'Information Management Score' (IM Score) is provided. In addition, a "Primary Score", gives the average scores of the Project and the first four disciplines, usually Structures, Mechanical, Electrical and Public Health. The ideal scenario is to complete all seven parts of the BIM-MM to provide a holistic portrait of BIM implementation across project teams. However, projects can still be assessed based only on the project part and at least one of the eight other disciplines.

### Data collection and analysis

Data collection was carried out by different project teams within Arup. The BIM-MM was advertised internally in Arup's offices for self-assessment use. This was supplemented with training videos, documentation and workshops to guide and encourage the use of the tool around the world. Then, individual teams identified appropriate BIM projects for examination. The project manager of each team ensured the completion of the assessment, either by carrying it out themselves, or by handing it to someone within the team. In both cases, different project members might be consulted to get more information needed for the test.

To analyse the results of the 213 projects, the comparative method was used. The comparative method is a fundamental tool of analysis, since it sharpens the power of description and focus similarities and differences across CSPs (Collier, 1993). Unlike 'case study' approach, comparative method does not provide highly contextualised and rich emphasis of individual CSP. Instead, it aims to identify "clusters of elements or configurations that support particular outcomes" (Schweber & Haroglu, 2014). It also assists in identifying the distinctive connections, trends and patterns when comparing processes and relationships across cases (Ragin, 1989).

## FINDINGS: APPLICATION OF BIM-MM

Analysis of the 213, exhibited in Figure 1, provides an overarching view of how BIM is being implemented across some critical measures. The figure shows the distribution of these projects through the six levels of maturity. In particular, it focuses on the first part of the BIM-MM, namely, the 'Project BIM Maturity' section, which consists of eleven measures. As seen in Figure 1, the numbers of projects with low levels of maturity (level 0 Non-Existent, level 1 Initial and level 2 Managed) is higher than the number of projects with high levels of maturity (level 4 Managed and level 5 Optimising). Examples can be found in six measures i.e. BIM Design Data Review, Project Procurement Route, Marketing Strategy, Open Standard Deliverables, BIM Contract and BIM Champion, in which all have fewer projects with higher levels of maturity.

For instance, in Project Procurement Route, the number of projects allocated to level 5 Optimising is over five times fewer than projects with level 0 Non-Existent (7% and 39%

respectively). The mapping of these projects enables specific areas of strengths and weaknesses to be identified. Three quarters of all the 213 projects (76%) have no BIM contract or provide poorly-defined BIM agreements in consultant appointment (top left of Figure 2).

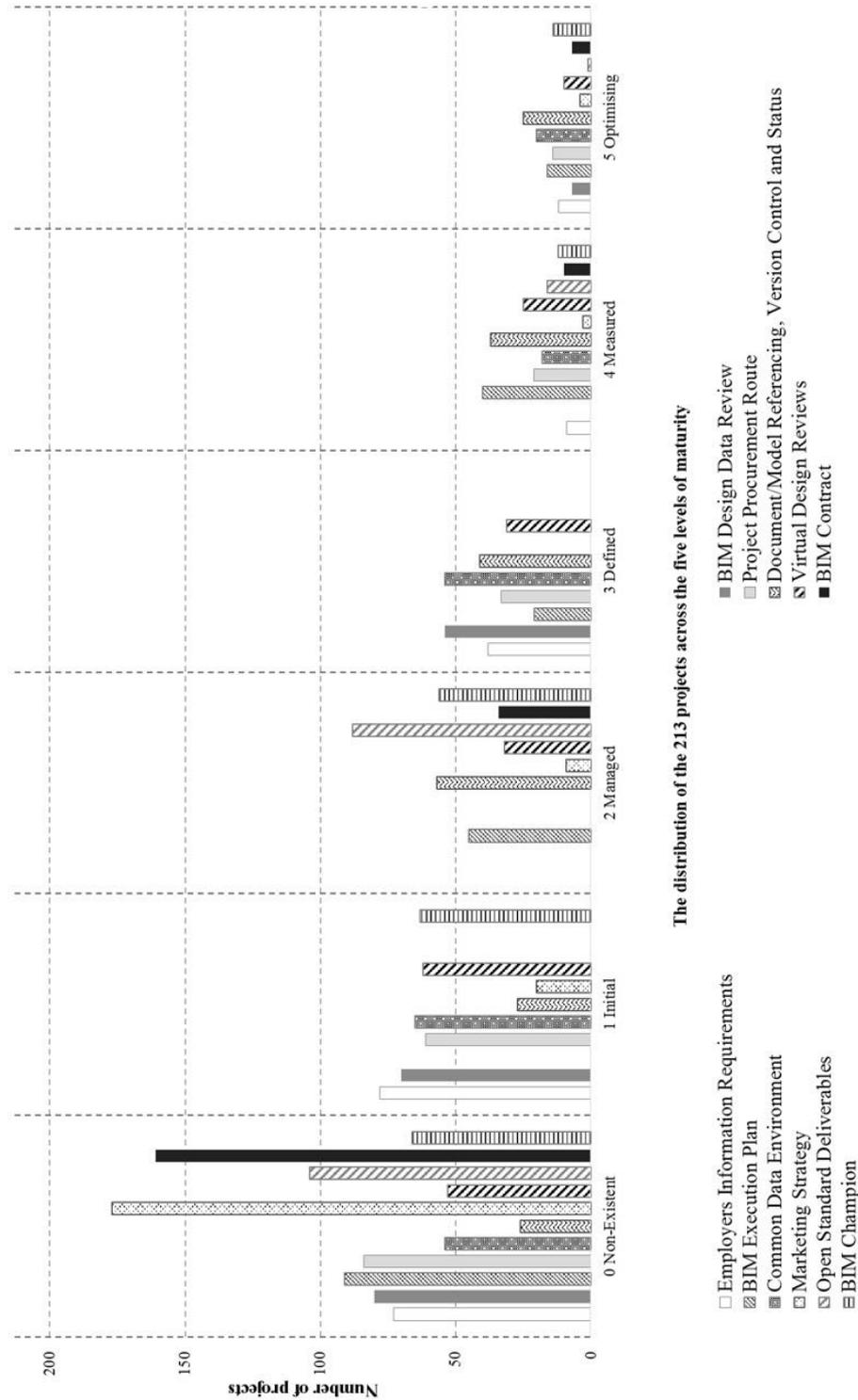


Figure 1: The performance of 213 case study projects against the five levels of maturity across the eleven measures

As a result, the company could explore the impact of this factor on their business. If the absence of a contract reduces the potential benefits of BIM, then all parties, including contractors, should sign up to an industry standard BIM contract.

Similarly, high numbers of projects have no Marketing Strategy (83%), defined by the BIM-MM as ‘BIM specific case studies to showcase and share the key points’. Whilst the lack of marketing strategy will not necessarily have a negative influence on the adoption of BIM, nevertheless the act of engaging with this AM has identified a potential area for development which might otherwise have been missed. Strengths can also be identified. In the ‘BIM Execution Plan’ (BEP) measure, 57% of the projects range between level ‘2 Managed’ to level ‘5 Optimising’, which means that BEPs have been used in all these projects to formalise goals and specify information exchange. Another example of strength is found in Document and Model Referencing, Version Control and Status with 75% of projects ranging between level ‘2 Managed’ to level ‘5 Optimising’ (bottom left of Figure 2).

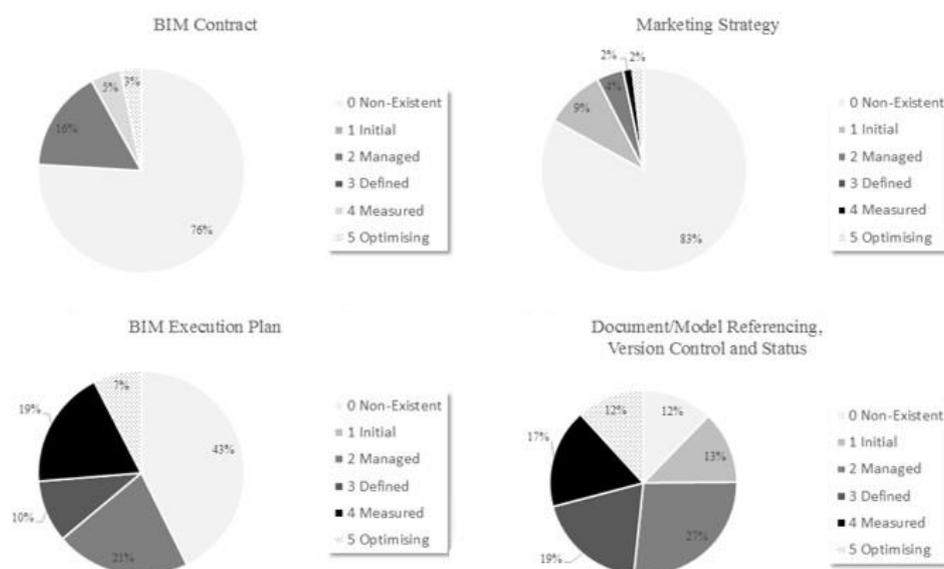


Figure 2 Examples of the distribution of the 213 projects across the six levels of maturity in four different measures

### The relationship between the BIM Champion and the rest of the measures

With the development of BIM, new roles have emerged in the AEC industry. ‘BIM Champion’ is one of these emerging roles which is evaluated in the BIM-MM. The BIM Champion is the person who has the motivation and technical skills to guide teams to improve their processes, push BIM utilisation and manage resistance to change (CIC, 2013). The degree of a champion’s engagement varies across different companies and sometimes within the same company across different projects. According to BIM-MM, five levels of maturity of ‘BIM Champion’ are identified (most of other measures have six maturity levels). Analysis of the 213 projects shows that approximately 70% of these projects have a BIM Champion, but with different levels of engagement, this is presented in Table 2.

The overall scores of projects allocated to each level of maturity have been averaged to isolate the effect of having a BIM Champion. For example, there are 66 projects allocated to level 0 Non-Existent BIM Champion. The average ‘Project IM Score’ of these 66 projects is 14.6% and the average ‘Primary Score’ is 23.5%.

Table 2 The five maturity levels of 'BIM Champion' and the numbers of projects allocated to each level

Maturity level	Description	No of projects	%
0 Non-Existent	No BIM Champion on this project	66	31 %
1 Initial	BIM Champion is identified but limited time commitment to BIM initiative	63	30 %
2 Managed	BIM Champion with adequate time commitment on this project	56	26 %
4 Measured	Leadership Level BIM Champion with limited time commitment on this project	12	6 %
5 Optimising	Leadership level BIM Champion working closely with BIM Taskforce champion	14	7 %

The same approach is applied to projects with all five levels of maturity and the results are shown in Figure 3. Interestingly, the average scores of projects are higher when the BIM Champion has a greater level of involvement in the BIM implementation process. The average of IM Score of projects with Champion level 5 (57.6%) is over three times the average scores with no BIM Champion (14.6%).

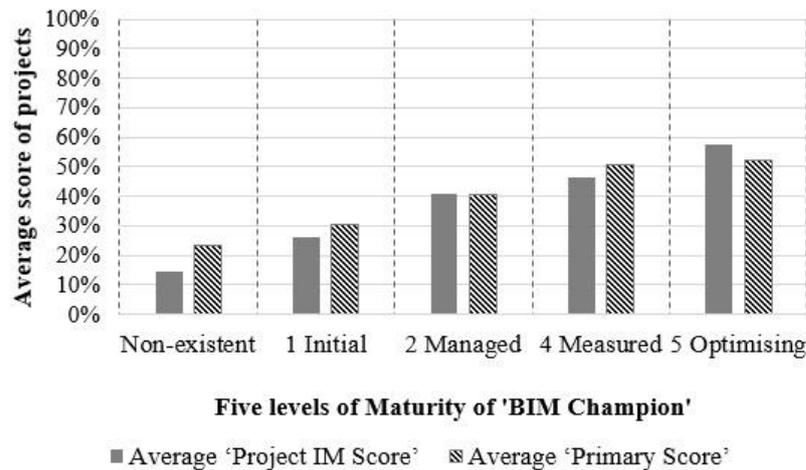


Figure 3 The link between the existence of BIM Champion and the project scores

Another interesting finding is the relationship between BIM Champion and the rest of the individual measures. Figure 4 shows the average scores of each of the ten measures across the 213 projects, split in terms of the BIM Champion level. Overall, there is a significant growth in the average scores of all measures between level 0 and level 4 of BIM Champion. All average scores of level 4 are at least twice the average score of level 0, and in some instances scores are significantly higher. This is exemplified in the BIM Execution Plan (BEP) measure, where average score in level 4 is 10 times the average score of level 0 (3.45 and 0.3 points respectively). The observed relationship between the BIM Champion and the overall scores of projects might be explained in the following manner. BIM Champions undertake actions at the leading edge of BIM's three core dimensions: technology, process and policy (Change Agents AEC, 2013). By looking at these three dimensions, BIM Champions ensure that teams are not treating BIM according to its fractional elements, but rather they are looking at the wider picture. They also define the current status of BIM and guide teams towards desired goals and aims. However, what is unexpected is that half of the measures have lower scores in level 5

compared to level 4. This is exemplified in BEP, Virtual Design Reviews (VDR), BIM Design Data Review, BIM Contract and Marketing Strategy. For instance, there are 1.3 points differences between level 4 and 5 of the VDR. The reason for this is not clear. In the literature there are no detailed studies that focus on the role of BIM Champion and this will require more specific research to identify the underlying cause.

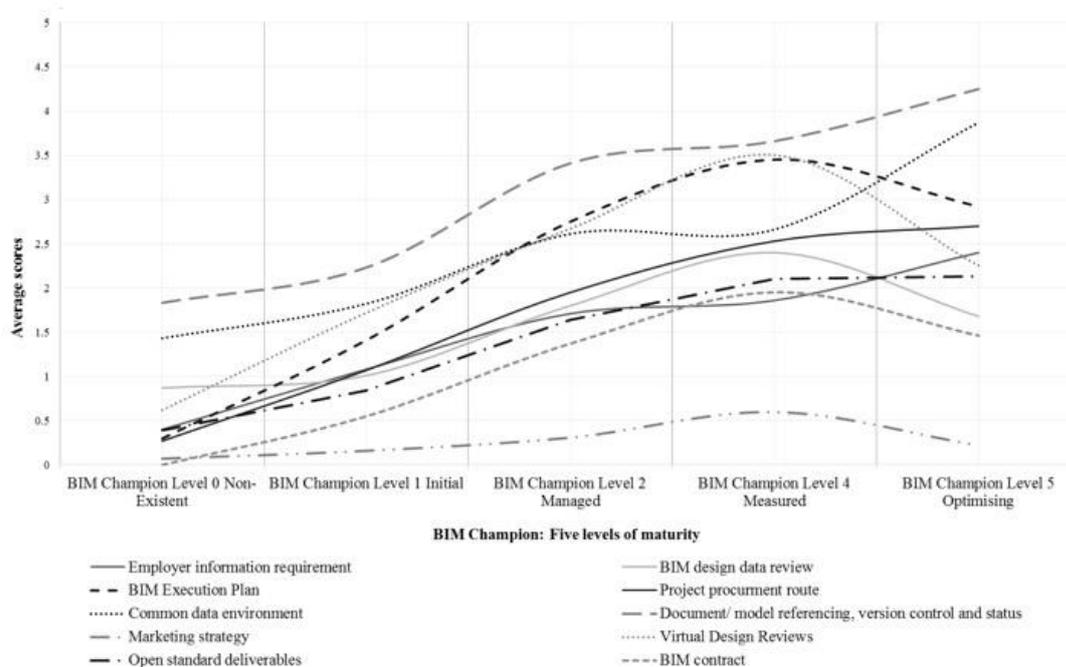


Figure 4: The impact of the BIM Champion on the rest of the measures

## DISCUSSION

This comprehensive study generates new insights over previous studies that evaluate BIM in use; in particular, by treating the BIM-MM as a method to observe how BIM is being implemented in the AEC industry. Through the use of BIM-MM, Arup is “aiming to drive a more open conversation about the use of BIM to improve its positive impact across the project spectrum” (Arup, 2014). By doing so, the BIM-MM can be used to engage different project teams in greater dialogue, which informs the decision-making process. This particular role of AMs has not been documented previously in the BIM literature, but it has been acknowledged in different research fields (Cole, 2006).

The maturity levels of the measures vary significantly across the 213 projects and it is important to note that not every project is expected to obtain level 4 Measured or level 5 Optimising. This is similar to the findings of Kam (2015) who argue that it is not necessary to push every project team to achieve the highest levels of maturity in every measure. Instead, the target should be defined by the organisation which should reflect the desired expectations. In their study which applies the VDC Scorecard to 108 projects, (Kam *et al.*, 2013), none of the examined projects have been allocated to ‘Innovative Practice’ overall (the VDC’s Scorecard levels of maturity are Conventional Practice, Typical Practice, Advanced Practice, Best Practice and Innovative Practice).

One interesting finding is the relationship between the BIM Champion engagement in the BIM implementation process and the overall scores of projects. It has been observed that the average score of BIM maturity levels is significantly higher when a BIM Champion has a greater participation in the project. However, part of the project score is directly due to the increase in BIM Champion maturity, but this in no way accounts for all the

increase in score. Companies should, therefore strengthen the role of BIM Champions in their practices in order to achieve sharper and more efficient business process of BIM. So no matter what level of maturity the 'BIM Champion' is, their existence, even if with limited time, leads to at least a 10% increase in average scores of projects. However, the case for investing resources in implementing a level '5 Optimising' BIM Champion is perhaps less clear.

## CONCLUSIONS

Since 2007, there has been remarkable developments in the field of BIM-AMs, with at least sixteen assessments to date. Despite this growth, there are still fundamental challenges to be addressed. In particular, the shortage of case study projects, which is one of the main challenges in performance measurement. Previous research in the field of BIM-AMs tend to focus on introducing new models without, in many cases, implementing them in practice. This lack of implementation makes it difficult for both academia and industry to understand the practicality of these AMs, their advantages and shortcomings. Arup is pushing the boundaries of BIM and they are currently leading the way in regards to BIM evaluation systems in the UK's AEC industry and beyond. Future directions of the BIM-MM will focus on supplementing the model with financial measures. The BIM Maturity Measure is about to become a key performance standard for Arup's global offices. The authors believe that such implementation is necessary if the opportunities promised by the effective BIM implementation are to be capitalised upon.

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# MAKING THE LINK BETWEEN BIM'S BENEFITS AND IMPLEMENTATION

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Despite the attention paid to measuring the perceived benefits of Building Information Modelling (BIM) increasing its adoption throughout the construction industry, important links between implementation, support and benefits have received little focus. This paper explores how the conditions of implementation define the benefits of BIM adoption. The findings from two case studies implementing and using BIM are presented and compared. The first is a large urban regeneration project and the second is a healthcare project. A well-recognised model of system success was mobilised from the field of information systems (IS) to reveal that irrespective of project size and type, without sufficient support that addresses business process reengineering implementation is focussed on technology and technical process. Focus is on the disconnections between organisational level BIM implementation and project level BIM implementation. An incendiary issue for both cases was BIM awareness amongst project participants and stakeholders, however, the effect of this on implementation success varies within each case study. In using the DeLone and McLean Model to systematically examine the system at a point of reconfiguration, benefits are captured relative to the implementation approach. This study highlights the significance of these interdependencies and argues for a more comprehensive approach to BIM benefits capture that recognises this to usefully inform implementation strategy development.

Keywords: BIM, implementation, benefits, assessment

## INTRODUCTION

A building information model is the digital representation of a built asset and its components ‘in a virtual assembly of interconnected database objects and associated metadata in a coordinated, scaled 3D model’ (Davies and Harty 2013b). Intuitively, this implies the application of various technologies to fulfil the elements of this definition and central to it is the use of 3D modelling software.

However, if the definition of the term BIM has or is to have a contributory effect on its adoption and implementation it should reflect the anticipated shift toward an information centric approach to design, construction and operation that includes both process automation and improvement (Dowsett and Harty 2014). Davies and Harty (2013b) comprehensively define BIM as ‘the process of users designing buildings, individually or in collaboration, using a variety of ICT tools (3D CAD, databases, interfaces) and associated business processes to represent and manage information in the model’. This also captures the synonymy of BIM and collaboration and implies that a fundamental implication for a number of, if not all, stakeholders is some level of business process

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reengineering will be required to use BIM as a collaborative mechanism (Morlhon *et al.*, 2014; Ashcraft 2014)

A large number of studies attempt to measure the benefits surrounding the implementation of BIM methodologies and processes but the predominant focus of these studies is on financial metrics that put a focus on the business case for the implementation of BIM (Barlish and Sullivan 2012; Becerik-Gerber and Rice 2010; Giel *et al.*, 2010). However, a critical necessity of management practice is to balance short-term and long-term organisational capabilities to adapt and evolve with regard to competition and industry requirements and it is well understood within the BIM implementation literature that BIM requires more than simply technology adoption (Howard and Björk 2008). Yet there exists no formal repeatable measurement framework that delivers iterative and transformative results for process improvement or promotes the process-oriented understanding of BIM and the extent of change necessary to achieve it.

Within this study BIM implementation has been conceptualised according to two assumptions drawn from the literature; firstly, that BIM is congruent with the definition of an information system consisting of technologies, people, and processes (Jung and Gibson 1999; Jung and Joo 2011), and secondly, that the implementation of information systems is the process of reconfiguring a complex set of technologies, actors and activities within existing systems comprised of various existing organisational, cultural and social characteristics (Harty 2008; Poirier *et al.*, 2014; Taylor 2007). This is particularly important in the assessment of implementation success when considering that many implementation initiatives are a process of ‘learning on the job’ in which innovations are shaped and dictated by these existing system characteristics (Barrett and Sexton 2006). In light of this, the failure to successfully implement BIM is most commonly a consequence of insufficient focus on the organisational and social aspects of implementation (Erdogan *et al.*, 2008).

## METHOD

Employed from the field of information systems the DeLone and McLean IS Success Model is used within the context of this research as a framework to comprehensively capture the positive and negative effects of BIM use on projects and how these have been affected by its implementation. The model has been applied, tested, reviewed and adjusted a number of times within a variety of IS contexts in response to both its utility as an assessment framework and at the request of the authors who encourage its modification to suit the context of use (DeLone and McLean 1992; Seddon 1997; Halonen 2011; Petter *et al.*, 2008).

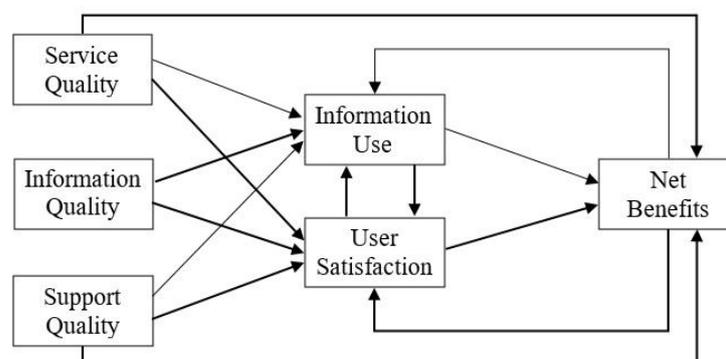


Figure 1: DeLone & McLean Model (Adapted)

An important factor to consider in using the model was how to translate the constructs into operational terms. For both case studies a series of semi-structured interview questions were developed to investigate each of the six quality constructs of the DeLone and McLean model made specific to BIM through a critical review of the literature. A conceptualisation fundamental to this study is that the implementation of BIM is the reconfiguration of technologies, activities and actors, therefore both the constructs and questions investigating them were designed to reflect this.

For the purposes of this study, Intention to Use and Use constructs were integrated into Information Use to reflect the information-centric principles of BIM and the disparate uses of this information by each stakeholder. In addition, Service Quality was replaced with Support Quality to reflect the effect of organisational and cultural context on the success of the system.

The design of the interview schedule enabled a systematic investigation of the constitutive elements of implementation and their quality into an observable system.

Questions regarding System Quality referred to the technical quality of the BIM system (e.g. efficiency and functionality); Information Quality referred to system outputs (e.g. relevance and informativeness); Support Quality referred to system support (e.g. adequate training and protocol effectiveness); Information Use referred to task based activities (e.g. nature and appropriateness of use); User Satisfaction referred to the attitude of the user (e.g. enjoyment and decision-making satisfaction); and Net Benefits referred to improvements in individual and organisational capabilities (e.g. overall productivity, cost/time savings).

Interviews ranging from 60-90 minutes in length were conducted with design team members and project leads to investigate project performance in relation to implementation of BIM on each. Interviewees in Case Study 1 consisted of the core design team interfacing with a specific design component: CLT contractors, MEP engineers, BIM Manager, Design Development Manager, and the BIM Consultant. The decision to focus on one design component was made because the case forms part of a larger study in which this project was used as a pilot to test the suitability of model and the methodology employed. Interviewees in Case Study 2 consisted of the core design team consisting of Architects, Interior Designers, Structures, and MEP disciplines.

The case studies examine BIM implementation at project level using the DeLone and McLean model to systematically construct a narrative of implementation and to investigate the interdependencies between its constitutive elements and accounts of net benefits. The analysis process resulted in three interconnected components. Firstly, a narrative of the cases providing an in-depth account of the implementation process and its impact on project success, secondly, the categorisation of the empirical data into the six constructs of the DeLone and McLean IS Success Model to provide a thematic map of the constituent parts of implementation, and thirdly, using the narrative interdependencies between each construct were then established to capture the relation between the conditions of implementation and project success.

## **FINDINGS**

The findings presented are an overview of the context of implementation for each case study and its effect on the benefits experienced on the projects. To illustrate the potential of the DeLone and McLean IS Success as a means to systematically link the more process-orientated conceptions of BIM implementation to the particularities of the empirical data the findings focus on the most significant benefits of system use. This is

also to illustrate the repeatability of the model in future studies to address the limitations of previous cost/benefit analysis methods that cannot capture context specific implementation issues.

### **Case Study 1 Project description**

The first case study presented is a large urban regeneration scheme in the first-phase of a five-phase programme providing residential units, retail and business space, community, culture and leisure space, an energy centre, a park and public realm. The project is also utilising cross-laminated timber (CLT) as a structural design feature. The design team consists of interorganisational disciplines.

The client/contractor aspires to implement BIM through to FM with the original bid for BIM developed by project leads to secure external BIM consultant for the project who was appointed during the detailed design stage after design team appointments had been made. Their first task involved conducting a number of workshops to determine client BIM objectives and aspirations and their requirements for BIM methods, workflow and deliverables though the stage at which BIM was adopted meant that the majority of these aspirations were not met or intended to be met in this phase of the project.

The consultant was responsible for developing the BIM Execution Plan (BEP), and to set up BIM protocols, standards, and model audit cycle requirements. The documents are located within the document management system (DMS) and are available to all project participants. Given the size of the project and the level of capabilities that are aspired to these documents are in constant development with input from design team members, primarily the BIM managers (whose experience varies considerably) within each discipline.

Their specific role within the project is BIM Coordinator, which involves federating the models received by the design team for the purposes of clash detection and coordination within Navisworks Manage. This also involved configuring a series of predefined Saved Viewpoints for levels, grids, risers, lifts and stairs within each building to define search sets in each building for clash tests. Some 3D views of design issues are saved and 'redlined' for project team review.

In comparison to Case Study 2 there is no company-wide BIM implementation programme for project-level system configurators to refer to for existing protocols.

### **Case Study 1 Findings**

According to the interviewees the most valuable contribution to the effective use of BIM on this project relates to the efforts made by the BIM Consultant to develop protocols that support the ongoing development of the model.

The model audit cycle stipulated within the BEP supports the standard and timely production of a 3D federated model that facilitates, early clash detection, easier interpretation of design intent and a faster design review. One interviewee described the model audit cycle and federation process developed and supported by the BIM consultants as:

- 1...one of the better led parts of the design process because it's been formalised and it's structured and every two weeks everyone re-issues and there's process and a protocol...

However, despite the appointment of the BIM Consultant having had a positive impact on the use of BIM within this project there are still fairly obvious constraints at a managerial level that have prevented the effective use of BIM for design activities. Much of which

originates from a fairly vague brief that has considerably limited the extent of change the BIM Consultant could make:

2...their brief to us was very vague, more or less, 3D, 4D, 5D, 6D would be a requirement but not essential, like a stepping stone, growing capabilities on this project to improve the next phase etc.

In effect, the implementation of BIM has involved overlaying a BIM methodology onto a traditional design programme so whilst there are improved capabilities in terms of task automation and more information of a better quality this is constrained by programmatic misalignment that prevents information exchanges at the most appropriate times. For example, early design issue identification was a commonly cited benefit of working within a BIM environment that occurred as a result of both the functionality of the technology but also the support provided by the BIM consultant to federate and manage models received according to the two-week model submission defined within the BEP. Yet by not clearly defining the information exchange process to reflect the front-loaded BIM process understood within the literature issues can be identified that may not necessarily be of critical importance. In which case, early design issue identification is by-product of a 3D environment rather than an intended process and there have been negative consequences. This had a direct impact on the amount of additional work the team members had to conduct in order to meet the constantly changing requirements and in some cases resulted in delays in package completion and was a particular issue for the CLT Consultants whose design progress is heavily reliant on the early receipt of information for prefabrication:

3...the benefits of BIM have not been fully realised since the coordination and clash detection processes are...happening later in the 3D process than would be useful for our design development...

More importantly, the amount of work varies depending on the discipline, their roles and responsibilities, which is something that did not appear to be considered either in contractual terms or appointments prior to the start of the project. To mean that, disciplines were appointed without existing technical capabilities and ultimately held the rest of the team up such as MEP, and other disciplines were being asked to produce information beyond their contractual obligations. In effect, without a clear understanding of strategic intent varying degrees of change toward a BIM methodology happened within the project depending on team member technical capabilities and innovative cultural traits. For example, quite late on the MEP team appointed a BIM Manager whose primary task was to manage the model rather than assist in the development of new processes; in contrast the CLT Contractors developed new workflows liaising far more with the project BIM Consultant to ensure compliance with project requirements and to improve existing practices for future work.

BIM as a method of working was implemented on the project after the design team had been appointed so there would inevitably be a learning curve for each discipline to varying degrees and a regularly occurring and potentially incendiary issue evident throughout the interview data was that there was no consensus of understanding of the plan to adopt BIM. Uncertain BIM deliverables and no clearly stipulated client information requirements makes it difficult for each discipline to strategise their approach to information delivery making the duration of the BIM-enabled design programme difficult to define so whilst there maybe improvements to design solutions. When these issues are presented within the DeLone and McLean model the importance of the effect of these antecedent conditions on the system, and consequently project performance

becomes available to system configurators in a comprehensible format to understand how and why the project performed the way it did, as shown in Figure 2.

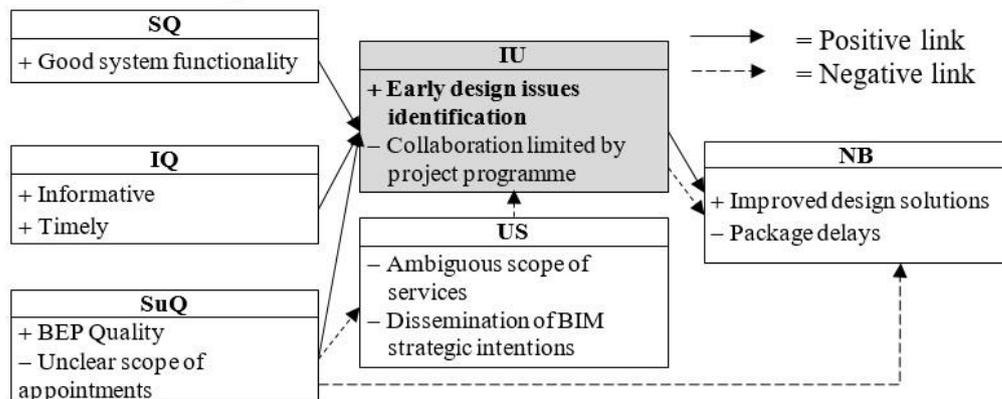


Figure 2: Case Study 1 Information use case - early design issue identification

In effect the project has followed a techno-centric approach to BIM implementation in which capabilities have improved but are limited in their scope by the constraints of a traditional design programme.

### Case Study 2 Project description

The second case study is a hospital refurbishment project expanding the emergency department within an existing hospital to improve clinical effectiveness and reduce patient waiting times. The design team consists of intraorganisational disciplines. The organisation has a company-wide BIM implementation programme with a dedicated BIM Group that develops protocols and processes for project-level dissemination.

BIM was driven by the architects for two principle reasons: firstly, within healthcare projects it is difficult to get clinicians to understand 3D space using 2D drawings, and secondly, to improve the process of equipment specification. The architectural team developed a BIM Strategy Plan for the project that sets out the objectives and goals for BIM use on this project based on a template made by the BIM Group. However this is limited in its extent because client expectations for BIM were not apparent therefore, the aspirational BIM use for the project is to Level 2 BIM for the design team only adopting only the collaborative principles of Level 2 BIM: ‘Full delivery of Level 2 BIM information is not intended.’

The key initiatives in place to fulfil this are the consistent use of modelling software by all design team members to produce a model every two-weeks for federation and to also use dRofus as an information management tool for the ongoing development of room data sheets and equipment quantification.

### Case Study 2 Findings

The primary benefits of using BIM identified within this project relate to the discrete technical aspects of the system, such as automation of manual processes and improved understanding of design intent related to the functionality of the technology employed.

However, satisfaction with system implementation varies among the interviewees depending on their role and task responsibility. For example, architects and structures benefit from the visualisation aspects of using the technology for the purposes of design interpretation, which contributes to design quality but they are not benefitting from early receipt of information from the MEP engineers. MEP engineers have benefitted from

minor productivity improvements from using the technology where it is most appropriate but these do not make a significant impact to their design process. They are frustrated that BIM has been implemented without sufficient consideration of their own design process in that the coordination of information can only happen if the information is there in the first instance, which is a process problem not a technological problem and related to requirements elicitation and the development of an information exchange process that supports this. Essentially, the implementation of BIM has only extended as far as the application of technology and the benefits of doing so tend to be limited to discrete productivity improvements rather than improved collaboration and coordination.

The main benefit to BIM use on this project relates to the architects and the improved consultation meetings they have with the clients but the effect of these benefits on other disciplines has not been fully considered within the context of the project as a whole. For example, the architects can now adjust the design to a greater extent than they would previously but what this means for the MEP engineers is that they are constantly having to catch up with the architects design programme. Moreover, there is no change control procedure in place so to identify any changes made so they:

4...either have to do it the old traditional way and export it into another format to do an overlay and use two different colours or do a comparison within Navisworks just to see what's actually changed (MEP CAD/BIM Manager)

In which case the interfacing disciplines have to spend additional resources to compensate for the improved technical capabilities the architects now have. Furthermore, the consequence of no change control procedure is that some of the work interfacing disciplines are working on may become abortive which has a knock on effect to productivity and design progress.

5...they might be coming near to the end of doing all those changes but we have to issue more out now saying, actually that layout's changed, here's our new model. So they, it's back to the drawing board for them kind of thing. (Architect Technician)

Clarity over roles and responsibilities and ultimately collaboration at the start of the project to define these would have been a useful contribution to improve the scope of benefits afforded from improved information use but the organisational context, in terms of existing business processes prevented this.

Perhaps most significantly, is that the team could only approach the implementation of BIM from a techno-centric perspective due to resourcing at an organisational level. The architectural leads attempted to secure consultancy service support from the BIM Group but this was denied on the grounds of insufficient credits. What this has resulted in is a collection of disciplines using the same technology, experiencing different levels of process improvements that have not been aligned or integrated effectively and in some cases may worsen the issues the technology was intended to benefit.

By examining the use of BIM on this project using the DeLone and McLean model fundamental differences between disciplines' work practices and processes have emerged against the context of implementation to highlight shortcomings and areas for improvement. These were then distilled into construct measures and used to populate the model providing a graphical illustration of the measure of focus and how the implementation of the system has affected this in terms of net benefits.

Primarily, there was no period of time prior to project commencement to determine where and when process conflicts may happen that would negate the benefits using BIM technologies. Consequently, they had no means to develop a sufficient strategy to

reconfigure processes and technologies to deliver the anticipated benefits and no resourcing allocated to support their reconfiguration.

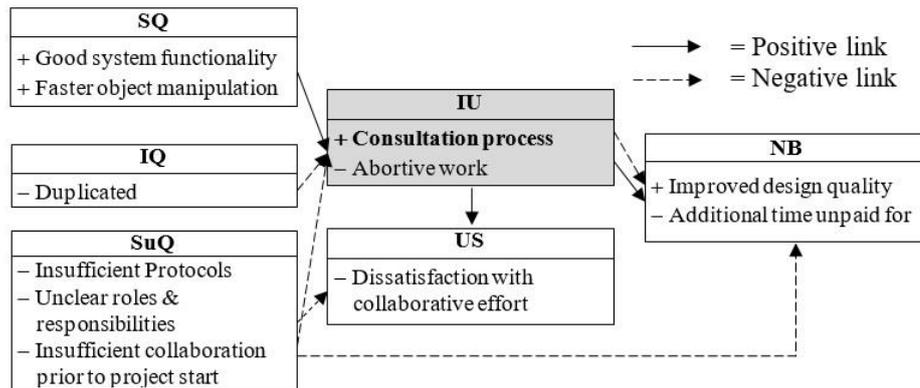


Figure 3: Case Study 2 information use case - improved consultation process

Essentially, the more significant benefits to information exchange anticipated from working in a BIM environment are left unrealised because the fundamental process changes required to do so are constrained by the organisational and cultural environment of the project. The implementation process proceeded in a relatively ad hoc fashion and as the interviewees discussed, would have benefitted from a systematic approach to implementation that would explicate how the actors, technologies and activities should be reconfigured to effectively deliver the projects information requirements.

## DISCUSSION AND CONCLUSION

As the literature and case studies demonstrate, the benefit that the technology affords is dependent on changes made at an organisational and cultural level to enable the effective implementation of collaborative processes and practices; essentially, creating an environment that supports and facilitates effective change management.

Neither case study employed any kind of implementation framework. BIM implementation happened on a relatively ad hoc basis and both organisations learnt by trying. The understanding of how actors in the system collaborate and communicate, such as the design programme, cash flow, information requirements, and contractual appointments, happened too late for any effective changes to be made. These reoccurring themes throughout both the literature and the case studies augment the argument for a more comprehensive methodology to assess BIM implementation.

Both projects followed a techno-centric implementation of BIM but for different reasons. In Case Study 1 BIM implementation proceeded from a techno-centric understanding of BIM at an organisational level evident in their conscious decision to focus more on technical process development through the appointment of a BIM Consultant and the technical responsibilities they carried out. In Case Study 2, BIM implementation followed a techno-centric process because this was the only option available within the organisational and cultural constraints of the project. What this means for improving implementation is that unless the potential incendiary organisational and cultural issues can be identified to a certain extent investment decisions for implementation are made relatively arbitrarily (Irani 1998).

Using the model has allowed connections to be made between the level of actor-technology engagement required to achieve the success measures and the antecedent cultural and organisational factors that affected that engagement; the factors that contribute to the production of information, how that information is used and the net

benefits of using that information. Respondents often criticised the structure of the project programme as a significant impediment to information use; if all stakeholders that have an effect on the way information is exchanged are not signed up to an information-centric BIM methodology and adjust their practices accordingly, information producers cannot utilise the technology effectively to fulfil the potential benefits they can see might happen.

Furthermore, by assessing the project benefits in parallel to the implementation approach users challenge their perceptions and understanding of BIM. They become more cognisant about their impact on the design process, more aware of BIM implementation as a business process reengineering initiative, more aware of the importance of clear strategy and coordinated processes, and finally more aware of the organisational and cultural factors that prevent, enable or expedite these.

The use of the DeLone and McLean Model has the potential to systematically link the more process-orientated conceptions of information systems to the particularities of the empirical data whilst maintaining utility as a generalisable approach to BIM benefits assessment in future studies. In other words, to a greater or lesser extent each construct within the model addresses one or other of the key concepts discussed within the BIM implementation literature. Moreover, the utility of the model constructs in addressing these concepts comprehensively and systematically means that what would previously have been isolated emergent issues can now be categorised and delimited to their interdependent system aspects. To mean that remediating initiatives can be applied rationally in terms of the inherent organisational and cultural constraints of the system rather than in an ad hoc fashion as was experienced in both case studies. From this critical success factors can then be identified along with key performance indicators to measure progress and design new processes relative to the project context that can explicate the aspired benefits of BIM.

The iterative approach to implementation that the model is intended to facilitate then becomes a starting point from which to redesign organisational functions processes into a collaborative environment and engender value in simultaneous and interdependent improvements.

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# IMPROVING INFORMATION/KNOWLEDGE MANAGEMENT THROUGH THE USE OF BIM: A LITERATURE REVIEW

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With the rapid development of the construction industry, its projects are becoming more complex. Information management plays an important role in this scenario. Various information technology (IT) systems have been developed to support project information management. As a 3D object-oriented system containing geometric and non-geometric information of a project, building information modelling (BIM) has become widely used to manage the project's information. On the other hand, knowledge is the most competitive resource in any organisation. In construction, knowledge management has gained increasing attention. Some IT-based systems have been established to aid knowledge management during a construction project. Although BIM is widely used in information management, BIM-based knowledge management is rarely studied. This paper presents a comprehensive literature review on BIM-based information/knowledge management. The literature on BIM-based information management is first reviewed in a systematic way. BIM-based knowledge management is the focus of the second part of the literature review. This paper concludes with a critical discussion to indicate the knowledge gap in current research and to identify future research questions and directions in this area.

Keywords: BIM, information management, knowledge management, literature review

## INTRODUCTION

Information management and knowledge management have been part of the construction industry for years. The fragmentary and temporary nature of construction projects makes it difficult for information to be communicated among project participants (Lindner and Wald 2011). Therefore, construction researchers have explored a variety of tools, methods and systems in order to improve information management in construction projects. Knowledge is at the higher hierarchy when compared to information and it is perceived to be the most competitive resource in most construction organisations (Rowley 2007). Several researchers have applied tools or strategies to assist knowledge management in the construction industry, such as ontology, knowledge maps and communities of practice (Carrillo *et al.*, 2000; Rezgui 2006; Lin and Lee 2012).

BIM is an information-integrated tool, which is different from other traditional computer-aided design (CAD) tools (Singh *et al.*, 2011). Information stored in BIM can be used to estimate schedule (4D) and cost (5D). In addition to 4D and 5D estimations, the design and construction information contained in the BIM model can be used by facility managers to evaluate energy consumption and generate better maintenance strategies.

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Moreover, researchers have recognised that BIM should be used in a collaborative way throughout the lifecycle of a project (Singh *et al.*, 2011).

Although knowledge is rated higher than information, at this stage, only a small number of studies have recognised the potential of BIM in improving knowledge management practice. According to these studies, some characteristics of BIM can certainly make specific knowledge management processes much easier. For example, 3D model representation and simulation can facilitate knowledge visualisation (Meadati and Irizarry 2010; Lin 2014). The parametric nature of objects contained in the BIM model can be seen as a tool to capture and store knowledge (Meadati and Irizarry 2010; Deshpande *et al.*, 2014). In addition, various knowledge management techniques integrated with BIM facilitate effective knowledge management, which include ontologies (Kim and Grobler 2009; Park *et al.*, 2013; Charlesraj 2014), case-based reasoning (CBR) (Motawa and Almarshad 2013), fault tree (Motamedi *et al.*, 2014), knowledge map (Lin 2014) and criteria measurement (Nguyen and Toroghi 2013).

Although several studies have recognised the capability of BIM to improve knowledge management processes, as a new research area, further research is required to explore how BIM can be used to achieve better knowledge management. Therefore, this paper aims to explore the shift from BIM-based information management to BIM-based knowledge management through a comprehensive literature review. Extant studies on BIM-based information management are first reviewed. The main focus of the first part will be on 4D, 5D, collaborative information management, and information management in facility management (FM). A review of the literature on BIM-based knowledge management will follow. After the literature review, a discussion will be made to identify the knowledge gap in current research and the future research questions and directions in this area.

## METHOD

This paper is based on a literature review. The sources for the literature on BIM-based information management are chosen from peer-reviewed English language journals. For the literature sources of BIM-based knowledge management, both peer-reviewed English language journal papers and conference proceeding papers are included. Two search engines were used to source the literature, namely, Web of Sciences and Scopus. They contain different databases which ensure that no omissions are made while searching for relevant literature.

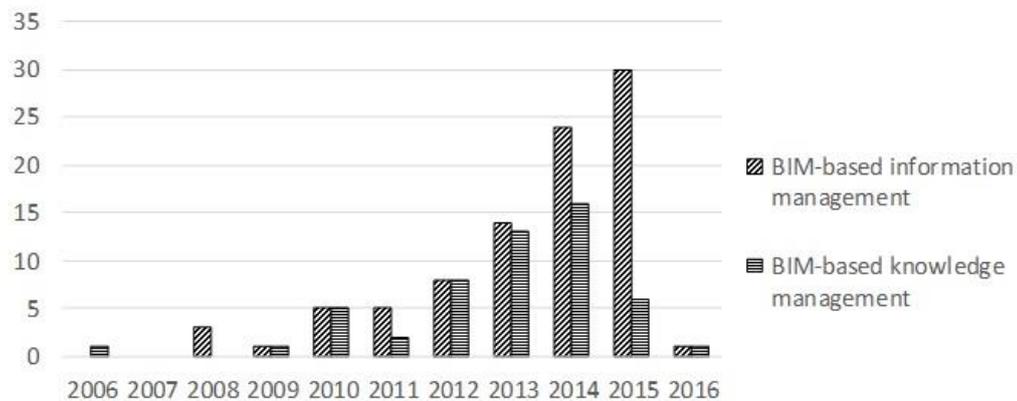
In order to search for the literature on BIM-based information management, keywords used include “BIM + information management”, and “Building information modelling + information management”. 217 results were obtained from Web of Science and 318 from Scopus respectively. However, a large number of results were repeated. After sorting them out, a total of 336 results remained. Although some articles contain the word “BIM”, they do not contain the concept of information management. Similarly, some articles contain the word “information management” but they have nothing to do with “BIM”. There were, however, some articles that included both “information management” and “BIM”. Unfortunately, they do not discuss BIM-based information management in depth. Therefore, such literature should be excluded. Finally, 86 publications were reviewed, which can be classified into 5 categories. These are 4D, 5D, energy analysis, collaborative information management, and information management in FM (see Table 1).

Similar to 108 publications on BIM-based information management, 23 journal papers and 30 conference papers about BIM-based knowledge management were identified. Since BIM-based knowledge management is a new research area, it is difficult to classify this area in detail.

*Table 1: Paper classification of BIM-based information management*

Categories	Numbers	%
4D and 5D	19	22
Energy analysis	13	15
Collaborative information management	28	33
FM	26	30
Total	86	100

The number of papers published in each year is analysed. Figure 1 shows the paper distribution of BIM-based information and BIM-based knowledge management separately according to the year of publication. Prior to 2010, there are few relevant studies. Figure 1 shows that research interest in BIM-based information management and BIM-based knowledge management has dramatically increased since 2011. This trend may result from government encouragement. For example, the UK government proposed a strategy on 31 May 2011, which mandated that all centrally funded projects are to be undertaken using BIM by 2016 (Cabinet Office 2011). When compared to BIM-based information management, very little literature can be found for BIM-based knowledge management.



*Figure 1: Paper distribution of BIM-based information management and BIM-based knowledge management according to year of publication*

### **BIM-Based Information Management**

BIM is an information-integrated tool, which is different from other traditional computer-aided design (CAD) tools (Singh *et al.*, 2011). Information stored in BIM can be used to improve schedule (4D) and cost (5D) estimation. For the 4D visualisation and simulation, BIM integrates the scheduled plan and 3D model in order to simulate the construction progress. Structural problems and conflicts among different disciplines and sequencing conflicts of construction activities would be identified proactively as BIM achieves 4D visualisation and simulation (Zhang and Hu 2011). Hu and Zhang (2011) developed an integrated 4D BIM to analyse and manage conflict and structural safety

issues during construction. Additionally, BIM is also used for the visualisation of construction scheduling and site planning (Chau *et al.*, 2004). As far as 5D is concerned, it integrates the 3D model with cost information such as quantities, schedules and prices. For example, Cheung *et al.*, (2012) developed a prototype to conduct cost estimation in the early design stage. Kehily *et al.*, (2013) linked BIM with cost estimate software containing lifecycle data such as time and interest rates to conduct a quicker and more accurate lifecycle cost analysis.

Since BIM contains both geometric and no-geometric information, it has been widely applied in the area of energy analysis. Most existing studies focus on how to make sure that information is exchanged effectively between BIM and energy analysis tools. For example, Gökçe and Gökçe (2014) applied Industry Foundation Classes (IFC) specification to facilitate the exchange of BIM model between design and energy simulation tools and information management platform. Cheng and Das (2014) developed a BIM-based web framework which can support automatic code checking and energy simulation.

BIM has been widely accepted and used in the design phase (Eastman *et al.*, 2008) and construction phase (Goedert and Meadati 2008). However, according to Bryde *et al.*, (2013), BIM has the potential to be used at all stages of the project's lifecycle. A number of studies have explored how to capture and store the information generated from design, construction, and operational phases to achieve better FM. Goedert and Meadati (2008) proposed a method to attach construction process information to the BIM, from which 3D and 4D as-built models are created for the owners to apply during the operation phase. Additionally, Liu and Issa (2012) proposed to integrate the BIM database and FM system in order to hand over full design information to the operation and maintenance phases, through which information management throughout the project lifecycle has been realised.

BIM is a central platform to integrate multi-disciplinary teams working on the same project. As a result, a lot of researches focus on collaborative working through the use of BIM. Singh *et al.*, (2011) developed a theoretical framework based on the BIM-server to support multi-disciplinary collaboration. Wang *et al.*, (2013) stressed that considering FM during early design stage contributes to the significant improvement of operation and maintenance during the FM phase. For this reason, they developed a BIM-based framework to involve FM information into the design decision making at an early stage. However, at this stage, interoperability is still a key barrier hindering collaboration practices (Patacas *et al.*, 2015). In order to address this issue, a few studies have started to explore how to use open and neutral data formats such as IFC and Construction Operations Building Information Exchange (COBie) to enable the exchange of digital information in a structural and efficient way between different systems (Gökçe *et al.*, 2013; Patacas *et al.*, 2015; Wetzal and Thabet 2015).

### **BIM-Based Knowledge Management**

Only a small number of recent studies have recognised the potential of BIM tools that can be used to improve knowledge management practice. Recent research on knowledge management under the BIM environment continues to mainly focus on one phase of the construction project lifecycle. For the design phase, Fruchter *et al.*, (2009) integrated two knowledge management applications, RECALL and TalkingPaper, with BIM software. This was done to bridge the digital document, paper document and speech, in order to facilitate the knowledge capture process. Wang and Leite (2015) designed a system that can be used to capture the knowledge generated during the MEP design coordination

meeting. In this system, a customised tag tool was established to facilitate the knowledge recording process. Kim and Grobler (2009) applied the ontological technique under the BIM environment to aid the design coordination process. Kivits and Furneaux (2013) indicated that BIM has the potential to enable collaborative knowledge management in the design and construction phase, which in turn will facilitate sustainability and asset management. Nguyen and Toroghi (2013) proposed a BIM-based framework to represent the knowledge contained in the Leadership in Energy and Environmental Design (LEED) to ease the sustainability assessment for a building design.

For the construction phase, Park *et al.*, (2013) combined BIM, augmented reality (AR) and ontology techniques to help collection and retrieval of defect information and knowledge, and AR-based inspection system to enable proactive field defect management. In addition, some researchers established a 3D CAD-based knowledge management system to integrate the 3D CAD object with relevant knowledge. Their purpose was to facilitate the knowledge sharing process during the construction phase (Jan *et al.*, 2013; Ho *et al.*, 2013; Lin 2014).

A number of studies also explored how to enhance knowledge management during the post-construction phase by using BIM. Charlesraj (2014) pointed out that as-built information stored in BIM model is valuable for FM. He further proposed a framework which links BIM with ontologies of FM to aid in knowledge management during the FM phase. Motawa and Almarshad (2013) also developed a knowledge-based BIM system for the maintenance phase, which helps solve current problems based on previous cases. Motamedi *et al.*, (2014) applied the visualisation function of BIM with various types of building knowledge to explore the possible root causes of failures in FM.

At this stage, very few studies have focused on managing knowledge throughout the project lifecycle by using BIM. Kivits and Furneaux (2013) explored the potential to integrate BIM with knowledge management to facilitate sustainability and asset management throughout the project lifecycle. Konukcu and Koseoglu (2012) pointed out the possibility of combining BIM and the supply chain to realise knowledge management throughout the project lifecycle. Due to the fact that BIM can provide a single platform for multi-disciplinary participants to work in a collaborative environment, Kim and Grobler (2009) improved the design coordination process by integrating BIM with ontological checking techniques. In addition, Wang and Leite (2015) developed a BIM-based prototype system in which a tag function was introduced to live-capture and represent coordination information and knowledge during the BIM-based design coordination process. However, current studies did not lay emphasis on how to manage knowledge throughout the project lifecycle and in a collaborative way.

Among these BIM-based knowledge management strategies and systems, we find that various knowledge management techniques were utilised with BIM technologies, such as ontology (Kim and Grobler 2009; Park *et al.*, 2013; Charlesraj 2014), case-based reasoning (CBR) (Motawa and Almarshad 2013); fault tree (Motamedi *et al.*, 2014), knowledge map (Lin 2014) and criteria measurement and reporting (Nguyen and Toroghi 2013).

## **CONCLUSIONS AND FUTURE PERSPECTIVES**

This paper mapped and investigated current research perspectives on BIM-based information and knowledge management through a comprehensive literature review. At this stage, many studies have exposed that information can be managed in an efficient way by using BIM. However, a limited number of studies have explored knowledge

management under a BIM environment. This paper reviewed relevant literature. Extant studies clearly show that future research in this area should lay more emphasis on collaborative knowledge management throughout the project lifecycle under a BIM environment. The following discussion analyses issues that were not considered in previous studies on BIM-based knowledge management and deliberates on new research directions and research questions.

As mentioned earlier, information can be managed efficiently by using BIM, and various aspects of information management in BIM environment have been explored. For example, project information stored in BIM can facilitate 4D and 5D, and energy estimation, which will reduce the time consumption significantly. Information management throughout a project's lifecycle has also been explored in previous studies. Additionally, as a centre platform, BIM enables multi-disciplinary participants to share their information in a collaborative way. However, interoperability is also one of the main barriers to BIM-based information management. Therefore, future research into BIM-based information management should pay more attention to interoperability issues. Research should not only work towards solving the interoperability among different BIM tools, but should also explore the interoperability between BIM tools and other information management systems such as the documentation system and expert system.

Since BIM only contains geometric and non-geometric information of a project rather than knowledge, BIM-based knowledge management is much more complex than BIM-based information management. Therefore, there are various aspects of knowledge management under a BIM environment that need to be explored.

Since BIM has the capability to contain multi-disciplinary information, the introduction of BIM eases collaborative information management, makes coordination processes more efficient, and reduces conflicts among project teams. However, existing studies on BIM-based knowledge management do not lay emphasis on collaborative knowledge management. In a construction project, designers have the intent and rationale that aid the construction phase (McCarthy *et al.*, 2000). Facility managers are in the best position to know the functionality and practicability of a building and the requirements of clients (Meng 2013). Contractors, have a higher level of construction knowledge and experience because of their specialist training, their in-depth knowledge of construction materials, methods and local practices (Song *et al.*, 2009).

Therefore, future research must make full use of the central platform provided by BIM to realise BIM-based collaborative knowledge management. Some knowledge management techniques and tools could be integrated with BIM to facilitate collaborative knowledge management. For example, web-based technologies have been widely used for collaborative knowledge management (Lin *et al.*, 2006). In addition, some knowledge strategies could be added to the BIM-based knowledge management system to enhance the aspect of collaborative knowledge management, such as communities of practice (Lin and Lee 2012). Therefore, integrating collaborative knowledge management technologies and strategies with BIM to facilitate the shift from BIM-based information to BIM-based knowledge management would be a novel research direction.

In addition, as an information-intensive 3D objects model, BIM can be used as a visual representation to facilitate knowledge management practices. According to Ewenstein and Whyte (2009), visual representations can be used to manipulate epistemic objects that enable different epistemic communities to work in a shared way. In this manner, the problem can be solved based on a shared understanding of problems. Luck (2007) also emphasised that the level of clients' understanding of the design can be improved in the

conversations with the support of artefacts such as drawings and models, and sometimes, the knowledge is embedded in the artefacts themselves. Therefore, future research can focus on using the BIM model as a visual representation to facilitate collaborative knowledge management.

Compared to the use of BIM for managing information throughout the lifecycle of a project, few studies have focused on managing knowledge throughout the project's lifecycle. Konukcu and Koseoglu (2012) proposed the possibility of combining BIM and the supply chain to realise knowledge management throughout project lifecycle. Kivits and Furneaux (2013) explored the potential of BIM to enable sustainability and asset management issues to be concerned at all stages of the project lifecycle through knowledge management. Although these studies have found the possibility of BIM to be used to assist knowledge management throughout the project lifecycle, more research is still needed. Future research should focus on how to integrate the knowledge from each phase of the construction project through the use of BIM. Due to the fragmentary nature of the construction project, and different project participants involved with different experience and knowledge (Dave and Koskela 2009), various knowledge management tools would be used by these project teams. Consequently, knowledge is difficult to be transferred and shared among project participants. Future research direction could turn the focus on how to connect knowledge management tools of each project team with BIM to facilitate knowledge management throughout the project lifecycle. Figure 2 shows the integrated framework in which BIM is used as a knowledge carrier to support knowledge management throughout the project lifecycle. However, to apply BIM as a carrier to transfer the knowledge contained in different knowledge management tools, interoperability would be a main barrier that should be addressed.

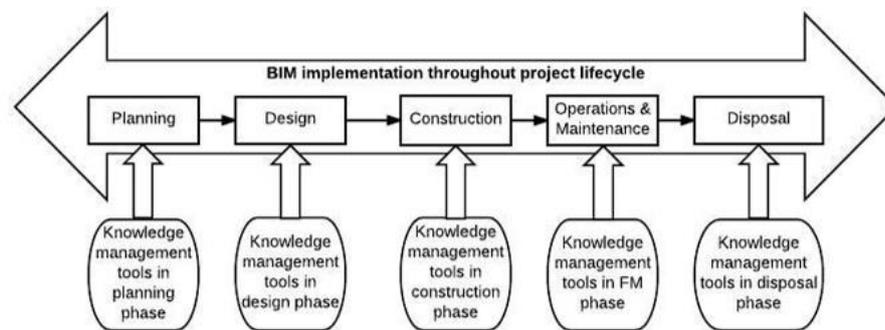


Figure 2: Proposed BIM-based knowledge management framework throughout project lifecycle

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# EXPLORATORY RESEARCH ON BIM INTEGRATION IN HOUSING REFURBISHMENT IN THE UK

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A whole-house refurbishment is challenging due to the complicated decision making process and inefficient integration of diverse construction information at the early design phase to develop a proper refurbishment solution. Although Building Information Modelling has been introduced to enhance the integration and coordination of construction information, current BIM uptake in the housing sector remains low with 13% due to a lack of practical guide for BIM utilization.

Thus, this research aims at identifying essential and practical BIM input data to determine an affordable refurbishment solution. This research adopts a case study with an energy simulation, and conducts a comparative analysis for reliability check of research outcomes. Consequently, seven major BIM input datasets for the assessment and four major datasets for the design phases are identified to develop an information enriched BIM model, and it is revealed that BIM is feasible to utilise for housing refurbishment when essential datasets are compiled and integrated into a BIM model. The findings of this research contribute to providing essential BIM input datasets that can be practically used for whole-house refurbishment and a better understanding of a BIM environment.

Keywords: BIM, housing refurbishment, whole-house refurbishment

## INTRODUCTION

The housing sector alone accounts for 27% of the total UK CO<sub>2</sub> emissions (Kelly, 2009), and 87% of those housing responsible for the 27% CO<sub>2</sub> emission will still be standing in 2050. Thus, the housing sector has a large potential to reduce CO<sub>2</sub> emission by improving energy efficiency of homes to achieve the UK government's CO<sub>2</sub> emission reduction target by 2050, and refurbishment is considered a better option than demolish-and-rebuild because of the financial and environmental benefits (Livingstone, 2008; Riley and Cotgrave, 2011). Yet, currently housing refurbishment is partially implemented because low initial costs with a short payback period are mainly considered, although current refurbishment practice is only capable of achieving limited CO<sub>2</sub> reduction with 25 to 35% (McMullan, 2007; Thorpe, 2010).

Consequently, there is increasing consensus among researchers that whole-house refurbishment is inevitable to achieve the reduction target (Boardman, 2007; Killip, 2008). The key benefits of adopting the whole-house refurbishment are significant amount of reduction of CO<sub>2</sub> emission and energy cost savings through the lifecycle (DECC, 2009; Construction Products Association, 2014) because an entire house will be

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refurbished in a systematic way by considering various refurbishment options and building information including housing condition data and energy performance.

However, refurbishment solutions are proposed at the end of design phase in the current refurbishment process when flexibility of refurbishment solutions and opportunities to explore various refurbishment alternatives are significantly limited (Ma *et al.*, 2012; Thuvander *et al.*, 2012). As a result, many researchers point out the absence of an integrated decision-making framework to estimate the financial and environmental impact of a refurbishment solution from the early design stage. Furthermore, they emphasise the importance of proper decision-making and the necessity of using proper information and communications technology (ICT) tools that support construction professionals considering various refurbishment solutions at the early design phase (Froese, 2010; Crawley *et al.*, 2008; Eastman *et al.*, 2011; Hannele *et al.*, 2012).

In response to current issues and limitations, many researchers state the potential and importance of Building Information Modelling (BIM) for informed decision making on refurbishment solutions at the early design stages. It is because BIM is capable of enhancing collaboration among stakeholders, and the improvement in integration of project information by exploring and comparing various refurbishment alternatives at the early design stages can lead to better refurbishment solution (Ma *et al.*, 2012; Basbagill *et al.*, 2013; HM Government, 2012). Therefore, this research aims at identifying essential input data for housing refurbishment at the early design phase and exploring how to integrate this information into the BIM environment to seek a financially and environmentally affordable refurbishment solution by a case study with an energy simulation.

### **Housing refurbishment and Building Information Modelling**

It is essential to cope with diverse information such as effectiveness of refurbishment measures, financial feasibility and environmental impact simultaneously from the early design phase (Killip, 2008), when there are more alternatives to select the most affordable refurbishment solution. Furthermore, a refurbishment project has two major unique characteristics compared to new build housing: a) Higher Risk (Doran *et al.*, 2009; Burton, 2012), and b) Complex Decision Making Process (Menassa, 2011; Thuvander *et al.*, 2012), which requires more considerate planning and data management for a refurbishment solution.

Indeed, a holistic approach to refurbishment solutions can achieve 60% of operational cost savings over 30 years by investing only 20% more capital cost in the construction phase (Flanagan and Jewell, 2005). Rysanek and Choudhary (2013) assert that refurbishment projects should utilise a tool to support informed decision making among various refurbishment alternatives, while considering multiple criteria such as the implication of cost and the environmental impact. According to Schneider and Rode (2010), 50% of possible refurbishment alternatives that can render better outcomes of refurbishment are neglected due to a lack of collaboration among key project stakeholders at the early design stage.

Potentially the use of BIM tools can improve the overall information flow throughout a project life cycle and facilitate collaborative efforts among project participants to integrate diverse construction information to make an informed decision at the early design phase (Eastman *et al.*, 2011; Hannele *et al.*, 2012; HM Government, 2012). Particularly, in a BIM environment, a single data source is built into a 3D model based on a parametric design, and project stakeholders are able to exchange instant feedback

simultaneously on designs and construction methods without manual re-entry of construction information. Thus, this capability can achieve continuous improvement on decision-making processes as all information can be stored in a single repository and retrieved based on single-source data (Froese, 2010; Eastman *et al.*, 2011). Despite the benefits of a BIM tool, current housing refurbishment practices to estimate the outcome of refurbishment projects rely on simple cost estimation tools and the experience of construction professionals (Kreith, 2008).

This is because BIM has been mainly implemented into large-scale new build projects (Arayici *et al.*, 2011), and small and medium sized enterprises are mainly involved in the housing sector, which contribute 92% (250,000 firms) to the total UK construction industry employment (ONS, 2014), and the BIM adoption in SMEs was identified as only 13% as of 2010 (Hamil, 2010). The use of BIM in SMEs is limited because there are no practical guidance and standardised BIM protocols to utilise BIM, and the investment in BIM systems is not economically feasible (Sebastian *et al.*, 2009; NBS, 2015). Although BIM standards such as PAS 1192 series have been developed and they provide a high level of 3D building model definition, they focus on a new build construction and there is no specific guidance about required data for each work stage. Thus, this research focuses on identifying essential BIM input data for whole-house refurbishment at the early design phase.

## RESEARCH METHODOLOGY

According to Yin (2003), a case study focuses on a contemporary event and answers to ‘how’ and ‘why’ questions. As this research explores why whole-house refurbishment should be implemented and how house information dataset can interact and relate in a BIM environment, a case study is adopted to answer the following questions: ‘why are different types of data required throughout the process?’ and ‘how can the required information be integrated and utilised in a BIM system?’ An actual model simulation with BIM datasets is conducted and a sample house model is examined by utilising relevant BIM tools: Autodesk Revit and IES VE.

Both tools are the most common and verified tools because Autodesk Revit is the currently prevalent tool in the UK compatible with AutoCAD platform that is still widely utilised in the UK construction sector (NBS, 2015). The IES VE has been evidenced by a number of researches for energy simulation in refurbishment and has a capability to simulate all possible building energy assumptions compared to other tools (Murray *et al.*, 2012; Crawley *et al.*, 2008). Since there is no ‘one-size-fits-all’ solution for housing refurbishment in the UK (Jenkins *et al.*, 2012), the tool must be capable of coping all possible alternatives and this requirement makes the IES VE relevant for this research. For a housing type, a solid wall house is determined since it is the most vulnerable to energy efficiency and in needs of refurbishment, which requires immediate attention (National Refurbishment Centre, 2012).

In order to develop a basic 3D model for simulation, the average housing condition data published by the UK government was used as the solid wall housing indicates a wide range of variation in its condition such as year built, construction types physical dimensions, extra retrofitted measures and construction materials (Jenkins *et al.*, 2012). This research follows the refurbishment project phases provided by the Institute for Sustainability and the work stage provided by the RIBA (Royal Institute of British Architects). The RIBA has outlined a plan of work (2013) that has been widely adopted in the UK construction industry as a generic construction phase, and recently the Institute for Sustainability, which has a partnership with the Technology Strategy Board (TSB),

published ‘Low Carbon Domestic Retrofit’ guide to provide a sustainable housing refurbishment guide (Institute for Sustainability, 2011). In particular, the TSB is a UK public body operated by the government coordinating ‘The Retrofit for the Future’ program by advocating the whole-house refurbishment. Thus, the work stages and phases by two professional bodies are adopted for a BIM simulation process. Prior to presenting the identified BIM datasets, this research checked reliability of BIM simulation result by conducting a comparative analysis with the previous research by a UK based professional consultancy on energy efficiency, which is Energy Saving Trust (EST, 2009). The BIM for housing refurbishment has been rarely studied and there is no precedent case study except the one by EST. Moreover, since both studies adopted whole-house refurbishment and used a solid wall house with the same U-values (See Table 2), the case study of EST is used for reliability check to confirm whether the datasets can draw the similar pattern in both research outcomes.

### Basic BIM Model: Detached Solid Wall House

The information of a basic BIM model for simulation is provided as shown in Figure 1 and Table 1 (Riley and Cotgrave, 2008, Utley and Shorrock, 2011, Neufert, 2012).

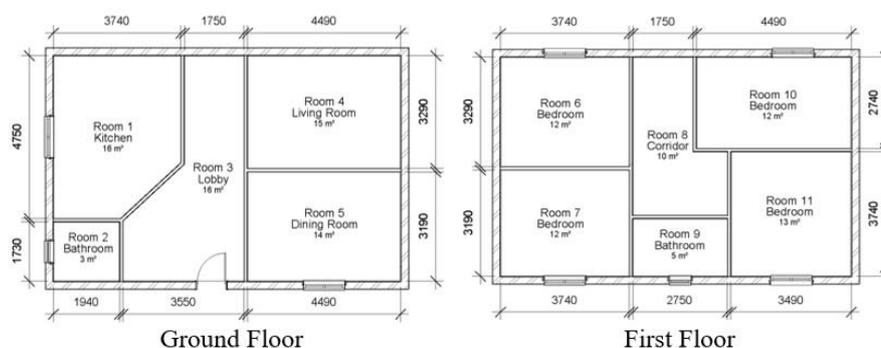


Figure 1. Floor plan for basic BIM model

Table 1: Detailed construction information

Element	Construction Type	Components	Thickness (mm)
Roof	Pitched Roof with Timber Joist and Rafter	Roofing Tile	25
		Wood (Batten)	25
		Roofing Felt	5
		Timber Structure	140
External Wall	Solid Brickwork Masonry Wall (Single Leaf)	Dense Gypsum Plaster	13
		Solid Brickwork	220
Floors	Suspended Timber Floor	Timber Joist Structure	225
		Chipboard	25
		Carpet	10
Ceiling	Generic Ceiling	Gypsum Wall Board	12.5
Windows	Double Glazing	Timber Frame	6mm Glazing
Exterior Door	Wooden Door	Wooden Door	44

\*Note: The Gross Internal Floor Area (GIFA) was used for the cost estimation.

## RESULTS AND DISCUSSION

### Reliability check for BIM Simulation Outcome

The reduction rates for energy demand for heating and energy cost for heating indicate high similarity, while the amounts of CO<sub>2</sub> emission indicate 42% difference as shown in Table 2. It is mainly because the EST included hot water and secondary heating while this research only included hot water. Furthermore, the EST included building service upgrades such as mechanical ventilation and efficient lightings while this research utilised

default building service setting available in BIM tools. It is found out that different heating sources and level of building service upgrades are important measures for energy efficiency and CO<sub>2</sub> reduction in housing refurbishment although this research did not include any specific building service upgrades as it is beyond this research scope.

Although this research outcome, which is 52% reduction of CO<sub>2</sub> emission, does not reflect the building service upgrades and the secondary heating, the research outcome is supported by the previous research results that the maximum of 60% CO<sub>2</sub> reduction can be achieved through whole-house refurbishment without building service upgrades (Boardman *et al.*, 2005; Construction Production Association, 2014).

Table 2: Reliability check for BIM simulation outcome

Description	EST House (Floor Area: 104 m <sup>2</sup> )		Basic Case House (Floor Area: 130 m <sup>2</sup> )	
	Pre-Refurbishment	Post-Refurbishment	Pre-Refurbishment	Post-Refurbishment
Roof U-value	2.30	0.10	2.30	0.10
Wall U-value	2.10	0.18	2.18	0.18
Floor U-value	0.74	0.15	0.70	0.15
Window U-value	4.80	1.50	4.83	1.54
Door U-value	3.00	1.00	3.03	1.03
Energy Demand for Heating (kWh/yr/m <sup>2</sup> )	597	73 (89% Reduction)	209.8	40.8 (80% Reduction)
Energy Cost for Heating ( £ )	1,498	251 (83% Reduction)	1,150	225 (80% Reduction)
CO <sub>2</sub> Emission for Heating (kg/yr/m <sup>2</sup> )	84.9	5.2 (94% Reduction)	84.5	40.6 (52% Reduction)

Thus, the BIM dataset identified through this research have shown its relevance for whole-house refurbishment and the simulation results show the significant energy cost savings and CO<sub>2</sub> emission reduction after refurbishment in comparison with the previous research data. Even though the building system upgrades and other heating source like renewable energy are out of scope in this research, they should be taken into account as possible options for energy efficiency, cost savings, CO<sub>2</sub> emission reduction throughout housing refurbishment.

### Essential BIM Input data and refurbishment process

This research examines the early refurbishment phases, ‘Assessment’ and ‘Design’ phases, to identify essential BIM input dataset for each work stage. As a result, the essential BIM input datasets are identified and summarised as seen in Table 3.

During the assessment phase, occupancy data is required to find out internal temperature and heating timing settings and SAP rating data will be used to set up a current energy use baseline for developing post-refurbishment energy use. After the assessment phase, various refurbishment alternatives need to be explored and compared using 3D house information model. When different refurbishment options are examined, the Building Regulations must be considered for the planning permission. In particular, the risk assessment for continuity of insulations between two different house elements, e.g. Wall and Floor junction, should be considered because the energy efficiency will be lower than planned due to loss of airtightness if continuity of insulations is not secured.

Table 3: BIM input datasets for the early design phase of housing refurbishment

Phase	Work Stage	BIM Input Dataset
Assessment	Strategic Definition	<ul style="list-style-type: none"> <li>• Housing Type and Year Built (As-Built data)</li> <li>• Dimensions :               <ol style="list-style-type: none"> <li>a) Floor areas (Floor Plans) and Storey heights</li> <li>b) Areas of all fabric elements (wall, roof, floor, window and door)</li> </ol> </li> <li>• Detailed Construction Information:               <ol style="list-style-type: none"> <li>a) Construction Types for all fabric elements</li> <li>b) Material Types for External windows and doors</li> <li>c) U-values for all housing elements</li> <li>d) Additional Extension or in-situ construction</li> </ol> </li> <li>• Occupancy data, SAP rating data</li> </ul>
	Preparation and Brief	<ul style="list-style-type: none"> <li>• Customer's Preferences (Park and Kim, 2014):               <ol style="list-style-type: none"> <li>a) Refurbishment Priorities of House Element (Floor, Wall, Roof/Loft, Window, Door, Heating System)</li> <li>b) Decision Making Factors for Selecting Refurbishment Measures (Initial Cost, Disruption, Payback Period, Low Maintenance, CO2 Reduction)</li> <li>c) Refurbishment Materials</li> </ol> </li> <li>• 3D House Information Model</li> <li>• Planned Whole-house Refurbishment Solution (Combination of Refurbishment Measures)</li> </ul>
Design	Concept Design	<ul style="list-style-type: none"> <li>• Building regulations</li> <li>• Energy Standards:               <ol style="list-style-type: none"> <li>a) Building Regulation 2010/2013 Part La (Minimum)</li> <li>b) Building Regulation 2010/2013 Part La (Notional)</li> <li>c) Fabric Energy Efficiency Standard (Maximum)</li> </ol> </li> </ul>
	Developed Design	<ul style="list-style-type: none"> <li>• Refurbishment Material specification:               <ol style="list-style-type: none"> <li>a) Thickness and Types of Materials</li> <li>b) U-value for Windows including frames and secondary/tertiary glazing system</li> </ol> </li> </ul>
	Technical Design	<ul style="list-style-type: none"> <li>e) Initial Material and Installation costs</li> <li>• Risk assessment for continuity of insulations</li> </ul>

## CONCLUSIONS

This research identifies the essential BIM input datasets during the early design phase that enable construction professionals to utilise BIM for improving their current refurbishment practice: seven major input data for the assessment phase and four major input data for the design phase have been identified (See Table 3). The results of this research show that it is important to prepare and integrate detailed house element information into a BIM model such as accurate as-built condition, cost and thermal performance information for successful BIM use in the housing sector. A 3D BIM model without reliable information and requirements cannot add more value to the customers and the construction industry. Thus, accurate condition assessment of an existing house is the most important task to construct a reliable BIM house model. Based on an information enriched BIM model, this research recognises that BIM can be feasible for housing refurbishment to facilitate an informed decision-making for an affordable refurbishment solution at the early design stage. The findings of this research contribute to shed light on examining potential BIM use for housing refurbishment and providing a better understanding of essential BIM input dataset for whole-house refurbishment. There has been a limitation to examine various combinations of refurbishment options such as building services systems and

renewable energy. Since this research is confined to whole-house refurbishment without building services upgrades, generalisation to other whole-house refurbishment cases with different housing types and combination of refurbishment options should be treated with caution. Also, the difference and allowance between simulated and actual results should be monitored and managed in whole-house refurbishment. Future research should focus on exploring further in the BIM datasets for construction and operation phases of refurbishment projects.

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# BIM ARTICULATION IN DIFFERENT-SIZED ARCHITECTURAL FIRMS

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The empirical domain of research into the implementation of Building Information Modelling (BIM) has tended to be large architectural practices working on mega projects. The majority of construction projects that use BIM (including mega projects) involve small- and medium-sized architectural firms. An understanding of how the commonalities and differences that different-sized architectural firms articulate and implement BIM, and how BIM practices are integrated across the supply chain that may consist of large and small firms, is essential if sector-wide reform is to take place. Research has been conducted that explores the distinctive nature of innovation in small construction firms, but less research articulates how BIM is played out, in the settings of large and smaller architectural firms. Results are given from case study enquiries of eleven different-sized architectural firms that use BIM. This research contributes to the understandings of the different contexts of large and smaller practices. Certain differences were identified amongst the different-sized firms, in terms of the way practitioners perceived BIM. Smaller firms mainly reflected the technical stance of BIM while more practitioners in the large firms expressed the practice-based approach in describing BIM.

Keywords: BIM, implementation, articulation, different-sized architectural firms

## INTRODUCTION

This research is concerned with developing an understanding of how different-sized architectural practices articulate and implement Building Information Modelling (BIM). BIM involves using advanced technologies for creating as well as operating data, in addition to standards and repositories for storing and accessing data, by different stakeholders across various organizations. There is a range of current policy drivers that aim to improve the delivery of the built environment through BIM. In the UK, for example, the BIM process is envisioned to improve the delivery of the built environment (BIM Task Group, 2011) by having a fully collaborative 3D BIM, with electronic asset information and documentation (Cabinet Office, 2011). BIM is proposed as a collaborative way of building, construction management, cost control, decision making and information exchange. All those involved in a development from conception through to completion should work to the same standard, allow access to information, and integrate various design aspects to detect conflicts and reduce mistakes. There seems to be no consensus in the extensive literature that has discussed BIM about the definition of the term. BIM is used differently by various collaborators, so there is a wide range of views of BIM. BIM has been described as ‘a new approach to design, construction, and facility management’ (Eastman *et al.*, 2008, vii) that targets various inefficiencies in

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construction practices including cost, project duration and interoperability of data. With BIM technologies, a virtual building is constructed with attached data required to support many activities across the lifecycle of a building (Eastman *et al.*, 2008). What differentiates BIM is the ability to create digital, shared, integrated and interoperable models rather than a disconnected collection of diagrams, drawings, models and specifications (Kymmell 2008). To improve visualization and eliminate conflicts, waste and risk, the building project and the construction process are simulated in a virtual environment (Kymmell 2008). Additionally, various kinds of information can be linked to the BIM file, including specifications, contracts, operation and maintenance manuals, analysis reports and simulation (Hardin 2009). A variety of technologies and processes used along with other related project management tools are considered to be BIM. BIM technologies include parametric three dimensional computer-aided design (CAD) technologies, three spatial dimensions with time and cost components, and Geographic Information Systems (GIS). Shared standards, databases and repositories, document management processes, and IT-based collaboration platforms are also becoming associated with BIM. In fact the concept, approaches and methodologies identified as BIM have been around for years (Eastman *et al.*, 2008), but became recently injected as BIM agenda discourse, and therefore attracted professional and industry awareness.

Various debates concerning BIM as well as large, small- and medium-sized firms are summarized in the next sections to clarify the problem statement and specify the research question. The research design and methods explain the research setting and how the empirical work was conducted in terms of data collection and analysis techniques. Then the findings provide interpretations of the data to relate the analysis to the broad themes identified in the pertinent literature such as the plurality of the term BIM, technical stances, and practice-based approaches. Sorting out various perspectives of BIM and linking the literature with empirical material in the analysis section, contributes to the understandings of how BIM was implemented and articulated in different-sized architectural practices. Finally the discussion and conclusions reflect on the research question and highlight the implications of the study, as well as new directions for research.

## **VARIOUS PERSPECTIVES OF BIM**

The term Building Information Modelling (BIM) was introduced to the construction management industry in the early 2000s (Garber, 2009). BIM has been defined in various ways; one example is 'a managed approach to the collection and exploitation of information across a project. At the heart is a computer-generated model containing all graphical and tabular information about the design, construction and operation of the asset' (BIM Task Group, 2011, 91). Succar (2010) talked about the multi-dimensional nature of the BIM domain as a combination of policies, processes and technologies. The technological aspects of BIM were the focus of many definitions (e.g. Rezgui *et al.*, 2009); however, BIM is not only limited to certain tools and technologies but to the interoperable information exchanges and business structures practices too (Garber, 2009). BIM is used to refer to an activity, tools, processes and technologies used to plan and manage construction projects (Eastman *et al.*, 2008, Demian and Walters, 2013), through the life-cycle of assets (e.g. Shetty *et al.*, 2013) from inception and design to demolition and recycling.

Several definitions of BIM refer to parts of the overall process (Coates *et al.*, 2010), as a number of participants are involved at different stages of the life cycle of projects and have different motivations to adopt BIM. Owners and facility managers are interested in

cost and asset management while architects can be motivated by the capabilities of 3D modelling in producing consistent drawings and eliminating spatial conflicts (Eastman *et al.*, 2008). Engineers focus on the performance of buildings, sustainability consultants can measure day lighting and solar orientation (Hardin 2009), and contractors can push for earlier involvement in construction projects. The increased number of participants involved in the overall BIM process created tensions between these different perspectives, and contributed to the confusion of what constitutes BIM. The plurality of BIM definitions suggests that there is no single way of describing what constitutes BIM but instead, generic characteristics commonly associated with BIM can be used to describe the term. BIM has been viewed from various strands of thought that can be grouped into three main perspectives: policy outlooks, technical stances, and practice-based approaches. Possible tensions can be identified amongst the normative BIM literature, i.e. the UK government construction strategy on BIM, and the descriptive BIM literature that is based on empirical evidence. Proponents of BIM promote the possible benefits and have high anticipations in terms of value, cost and carbon improvement (e.g. Rezgui, Zarli and Hopfe 2009, BIM Task Group 2011). On the other hand, there are opponents who are still unconvinced by the purported advantages of BIM, as there is not enough empirical evidence to support them yet.

There seems to be a substantial amount of heterogeneity regarding how to describe BIM. Additionally the existing research on BIM often presumes that architectural practices are similar and privileges large firms, despite the sizable proportion of smaller firms that are currently underrepresented. The majority of construction projects that use BIM (including mega projects) involve small- and medium-sized firms. An understanding of how the commonalities and differences that different-sized design practices articulate and implement BIM, and how BIM practices are integrated across the supply chain that may consist of large and small firms, is essential if sector-wide reform is to take place.

### **BIM in different-sized practices**

There appears to be a significant amount of empirical research on BIM which favours large practices working on mega projects (e.g. Taylor and Bernstein, 2009, Davies and Harty, 2013), as it is often argued that BIM has little benefit for small- and medium-sized firms (Arayici *et al.*, 2011, Leeuwis *et al.*, 2013). There is a wide range of design and construction firms varying from large companies that provide various services and work in many countries to smaller companies that usually work on small projects and offer particular services like housing projects (Symes *et al.*, 1995). Different ways of measuring firm size (for example, architectural firms) can be used according to the number of architects, the number of design-related professionals, the number of all professionals or the total number of billings (Symes *et al.*, 1995). Given that architects increasingly work as part of a team of various professionals, engineers, planners, landscape architects, interior designers and surveyors (Symes *et al.*, 1995), firms are examined in this study using a three-way split depending on the number of all professionals: firms with 1-30 staff are considered small, firms with 31-50 staff are medium and firms with over 50 staff are large.

Some of the small- and medium-sized firms are beginning to use BIM; however, there is little understanding of how BIM is perceived by the practitioners in this sector. Previous research has examined professionals' accounts of their work in architecture (e.g. Cohen *et al.*, 2005, Sturges, 2013) but tended to consider leading firms only (Sturges, 2013), as if they are exemplars of architectural practices. Cohen (2005) attempted to cover a wide range of architectural practices by studying non-professional organizations such as local

authorities, a building contractor, a property developer as well as architect practices, the Royal Institute of British Architects (RIBA) and a school of architecture. However, Cohen *et al.*, (2005) did not make a distinction between the nine architectural practices they studied. In fact architectural practices are not uniform and the difference between large and smaller firms needs further attention.

A large number of architects work in small- and medium-sized practices: according to a report of the Architect's Council of Europe (ACE) (ACE, 2012) less than 1% of architectural practices have 31 or more architectural staff. The survey in this report covered 95% of the profession in Europe and revealed that a noticeable majority (63%) are practices that have one person only, 18% have two people while 15% employ 3-5 staff. In the UK, for example, out of 6385 architectural practices, there are only 65 architectural practices with 31 to 50 staff and 16 practices with over 50 staff (ACE, 2012). This sector study revealed that the profession of architecture continues to undergo economic crisis; as a result large practices made cuts in their staffing, which in turn increased 'micro' practices set up by redundant architects (ACE, 2012).

Small architectural firms are found to operate in different ways in comparison with larger firms and have a unique complex behavioural and organizational context (Lu and Sexton, 2009). In fact, the study by ACE (2012) mostly compared results across countries but also showed some differences between small and larger architectural practices. One example is that larger practices appear to show more optimism than smaller ones, as fewer than 20% of large firms (with 30 or more staff) expected workload to fall in the next year in comparison with about 40% of smaller practices (with five or fewer staff) (ACE, 2012). Small professional service firms in the built environment are not only vital to the success of the design, construction and property industries but also to their long-term viability (Lu and Sexton, 2009).

Despite the substantial proportion of small architectural firms, most studies focus on large international firms, as they are generally considered to be the frontrunners in the application of BIM, as one example. Only little research is beginning to consider small architectural firms, who are located in a distinctive business environment compared with other sorts of industry firms (e.g. Leeuwis *et al.*, 2013, Lu and Sexton, 2006). Leeuwis *et al.*, (2013) unravelled the uptake of BIM use in small architectural firms in The Netherlands and found that their use of BIM is mostly restricted to internal processes only. One possible explanation for this limited use of BIM in small architectural firms is due to the lack of experience within these firms, as well as among their clients and other participants they work with (Leeuwis *et al.*, 2013).

### **Summary and research question**

The research problem is defined from two key issues. First, the ambitious push from policy drivers stressing that BIM is the way forward but at the same time, there is still ambiguity regarding what BIM actually involves. Second, the fact that the empirical domain of research into the implementation of BIM has tended to focus on large practices working on mega projects. Thus the research question aims to explore the commonalities and differences of how BIM is articulated and implemented within the context of different-sized architectural firms.

## **RESEARCH DESIGN AND METHODS**

The empirical material discussed in this paper represents one aspect (that of commonalities and differences of BIM implementation and articulation in different-sized firms) of a larger research project exploring BIM-enabled projects in architectural

practices in the UK and USA. The overall approach to research that has been taken in this study is focused on interpretations of qualitative data. Adopting a qualitative approach in this research enabled exploring BIM articulation as ‘lived experience’ based on the accounts of BIM practitioners, which is similar to earlier studies (e.g. Caven and Diop, 2012). Caven and Diop (2012) explored a career in architecture and based their findings on the accounts of architects in the UK and France within an interpretive paradigm.

The interpretive approach enables forming rich understandings of meanings (Silverman, 2006), it allows exploring how BIM is articulated and assists in identifying the main characteristics associated with BIM within different-sized architectural practices.

### **Research setting**

The setting for this study is eleven different sized firms which envision themselves as leaders in architectural services. Firms in this study are identified by numbers from 1-5 if they are considered large and employ over 50 staff. Each one of these large firms has offices worldwide and at least one office in both the UK and USA, their employees range from 950 to 3500 in a range of offices (13-44) worldwide. Firms with 31-50 staff are considered medium, while firms with 1-30 staff are described as small. Small and medium sized firms are grouped together and described by letters A-F. All firms have a focus on architecture amongst other specialities, including engineering, planning and consultancy. The firms have been selected because of their engagement with BIM but varied in their experience. The research methods used in this study for collecting and analysing data are explained below.

### **Data collection**

Data for this research were mainly collected using open-ended questions in semi-structured interviews. Although the interviews involved the same general questions, there was flexibility for exploring areas of special expertise to each interviewee in depth (Isabella, 1990). For example, some interviewees gave more details about the technical aspect of BIM they are involved in, while more senior participants or regional managers talked about BIM from a strategic level. Most interviews were one to one but all together 39 interviews were conducted with 49 practitioners, as some participants came together to certain interviews. Interviews were conducted in 18 regional offices of architectural practices based in Houston, Dallas, San Francisco and London. Following desk-based research to gather background information and understand the scope of BIM projects within these firms, the firms were contacted through academic colleagues in the UK and USA. The firms were asked to identify professionals involved in BIM projects in 2-3 offices in the USA and UK. Some of the interviewees also helped broker access to other firms or regional offices of their firm. Additional complementary materials including 452 pages of documents, 69 slides and 10 hours of observations were also collected to help understand the context and interpret the interview data.

### **Data analysis**

Thematic coding was used to analyse the interview data; this technique indicates themes emerging from the data. In this interpretive approach, researchers make sense of the data and develop themes about their meanings (Creswell, 2003), through a messy iterative process or dialogue between empirical data or evidence and theoretical constructs extracted from the literature (Orton, 1997, Eisenhardt, 1989). One example of this iterative process is the comparison of how BIM is interpreted by BIM practitioners against how it is described in the literature. All the interviews were transcribed verbatim, and then checked against the audio files for consistency and correctness before starting to

code the data. This also helped in the familiarization process of the whole dataset, and served as a further step of giving an overview of the data prior to coding. Qualitative analysis software, NVivo, was used to help organize and identify abstract key themes from the interview transcripts. Other complementary materials collected were referred to frequently to help understand the context.

Initially, data were analysed in NVivo in a preliminary manner using topic coding, in which segments of data concerning specific topics were grouped together for additional analysis. Then a process of unpacking the general topics and preliminary descriptive codes (Charmaz, 2006, Andrade, 2009) created additional focused codes (Andrade, 2009). One example of this topic coding is the BIM definition generic code, which was later unpacked. The coding schema was finessed over 12 months of work, going through three main iterations of coding.

## **FINDINGS**

### **Plurality of BIM**

Within large and smaller firms, the participants found it challenging to articulate BIM, and their descriptions were generally split between the technical or practice-based focus. The participants were asked to define BIM as an introductory question in the interview. It was surprising to some interviewees to be asked this question. An Information Systems Application Administrator “at Firm 5 (London)” seemed unsure and said: ‘How do I define BIM? It’s a good question. (Laughter) It’s a good question. I don’t think there is an easy definition.’ The interviewees in the beginning were not sure how to define BIM, and then came up with an answer of how they perceived BIM. One of the reasons for this difficulty in describing BIM was that the term BIM covers a wide range of things, as the interviewees articulated. An Associate and BIM Manager “at Firm D (London)” commented: ‘I bet everyone laughs when you ask them that. For me BIM is a hugely broad topic and it covers so many things.’ Additionally people perceive BIM differently, a Director of Technical Development “at Firm 4 (London)” stated: ‘How I define BIM and how other people see it is different.’ Practitioners articulate BIM in a different way even in the same office, depending on their experience and involvement in the BIM process, as this participant noted:

If you talk to two of our studios, like if you talk to our architecture studio upstairs or if you talk to the studio you just walked through, they would have two different answers, Regional BIM Manager at Firm 1 (Houston)

BIM was defined in many different ways; twelve different codes emerged in NVivo under the BIM definition including information management, collaborative work across disciplines, new ways of working and a work process as examples of popular codes across the data set. This plurality of BIM was consistently reflected in the data:

BIM is, it’s a tough one to define... I think that too many people think of it as just software...the way I would describe it, it’s virtually constructing our projects with integrated systems that allow information integration and connectivity...But it’s also a process in that it’s shaping the way we integrate and collaborate with other consultants, Associate and Digital Design Leader at Firm 1 (London)

In general, BIM definitions conveyed by the interviewees, in different-sized architectural practices are diverse but were grouped under either the technical which were mostly represented in the smaller firms or practice-based perspectives which were more evident in the large firms. The following two subsections elaborate on the technical and practice-based focus of BIM.

### **Technical focus of BIM in the smaller firms**

For a large number of participants, mostly in the smaller firms, the term BIM is communicated as software only. For those who are aware of the broader processes and practices of BIM, the focus is still on object-oriented approaches to modelling within advanced CAD packages such as Revit:

Well for us, we've got a bias towards the three dimensional nature of it, Architect at Firm C (London)

Revit is a totally distinct package from Auto CAD. Revit is a group of integrated products that includes Revit Architecture, Revit Structure, and Revit MEP. Revit architecture is one of the well-known products for using BIM in architectural design. Revit also facilitates energy simulation and load analysis, structural analysis and includes the ability to import models from Sketchup, a conceptual design tool, as well as other systems. This focus on the technical aspect of BIM within the overall broad idea was evident in the smaller firms. Only some interviewees from the larger firms noted that most of their knowledge is mainly limited to Revit, and that was the meaning of BIM to them:

I think of it just in terms of the one program since that's the one we mostly use. The term has been around for a while but I didn't have a lot of experience or knowledge of it before we started using Revit. So I'd say most of my knowledge about BIM is related to Revit, Project Architect and Project Manager at Firm 1 (Houston)

Many interviewees formed their description of BIM around the software packages involved, and the modelling and analytic aspect of BIM. One of the technical-focused definitions of BIM in the smaller firms was mainly around inputting and connecting information in the model as a basic concept of BIM:

Building as a verb or building as a noun. People say modelling or management or managing and to be perfectly honest it doesn't matter. All we're trained to do is to connect the information so each piece of information exists once... And that's the very, very simplest low level of concept of BIM I can manage, BIM Manager at Firm B (London)

Most of the participants from the smaller firms expressed the technical stance of BIM. The experience of the interviewees and in some cases the perspective of BIM was restricted to the technical stance within the general broader idea of BIM.

### **Practice-based focus of BIM in the large firms**

The practitioners who expressed their perception of BIM from a practice-based approach were largely in the large firms. In the large firms, the interviewees confirmed that BIM is not just about software. Rather BIM is about work processes and collaborations using different tools and technologies:

It does not describe a tool, it does not describe Revit, it describes the process ... so when we say BIM it could be Archicad or even AutoCAD, 3D and all of these different things, BIM Manager at Firm 2 (Houston)

The participants also expressed that BIM involves work processes and people. The primary focus of a BIM process is about information management to create a good project. The secondary purpose is to facilitate the coordination of the input of different consultants to meet the needs of clients:

How do I define BIM? Okay it's to me? What does it mean to me? It's a process to me of compiling and organising information that will help our team design a great project... that's primary, and the secondary would be to help with the co-ordination efforts of various consultants and the client's needs, Associate, Design and Technical Abilities at Firm 5 (Dallas)

In the same way in the smaller firms, some participants talked about how BIM changed their work processes to make it more efficient, when they defined BIM:

It's change of every little piece of what we do, to streamline and make the whole process more efficient', Associate Director at Firm F (London)

However more participants from the larger firms conveyed the practice-based approach. Taken as a whole, there is no agreed definition as to what BIM actually meant in different-sized architectural firms. Yet the different organizational contexts in large and smaller firms influenced the individual interpretations of BIM in most cases. BIM practitioners defined the term BIM differently according to their experience of BIM projects in the firm; nonetheless, certain characteristics were commonly associated with BIM.

## DISCUSSION AND CONCLUSIONS

This research focused on five large USA and UK architectural firms, and a follow-up sample of six small- to medium-sized firms using BIM. The case study findings shed light on how BIM was perceived by practitioners in different-sized firms. The BIM definitions articulated by the practitioners showed the plurality of the term BIM, and the different perspectives taken in architectural practices to describe it, such as the technical focus and practice-based focus. In the technical focus, BIM definitions were limited to certain tools and technologies while in the practice-based focus, the work process was considered as well as the people and software packages involved.

The plurality of BIM, identified in the case study findings, was consistent with the literature reviewed earlier (e.g. Succar (2010) who talked about the multi-dimensional nature of the BIM domain. The accounts of BIM practitioners confirmed the different perspectives of the BIM construct. The UK government policy outlook (BIM Task Group, 2011) was also reflected in BIM practitioners' accounts as a driver for BIM implementation in the UK, particularly in the smaller firms. Technical stances on BIM (e.g. Rezgui *et al.*, 2009) dominated the way BIM was described in both large and smaller firms, while other participants, mainly in the large firms, took the practice-based approach (e.g. Davies and Harty, 2013) to describe BIM. The findings contributed to extending our understandings of how different-sized architectural practices interpreted BIM-enabled projects.

The research extends our knowledge of how large and smaller interdisciplinary architectural firms were using BIM, unlike the majority of earlier research, which favoured large firms working on mega projects (e.g. Taylor and Bernstein, 2009, Davies and Harty, 2013). The responses collected from the large firms were also mostly evident in the smaller firms. However, the findings did identify certain differences between large and smaller interdisciplinary architectural firms, in terms of the way practitioners perceived BIM. One example is that the smaller firms mainly reflected the technical stance of BIM, while more participants in the large firms expressed the practice-based approach in describing BIM. Another example is that those participants who found it hard to define BIM were in the large rather than smaller firms. The unique nature of smaller firms is consistent with the emerging literature that articulated the distinctiveness of small firms (e.g. Lu and Sexton, 2006, ACE, 2012). Unlike what former research on BIM use in small architectural firms found (Leeuwis *et al.*, 2013), BIM use was not restricted to internal use only in small firms, as the broader process of BIM also had value to smaller firms.

The results of the research are restricted by the extent of representativeness and generalizability of the selected firms. These limitations were taken into consideration by a careful sampling strategy to choose representative firms. In addition, BIM descriptions given are implicitly related to industry rhetoric and policy definitions. The empirically-based definitions of BIM presented in this study are dependent on the interpretations of interviewees, how they themselves understood and used BIM, and the research project information given to them prior to the interview. In addition the research was conducted at a certain point in time and the perception of BIM might change over time given the fast development of BIM adoption. It would also be of interest to contrast or confirm BIM practitioners' accounts by non-BIM users in future research or over a long period of time.

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# EXPLORING THE CONSEQUENCES OF 4D BIM INNOVATION ADOPTION

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UK Government has ambitions for improvements in construction project time predictability. Better management of construction innovations into use could help with this aspiration, but despite a recent drive advocating Building Information Modelling (BIM) innovation adoption, the construction industry is still perceived to have low innovation levels in comparison with other sectors. The purpose of the work was to explore the use and consequence of 4D BIM innovation in relation to construction time predictability. Insights were gained using semi-structured telephone interviews conducted with a range of construction practitioners. Several dimensions of consequences of 4D BIM innovation adoption were considered including desirable/undesirable consequences, direct/indirect consequences and anticipated/unanticipated consequences. In addition to consideration of the benefits and demand for 4D BIM, the results also reveal criticisms over current planning mediums and process inefficiencies. Results also reveal concerns over the additional work required to create 4D plans, and the quality of the plans produced.

Keywords: 4D planning, Building Information Modelling, BIM, innovation diffusion

## INTRODUCTION

A 2013 UK Government strategy report (HM Government, 2013) outlined a ‘Vision for 2025’ for six key aspirations including construction project time performance. By 2025 this is targeted to be 50% faster than the 2013 performance, with measurement achieved through ‘time predictability’ key performance indicators (KPIs). Whilst it can be argued that improvements in construction time predictability and reductions in construction time are distinct and should be disentangled, the use of 4D BIM is considered a useful addition to the construction planning process that can help realise these dual Government ambitions. 4D BIM is where a 3D-model incorporates the fourth time dimension in order to simulate and rehearse planned construction sequences.

Key benefits of the application of 4D planning involve the reduction of uncertainty from the planning process. Previous quantitative research presented at the 31<sup>st</sup> ARCOM conference reported on an investigation into the diffusion of 4D BIM as an innovation, and an increasing rate of adoption was found with the typical time lag between awareness and first use revealed as being between 1.75 – 3.00 years (Gledson, 2015). As part of a wider PhD project, concurrent qualitative data was also collected to support the findings of the quantitative research. In particular the aim of this research was to further explore and predict the consequences of 4D BIM innovation adoption, and to ultimately consider if the use of 4D BIM can help improve the time predictability of construction projects in

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order to improve certainty and therefore speed. This paper presents summary results of some of the qualitative data gathered.

#### **4D BIM as an innovation**

An innovation is defined as “*an idea, practice or object that is perceived as new by an individual or other unit of adoption*” (Rogers, 2003). Though innovations may offer improvements, many researchers (Demian and Walters, 2014; Gambatese and Hallowell, 2011; Koskela and Vrijhoef, 2001; Slaughter, 1998) believe that the industry suffers from low rates of innovation generation and absorption. Innovations have been classified into five separate innovation types by with researchers (Koskela and Vrijhoef, 2001; Reichstein *et al.*, 2005) arguing that the most frequent innovation types in construction are *incremental* or *modular* in nature, and are usually product, rather than process-based generated by suppliers, because of difficulties in implementing innovations that require larger scale systematic change. The structure and project based nature of the industry have both been identified as affecting the rate of industry innovation adoption (Dubois and Gadde, 2002; Emmitt, 2010; Harty, 2005; Taylor *et al.*, 2004; Winch, 2003) and Walker (2016) argues that “*effective innovation requires an understanding of the context in which the innovation came about, the way that it may be adapted or replicated in future and the implications of this on creating value for an enterprise or organization*”.

Despite having its origins in the late 1980s through the work of Marin Fischer and associates from Stanford University, 4D BIM as an innovation has recently come to prominence partly because of the targeted improvements in construction project time predictability (HM Government, 2013), and because industry practitioners have been encouraged to challenge standard planning solutions (Greenwood and Gledson, 2012). The use of Building Information Modelling (BIM) offers opportunities to enhance functions of construction planning. BIM has been categorized as an innovation (Brewer and Gajendran, 2012; Davies and Harty, 2013) that is radical, transformative and disruptive (Gledson, 2016).

The rich information contained within a BIM can be re-used for purposes such as time scheduling (Kensek, 2014) in 4D mediums that link a construction programme to a 3D-model. 4D BIM can be described as a method that allows the combination of 3D representations of the product that is to be built, with the time schedule data (and possibly a 3D representation of the surveyed existing site conditions) to virtually model the process of construction. “*Such integration, in turn, allows for three dimensional representation of when and where physical objects are planned to be built or demolished and enables co-builders to visually identify conflicts between their different work tasks and domain specific designs. This function should, in theory, support the planning activities for the above described co-creation construction efforts*” (Trebbe *et al.*, 2015).

Currently, 4D BIM enhances traditional construction planning by allowing visualisation and interrogation of construction sequences (Gledson and Greenwood, 2014, 2016). Traditionally, the most frequently used communication formats for planning were bar charts produced from CPM scheduling software. Researchers have also identified that 4D BIM is able to improve communication of the construction plan by helping narrow the communication gap (Dawood, 2010; Heesom and Mahdjoubi, 2004; Liston *et al.*, 2001; Mahalingam *et al.*, 2010) which should, in turn reduce the ‘*transactional distance*’ between actors (See Barrett, 2002; Moore, 1993; Soetanto *et al.*, 2014).

Rogers (2003) identifies one of the main criticisms of diffusion research as a ‘*Pro-innovation bias*’, where, because innovation is implicitly a positive word, the bias is the

assumption that an innovation should be diffused and should be adopted by members of the social system in a rapid manner.

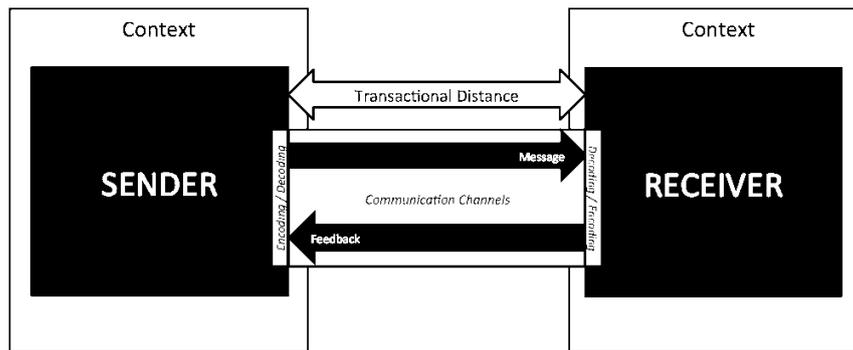


Figure 1: Transactional distance within communication processes

### *Consequences and the pro-innovation bias*

However, there are always consequences involved in any innovation adoption, and these consequences can be negative as well as positive. Walker (2016) argues that unintended consequences require minimization and intended consequences require amplification. There is however, little research in the way of the consequences of innovations and Rogers (2003) attempts to clarify why this might be. He suggest that change agencies assume or over emphasize that all aspects of innovation will be positive; that data collection methods are usually inadequate; and the effects of consequences are not readily measured.

Rogers (2003) believed that it would be useful to analyse three dimensions of consequences:

- Desirable versus undesirable consequences
- Direct versus indirect consequences
- Anticipated versus unanticipated

In this research, during the semi-structured interviews participants were asked to consider these dimensions in relation to 4D BIM.

## **METHOD**

Qualitative interviews were conducted concurrently while data were collected through the questionnaire survey. The questionnaire concluded by asking Participants if they would be willing to participate in a follow up interview. In total 13 participants agreed and subsequent telephone interviews were arranged. The question list was sent in advance to allow participants to more fully consider their responses in advance of the interview. Audio from all interviews was captured digitally and verbatim transcripts were produced using a word processing application. The Computer Assisted Qualitative Data Analysis Software (CAQDAS) package used earlier was used to aid the analysis of the qualitative data. Codes were pre-assigned to capture and compare the responses against each question with subsequent coding occurring during the analysis as various themes emerged.

## RESULTS AND ANALYSIS

Many researchers (Demian and Walters, 2014; Gambatese and Hallowell, 2011; Koskela and Vrijhoef, 2001; Slaughter, 1998) (Slaughter, 1988; Koskela and Vrijhoef 2001; Gambatese and Hallowell, 2011; Demian and Walters, 2014) believe that the industry suffers from a low rate of innovation. Participants were asked:

### **What is your assessment of the level of innovation in the construction industry?**

Construction was described as “*Not a highly innovative industry*” (Participant 7), there was general agreement with the literature that there was a low rate of direct innovation and that construction “*lags behind other industries*” (Participant 47). Criticism of traditional construction methods and techniques were expressed, with concerns that even though newer, safer means of performing construction work were available, low levels of such technological innovation adoption were apparent. Participants considered that typical innovation adoption in construction related to alternative or substitution materials, such as “*the likes of light fittings [that] have changed to LED types*” (Participant 94). These are what Slaughter (1998; 2000) referred to as *incremental innovations*, which create improvements to existing practice with minimal impacts upon the wider system. Despite this, several participants were optimistic about both recent trends in construction innovation “*it is improving [in] the last few years*” (Participant 41) and future opportunities “*there are lots of barriers in the way, but I do think it’s getting there*” (Participant 56). Several of the barriers discussed related to industry structure.

Researchers have also argued that construction innovation must be considered within the context of the industry itself because of the characteristics of the industry; that it is analogous to a decentralised complex system, project based in nature, using Temporary Project Organisations (TPO) as delivery vehicles. Various researchers believe that these attributes directly affect the impact of innovations (Dubois and Gadde, 2002; Winch, 2003; Taylor and Levitt. 2004; Harty, 2005; Emmitt, 2010). Participants were asked:

### **Does the way the industry is structured affect the levels of construction innovation?**

This question promoted particularly emphatic responses from participants “*yes, massively so*” (Participant 7) and “*I think there is a massive problem within the industry in the way that it is structured*” (Participant 95). The location-dependent and project-based nature of the industry was identified as key aspects affecting levels of innovation, “*I think there is lots more challenges than the likes of the manufacturing industries. Obviously [there is the] location of where you are building compared to being in a more static place ... we are building in a different place each time ... [and] ... the structure, culturally is very different*” (Participant 56).

Rogers (2003) considers ‘the nature of the social system’, its norms, and degree of network interconnectedness, to be a key aspect when considering the diffusion of innovations. Rather than explicitly discussing industry structure, participant concerns were focused more on the norms of the construction system including aspects of fragmentation, procurement processes, the market environment and business practices whilst challenges of *culture, time, and system complexity* also featured heavily in the interviews.

### **Has 4D BIM impacted upon the planning of construction work?”**

In terms of actual 4D BIM use some participants considered that it was used more on “*bigger and more complex jobs*” (Participant 53) and that “*for the bigger projects, [such as] Terminal 5 [etc.] it’s really important*” (Participant 11). Some participants from

adopter organizations noted that 4D BIM was being treated as a kind of added value service, only being provided as a specific additional service and then only if specified by the client team *“At this stage 4D BIM is dependent on the client buying into the concept; not de-facto given in our typical workflow. Still seems to need mainstream acceptance”* (Participant 184). Similarly, Participant 8 noted that his organization could provide 4D output, but were *“working purely based on demand. They are only providing it if it has been specified or clearly asked for”*.

In contrast, several participants who work for early adopter organizations that had implemented 4D BIM and had used this innovation across multiple projects were able to provide numerous examples of the benefits, which included: options analysis; being able to provide the client with alternative proposals; successfully resolving logistical challenges on site; arranging early procurement of materials; and reduction of programme durations.

One flaw with the use of bar charts for communication was identified by participant 19 who also advises on one of the major strengths of 4D BIM as an innovation: *“Nobody really looks at a programme do they? No, but they would look at a [4D] video of how the job is going together and they would understand it ... because it's visual, everyone knows what the building looks like when it goes up, and what it will look like half constructed, but if they looked at the programme they wouldn't really have that visual image in their head”*.

Participant 63 however, noted caution when identifying that, despite the communication advantages that 4D BIM innovation offers through better visualizations of the plan, the traditional lack of a feedback loop to aid communication comprehension remains. *“In terms of construction I'd say that it [4D BIM] has increased the representation and visualization aspects, but what is missing in every part of the construction, in terms of planning, is the feedback. We take things for granted so we don't challenge anything ... we talk about planning construction work about how it is about sequencing, but we don't improve it, [using] feedback. We just do it and say, 'Yes, I can see the plan, that is what I am doing' but we don't challenge that. We don't optimize the process, which BIM can do by increasing the representation for all stakeholders”*.

### **What are the consequences of 4D BIM innovation?**

#### *Desirable and undesirable consequences*

Participants articulated several desirable consequences including, the greater levels of detail in which the construction plan can be communicated, and the visualisation benefits of being able to see objects within the model being virtually constructed in alignment with the agreed construction sequence.

Other participants however viewed additional work content created as one of the undesirable consequences. *“I describe 4D BIM as a managers dream and a planners' nightmare. For the manager he can go into depth ... [and] then decide whether he likes it or not and if something needs changing. It's a planners' nightmare because he's not just engaging with one manager... you get maybe 3 or 4 managers input which means that the programme is constantly getting more and more input, until you manage to hit something which in theory is good enough to be construction issue”* (Participant 7).

Participants generally see increased levels of client involvement as an undesirable consequence that will generate dysfunctional conflict. However, despite these concerns, the experiences of Participant 48 suggest that construction actors will continue to fulfil traditional roles regardless of the opportunities provided by 4D BIM innovation *“I would*

*say so far we have had very little interrogation of our programmes at all and anything 4D that we have done. It purely seems to be viewed as a visual tool by the client and a pretty picture”.*

#### *Direct and indirect consequences*

Several participants discussed the direct consequences in relation to the benefits of 4D BIM addressed elsewhere in this work. Participant 41 however, articulated the rapid diffusion of this innovation in work winning environments as a direct consequence, *“I suppose the best thing is the take up of it and almost the fact that it is expected to be used during work winning now”.*

Indirect consequences related to being able to prove the benefits in order to justify use. The challenges of being able to quantify such outcomes were something considered by Participant 8 *“We are not at the stage of being able to measure benefits of it ... I would say that once we have completed that learning curve, then we can start measuring output data and see if our output data has improved against our traditional output data”.*

Participant 41 also suggested that the quality of the construction plan might be inferior to current methods used. *“There is an argument to say that when you hand drew a programme, before you committed it to paper, you were bloody sure that it was right... because the consequences of having to alter it, were laborious. Whereas now, people can just quickly knock up a bar chart, print it off, issue it, and not worry about if it is as accurate as it could be”.*

#### *Anticipated and unanticipated consequences*

Most participants however, believed that programme quality would increase as a result of the adoption of 4D BIM innovation particularly in terms of planning and sequencing the work, *“It has highlighted quite a few [incorrect] things within my logic that I have used on several jobs in that past and it has bettered my programmes and made them more workable”* (Participant 53).

Negative anticipated consequences were that contractors might lose out on available work as *“you would have more idea of what temporary works was needed by having 4D BIM ... it might help with the pricing, but also you might put too much [money] in and possibly price yourself out”* (Participant 47).

Unanticipated consequences included aspects of process:

It has highlighted the culture I suppose, it has highlighted the way we do, the way we approach things ... general working practices. Without being able to observe 4D BIM innovation, I suppose I wouldn't have identified this lack of feedback ... I wouldn't readily have identified that, so it has allowed us to understand the problems that little bit better (Participant 63).

... and the current rate of diffusion:

There is definitely a demand there from the work winning side of things and we are having to move forward in order to delivery that really ... It's been noticeable, it seems to be increasing pace all the time (Participant 41).

### **Do you think the use of 4D BIM can help improve the time predictability of construction projects?**

Participants generally believe that some level of improvement to construction project time predictability can be achieved with the use of 4D BIM. *“4D allows you to be more accurate in your estimations, planning wise. It's better visually, people clearly understand it and grab the concepts and actually see what need to be done first rather than trying to work through a Gantt chart”* (Participant 11).

Participant 8 argued the need for more reliable information to be available for the planning of construction activities and task durations in order for this increased level of accuracy to be realised. This participant identified that this could be achieved through the future capture of actual performance data and the re-use of this information to determine future task durations. *“I think, being able to feed output data back into the cloud would be a big help ... being able to record your actual progress and then feed your actual progress back ... download that data to your next program, should give you greater certainty in your durations”*.

Participants usually considered that predictability improvements could be gained by also altering other aspects of the project delivery process, such as increasing off-site periods in order to reduce on site periods. *“[For] time on site, I would say yes, the time overall from inception, I would say no. I think, [that] the time they spend producing models in the first place and the information within the models [will help]”* (Participant 53). Optimising project tendering and procurement practices to enable earlier involvement by constructors was also considered. *“I think using 4D BIM innovation in the design process phase ... to visualise [the construction process] we would be able to improve, understand and optimise, potentially from the ‘strategic definition’ stage, however that is hindered by your typical procurement [arrangements] in terms of sequencing appointments”* (Participant 63).

The use of 4D BIM innovation in conjunction with greater use of other construction innovations such as pre-fabrication and modern methods of construction (MMC) was considered to be a more pragmatic method of improving construction project time predictability. *“I think it can help improve time predictability, but I’m not sure it can do it to the point where projects will be delivered 50% faster, certainly not on its own. I think the only way you [are] going to get it that much faster, is if you massively increase [the use of] offsite construction”* (Participant 8). In contrast, Participant 7 who has extensive use of 4D BIM innovation believed that his current project where 4D BIM is being used in conjunction with MMC whilst maximising the advantages of virtual prototyping would achieve the desired results. *“Yes I actually think the target is achievable ... I believe an improvement of 50% faster is possible, certainly. From my experience with 4D in the last 5 or 6 years I definitely think its achievable, I think you may see it going even higher than that”*.

## DISCUSSION

Previous related quantitative research by Gledson (2015) found an increasing rate of 4D BIM adoption with the typical time lag between awareness and first use identified as being between 1.75 – 3.00 years. The ultimate aim of this supporting qualitative research was, to determine its effect, through exploration and prediction about the consequences of this innovation. 4D BIM can be considered to be a modular technological process-based innovation and the data reveals that the structure of the sector continues to impact upon the levels and types of innovations that are successfully realised. Only innovations that prove a good fit contextually and environmentally have a chance of adoptive, adaptive or replicative success (Dubois and Gadde, 2000; Walker, 2016). In this investigation, regardless of the timing of adoption, two adopter attitudes emerged, those who had adopted and absorbed 4D-planning methods irrespective of the will of external agencies, and those who provided 4D BIM only when required to (e.g. through client demand or expectation or job scale). Several benefits were articulated and recent increases in demand for 4D BIM were noted.

The data show criticisms of current planning mediums and processes, but recognition of the likelihood that planning output created using 4D BIM methods should increase interrogation of the plan by project stakeholders by facilitating feedback loops. Increased engagement by construction team members is welcomed but additional efforts in exploring multiple alternative scenarios are a concern in terms of resource levels required to undertaking effective planning. Construction team interactions are seen as helping validate the plan resulting in increases in precision and detail that are also better communicated to the workforce with a resulting improvement in construction project time predictability and opportunities for potential time-savings. However, the prospect of input from external project stakeholders was not particularly welcomed: there was concerns that increased plan-transparency may result in negative interactions with the client team.

## CONCLUSIONS

4D BIM has been proposed as an innovation that can help improve the time predictability of construction projects, which is needed to help realize current UK Government strategic aspirations. There are always consequences of innovation adoption, but to date, there has been little in the way of research about such consequences. This work contributes by addressing three dimensions of consequence of 4D BIM innovation adoption: *desirable/undesirable* consequences, *direct/indirect* consequences and *anticipated/unanticipated* consequences.

The principal consequences of 4D BIM innovation adoption are the opportunities afforded by the facilitation of feedback loops to further reduce transactional distance within plan communication; the associated potential increases in planning effort needed because of resultant additional interactions with construction team or client team members; the increases in the quality and validity of the plan produced; and an obvious client demand for this planning output experienced in front end work winning situations.

Respondents considered that while use of 4D BIM is expected to facilitate some improvements in construction project time predictability, targeted efforts across a range of other more familiar areas (such as better quality production information; allocation of appropriate pre-construction periods, and greater use of modern methods of construction) can also help address the time predictability problem. Future research efforts focusing on the capture and use of as-built performance data to prove the benefits and further justify the use of 4D BIM innovation would be welcomed.

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# **BUILDING INFORMATION STANDARDS: BIG DATA TECHNOLOGIES PREVENTED FROM BECOMING BIG IN BUILDING**

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The increased use of BIM in the building sector have led certain actors to commence riding on the big data hype. Big data techniques allow the use of unstructured data alongside structured data to an extent that was previously impossible. Science and technology studies (STS) approaches are used to examine information standards as a technology to organise big data applications in building. Crucially, opportunities are strongly guided by the data that is collected about buildings, and thus by the understanding of what a building is. Building information standards are viewed as performative and their becoming as a process of power, understanding and emerging interests. The empirical material stems from a study on the shaping of a Danish classification standard and its implementation in a Danish hospital project. The analysis shows several performative aspects and particular ways in which a building can be understood: First, there is a focus on the internal structure of a building as a product and less on the process that leads to making a product. Second, a systems theory approach to building structure understands building components as having functions in a way that aligns well with the installation part of the building. Third, delimitations within which information standards propose to collect data implies a focus on building components as material over components being economical entities. Performativity struggles during the shaping of the standard are expected to continue also during its implementation phase in an environment where multiple standards co-exist. On this background we discuss whether the building information standard, meant to be a big data technology enabler, might become a barrier for big data.

Keywords: big data, classification, performativity, standardisation, STS

## **INTRODUCTION**

Building projects are increasingly guided by building information models that generate data on building products and processes providing big data opportunities. The increased use of information models in building is accompanied with a need to standardise the collection and structuring of the data in those models. Such focus on standardisation contrasts with voices in the big data discourse that promise a more heterogeneous reassembling of a variety of structured and unstructured data to create value (Mayer-Schönberger and Cukier 2013, Simon 2013: 29-47). Instead, it seems to be in line with historical developments in building where standards traditionally play an important role (Carassus 2002).

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Standardisation serves an instrumental purpose in building by promoting similarity across time and space. The consistency of a standard allows people to coordinate their actions and aim for more complex achievements, while at a time standards built on knowledge structures in practice and therefore usually encompasses ambiguity in their ordering attempt (Bowker and Star 1999, Busch 2011, Timmermans and Epstein 2010). In building information models, a common standard allows information about building components to be gathered and used in a more systematic way across different parts of building design and the production site. It centres on a need for a more common terminology and structure concerning products and processes that are intended to help identify to different actors what components are or will be used in a building (Koch and Jacobsen 2014). In this way, information standards provide a solution to interoperability problems between actors using different classification systems.

However, the solution to interoperability problems proposed in a standard is not straightforward. Science and technology studies (STS) based approaches problematise seemingly neutral technical solutions such as standardisation to show that they can and should be viewed as deeply normative. Standards are developed by professionals with a certain understanding of appropriate ways to organise building, or more cynically, representing certain interests within the building sector. These normative understandings shape the standard through strategic and everyday decisions that have to be made when developing standards. Over time, as a standard stabilises, the normativity engrained in a standard has a tendency to become viewed as neutral or even natural (Bowker and Star 1999, Timmermans and Epstein 2010). However it may look, a standard is not neutral or natural at all and can therefore at any time be questioned and opened up if sufficient strength is mobilised.

In this paper we use STS approaches to critically examine the standardisation of building information systems. The human work involved in creating and maintaining standards for data structuring and those mechanisms that makes the outcome invisible or appear neutral have been explored previously in the seminal work of Bowker and Star (1999), and to some extent in related works on standardisation (Brunsson and Jacobsson 2000, Timmermans and Epstein 2010). Opening up the shaping and structuring of data in building is relevant to us because of the material effects of data on the development of buildings. Standards on data collection and structuring influence not only the knowledge that is being generated but also have an impact on the buildings being built. Callon's (2007) notion of performativity is used to show the struggle between different socio-technical networks in standardisation of building information systems. This paper will show that such struggle leads to certain understandings of a building to be favoured. Furthermore and in line with Callon, this paper will also argue that any stabilisation of meaning is a temporary outcome, and show that there are multiple sites for a performativity struggle.

Empirically, this paper builds mainly on a case study of a building information classification system – the Cuneco Classification System (CCS). The CCS is a Danish standard for handling building information that contains rules on classification of building information, the number of information levels and the measurement of building components. The CCS promises to provide automated identification and classification, which should allow a smooth transfer of data between actors using different software packages in building (Koch and Jacobsen 2014). This paper is part of a longitudinal study in which the CCS standard is followed during its formation and subsequent implementation in the design and building of a Danish hospital. The empirical material will show that the shaping of a standard stabilises on particular ways that a building can

be understood. The implementation phase in the hospital buildings shows that after a certain understanding is stabilised in a standard there is still room for multiple understandings captured in multiple standards. The stabilisation of the CCS standard around certain understandings and stakeholders during the shaping of the standard is therefore challenged again on a different site, for example during the implementation of the standard.

## **METHOD**

Theoretically, this study is mainly based on STS literature on classification, standardisation and information technology, and on performativity. The central methodological approach follows Bowker & Star's fourth methodological theme for studying information infrastructure, namely uncovering the practical politics of classification and standardisation as they are designed (1999: 44-6). We use a longitudinal case study that follows the design of standards as they emerge. Callon's (2007) concept of performativity further legitimises scrutinising standard creation and implementation, and opens up space for multiple struggles between statements and reality. Furthermore, a brief review was done on standard creation and implementation which shows some cases of multiplicity and interaction within and between standards.

Empirically, this paper follows a mixed method. Most weight is on the qualitative study of the shaping of the Cuneco Classification System (CCS) in a Danish community of Architects, Engineer and Construction (AEC), and the implementation of the CCS in a Danish hospital design. The empirical material was gathered in connection to an intensive longitudinal study and included interviews (57), participant observation of events (18) and a document analysis. Second, this qualitative in depth material is complemented with a quantitative study on the existence of other building information standards in Denmark. The large amounts of data and information collected in the course of the study have made us decide to be selective of the information that will be presented in this paper. The empirical material will be used to show different aspects of performativity and multiplicity among standards.

## **THEORETICAL FRAMEWORK**

### **Similarity and performativity in standardising**

Classification systems are described as segmentations of the world that do work in the world (Bowker and Star 1999: 10). Ideal classification systems are consistent, have mutually exclusive categories and cover all that is intended to describe (Bowker and Star 1999: 10-1, Busch 2011). Classification may be done ad hoc, but tends to be standardised to varying degrees. As mentioned, standards create similarity and homogeneity across time and space. Consistency of form or understanding allows people to coordinate their actions, and subsequently the consistency and increased coordination allow for higher complexity in the things people may achieve in a society (Bowker and Star 1999, Busch 2011, Furusten 2000, Timmermans and Epstein 2010). The Cuneco Classification System (CCS) is an example of a standardised classification system that provides a systematic ordering of building information.

As a mechanism of coordination standards have a rule like character (Brunsson and Jacobsson 2000). The power that become embedded in standards makes it an interesting area of political manoeuvring. After all, a standard corresponding to one professional group's understanding and goals requires less adjustment and can be used as an instrument to move others. It is in this light we follow Bowker and Star's methodological invitation to study and uncover " the practical politics of classifying and standardizing"

(1999: 44). Following the process of shaping a standard, it can be shown which perspectives on building are embedded in the outcomes.

That standards have an impact on the building being build is perhaps evident for conventional standards, but also applies to information and classification standards. The idea that information does not merely represents reality but actively helps shape is captured in the concept of performativity (Callon 2007, Mackenzie, Muniesa and Siu 2007). As pointed out by Gond *et al.*, (2015), this STS inspired understanding of performativity has found its way into organisation and management theory. Callon's (2007) performativity guides this study in at least three different ways. Firstly, performativity further legitimises to study the process of standard creation and implementation as the ideas stabilised in standards help shape reality. Second, Callon presents theoretical frame to study performativity in the making: i.e. the assemblages of actors and statements that collaborate and compete in a struggle for survival in a mutual adjustment between statement and practice. Thirdly, the understanding that the process of struggle and mutual adjustment happens time and again can be read as an invitation to look at multiplicity in both creation and implementation phases of a standard.

### **Opening up for multiplicity within and between standards**

Despite ideals of homogeneity - a standard is after all a mechanism for coordination through making things similar - there several domains where multiplicity persists. Starting with relatively limited forms of multiplicity in standards, the text will discuss increasingly radical forms of multiplicity occurring in standardisation literature. Following a distinction between standard creation and standard implementation (see also Botzem and Dobusch 2012), there are cases showing multiplicity in both phases.

A study of the development of the JAVA programming standard shows that struggles between different understandings of the standard may persist when a single standard is being developed and alternatives have been excluded already. In the JAVA case, initial exclusion is challenged during standard maintenance and development by threatening to develop an alternative standard (Garud, Jain and Kumaraswamy 2002),

A discussion on multiplicity between standards may start with the well-known technological standard battle between VHS and Betamax videocassette recorder technology (Cusumano, Mylonadis and Rosenbloom 1992). Multiplicity is here initially present but is strongly reduced as one standard becomes dominant. In other cases, dynamics between standards have led to co-existing standards. Such outcomes have been observed in sectors such as international coffee certification (Reinecke, Manning and Von Hagen 2012), local fast food markets (Berman 2013) and telecommunication (Genschel 1997, Shen *et al.*, 2013). Multiplicity may conceptually be taken a step further when multiple standards do not compete or co-exist but co-evolve into hybrid standards. A case of co-evolution into a hybrid standard is observed in the development and diffusion of the Chinese 3G network (Shen *et al.*, 2013). An extreme case of multiplicity is presented as reflexive modernisation in a study of an Electronic patient record at a Norwegian hospital (Hanseth *et al.*, 2006). Here multiple outcomes of standardisation are considered unavoidable due to side-effects of the effort to standardise.

### **Summing up**

The performativity of standards and differences in understandings that guide its shaping and implementation may serve to expect the persistence of multiplicity. This multiplicity is found in the literature on standards. During the shaping of the standards we see processes that can be characterised as political: as collaboration and competition, but even

co-evolution. In the next sections, shaping the CCS standard will be described and discussed.

## **THE SHAPING OF THE CUNECO CLASSIFICATION SYSTEM**

### **Development of the CCS standard**

Prior to the establishment of the Cuneco development centre in 2010-2011, industrial players made some important moves that paved the way. An organised alliance of the largest engineering and contracting companies, operating on a multi-national level, carried out an investigation of classification and published a report advocating a Danish classification for construction. This gave extensive and somewhat external help and support to the core classification advocates. The government authority also generated a funding possibility by positioning an EU program in support of classification in the building industry.

BIPS, an industry association took charge of formulating an application, and a positioning process commenced in which some community players with their understanding of classification were included, while others were excluded. The Danish CEN/ISO organisation became involved and so did the building clients association. However, the constellation did not allow inclusion of Technological Institute or Aalborg University, two important institutional players in the AEC sector. Aalborg University was profiled with an alternative technology, and also with outspoken criticism of the very idea of making a classification that the Danish Building Classification, DBK, had already attempted. BIPS managed to collect a winning coalition and received the funding.

In this process, the basic ideas of the previous attempt were incorporated to begin with, but shortly after obtaining funding. The centre took the name of Cuneco, inspired by the Esperanto word for community “kuneco” (Cuneco 2014). The organisation of Cuneco involves a centre manager, a secretariat, a steering group, a partnership and a project organisation. Projects cover the four main areas named hereafter and also test the developed elements of infrastructure. The Cuneco classification system consist of mainly four elements (Cuneco 2014): Classification, Property data, Information levels, and Rules for measuring.

The classification developed here build on a conceptual systematic ordering of information about a building using a basic process model linking resources, processes and results (Ekholm and Häggström 2011). The single building is broken down into elements. The data related to the properties of these elements is to be given a decoupled structure where information levels refer to the gradual levels of detailing in the process of designing, building and operating a building. The rules for measuring the elements (metrics) are to be standardised as well, so that elements are assigned well defined volumes, lengths, weights etc. All these elements are to be stored as basic digital data on a server that is available for users in a cloud-based solution. Cuneco’s vision also encompasses forming a business model for the long-term maintenance and further development of the classification and especially the accumulation of property data for building elements.

When funding was obtained in 2010, the centre initiated and gradually finalised a series of development projects covering the vision for the entire program. Elements of the classification thus began to materialise. When initialising the project, much of the basic thinking and results obtained from the previous development program (DiCon) were adopted again. This provoked criticism from some players, as they meant that these concepts had proved unusable in practice (including ISO 12006-3, IFC, and DBK 2006);

however, leading players from Cuneco insisted that this basis was fundamentally solid even though it needed updating and further development.

An early analysis focused on user needs and value creation for users. This analysis took more the shape of a stakeholder analysis, conceiving of users as large interest groups, such as architects and building clients. An important result of this exercise was however to generally ask all the development projects initiated to conceptualise user scenarios, making it explicit how the classification and the other developed standards should be used in practical situations.

One design issue is how to create rules for identifying building components. Here the central designer drew on electrical and installations standards based on systems theory, claiming that all building components have a basic function that can be neatly separated and ordered.

Building component: a delimited part of a building, which in itself or in combination with other building components have a characteristic function in the building. (Cuneco 2012)

The delimitation of such an understanding became more broadly known in the spring of 2012, where a proposal for the Cuneco classification system (CCS) of building parts was launched – first, a system for classification on a relatively aggregate level, and later a set of tables for six structural aspects: type, product, composed product, place, function, and supplementary aspects. It is proposed to separate classification and property data, keeping classification as one property among others for objects. This is also seen as preparation for future use of other classifications. It has had a reputation for being biased towards installation components:

I don't understand why they don't let me reorganise their building component classification, it is rather impacted by an electrical installations view, and it should be different. (Consultant and expert in building data structuring, interview Jan 2016)

Another design issue is the relation between classification and property data. Ekholm (2010) who proposes a reference system for property data, argues for the need for a theory for structuring property data (see also Ekholm and Häggström 2011). The 2012 proposal for property data was a rather independent development of property data with a systematic structure and relation to classification, but it did not have a theoretical foundation. Furthermore, the proposals for classification continue to have an unclear theoretical basis.

### **Implementing the CCS standard in a Danish hospital project**

By the summer of 2012, the first major test project commenced, which involved a large Danish hospital project. The first prototypes and testing activities were developed during the autumn. In this context, the building client became allied with six software suppliers. Together, their six systems cover parts of the information flow from early conceptual design of a building (one system), over detailed design (two CAD-systems and a BIM system), cost and budget calculation (one system), and space management (one system). According to the project manager, the systems are able to identify building components, classify them and sort them. This also involves data flows supported by the chain of the six systems:

At [the hospital] we are now at classification of rooms and about to classify building components. The six participating IT companies can actually all, almost all, classify. We have made an internal demo of an information flow...: [lists the six systems]. The programs are capable of doing that. With CCS we can classify, sort, identify. The programs are further than I thought. (Project manager, interview Nov 2012)

By January 2013, it became clear however that classification of rooms had been a very rocky process, which led it to be abandoned. The client organisation later communicated that the handling of building components in the tendering process for the earth and foundation works had enabled considerable savings.

During late 2012 and early 2013, the centre experienced serious delays and obtained new funding for implementation. The funding authority also accepted a new prolonged schedule. Recruitment of project managers and project members, as well as living up to internal quality procedures, are frequently cited as the reasons behind delays (interviews).

By January 2013, the information level structure proposal was launched and sent to a hearing. This was the first processual element of standards Cuneco produced, the other elements being focused on the product. The proposal operates with six levels of information, and proposes user 'views' as part of the user interface tackling the envisaged growth of building information along the process of designing and operating a building. These proposals received a number of comments from the broader community, which led to a revision carried out in the spring of 2013. By early autumn, the development of a classification of resources was well under way, and the centre was actively planning and initiating testing projects.

During 2014-2015 a portfolio of test projects were carried out. The central server was implemented and a portfolio of roughly twenty standards was launched. However, the resource classification supported production processes remained very general.

### **Multiple standards in the Danish building industry**

In December 2014 the BIPS industry association carried out a study on the use of building information standards in different stages of the building process. The study was conducted among some of the members of the association, which are architect firms, consulting engineering firms, building clients, contractors and other building actors (Bips 2015: 20). The results show that the CCS operates in a standard landscape where a number of different information classification standards are used. First the Revit software represent 65% of the BIM software in use. Second, proprietary standards score the highest. Then, the Standard for Buildings (SfB) is used about twice as often as the CCS classification which corresponds to a top coverage of 54% in drawing and 27% in operations. The Danish Building Classification (DBK) is used by a roughly equal amounts of people as the CCS classification. Adding to the diversity in the standard landscape, about a third of all respondents claim to use an own system (Bips 2015: 20). Notwithstanding the fact that these numbers will change over time, they give weight to the importance of understanding multiplicity among standards as a current reality in the Danish building sector.

## **DISCUSSION**

The shaping of the CCS system shows three particular ways in which actors define how a building should be understood. The first performative aspect focusses on the internal structure of the building as a product and less on the process that leads to making the product. The focus on internal product features can in a power politics perspective be interpreted through the reconstitution of architect and engineering firm regime in the Danish building industry. The contractors are relatively weaker. They represent the interest in standards for the data on the process and did not manage to establish this as equally important in the standard development process.

Second, the systems theory approach to the internal structure reflects an understanding of building components as having “functions” derived from electrical installations. This performative aspect applies strongly to the installation part of the building, but does not always apply easily to types of building components that have more than one function in a building. Take the example of concrete and wood which in this case have both façade and structure bearing functions and may thus be more difficult to classify. Also it does not support a more compositional shaping understanding as needed by architects. Again, here the very narrowly organised development organisation assured that just a core group had influence on the design of the standard. This group assigned the standard development to a consultant strongly schooled in the installations standards with its functional systems theory approach.

The third performative aspect, the delimitations of the standard, views the process and the product, ‘a building’ as its cores, and largely disregarding design of agglomerations of buildings, the design of roads and infrastructure. But also important, it structures data with a focus on building components as materiality over components being economical entities or components being something that need to be delivered and in need to be transported.

There are some interesting observations on multiplicity to make as well from this study. First, in the building sector the fragmentation of data leads actors to appeal for a common mediated system. The common standard the designers of CCS aspired to create turned out less of a common and mediated systems as intended. At the same time the BIM software Revit represents a strong market driven standardisation within design. Standardisation is perceived as a solution to fragmentation but may be of limited use as multiple classification systems persist to co-exist. The persistence of multiple standards for building information standards in Denmark caution any aims for a grand homogeneity. When dealing with the politics of shaping of information classification standards, it may be important to recognise that there are different legitimate and relevant structures to collect and save data. What is considered relevant and legitimate will vary depending on the context, and is influenced by different understandings and interests of what a building is or should be. Following Callon (2007), this multiplicity carries on through the implementation phase where again different standards-user networks compete and co-exist. Multiplicity extends beyond the struggle/intersections between different understandings of building, into multiple struggles/intersections. Different understandings of buildings compete and co-exist in multiple locations time over again.

## **CONCLUSION**

We set out to investigate standardisation of data structures using Bowker and Star's (1999) ideas on uncovering the politics of classifying and standardising and Callon's (2007) notion of performativity. Ideas about freely combining unstructured data neglect the hard work and politics involved in data structuring practices. Opening up the shaping and structuring of data is relevant to us because of the material performative effects of data on the development of buildings. Standard shaping can be explained to be about competition and collaboration between professionals, understandings and interests about what data is needed and appropriate to build. In a single standard this has been shown to create certain biases depending on how data and building are perceived. The shaping of the CCS standard has reflected a designer actor alliance with prevalence for the building as a physical entity, physical building properties and structures, and a functional building component definition. Such stabilisation of the understanding of a building comes necessarily at a cost of disregarding other interpretations such as process-based view of

building, components with multiple functions, economic and transport features of components.

After stabilisation in a standard, multiplicity persists during the implementation or diffusion phase of a standard. The CCS standard has to work in an environment where several other standards are in use, each reflecting their particular assemblage of actors, interests and understanding on building. Multiple understandings collaborate and compete during the shaping of a standard and in later stages of the standardisation process. Thus, not only are there multiple understandings, there are also multiple locations for such understandings to perform. In conclusion, this paper underlines that visions of homogeneity in data structures to be created through standardisation technology are unreflective of the conditions observed in our case. Here, multiplicity persists as a temporary stabilisation of understanding in a single standard, is followed up by new places for contestation during standard implementation. Holding on to ideals of homogeneity may under these circumstances prevent data use from becoming big in building.

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# THE ACTORS' PERCEPTIONS AND EXPECTATIONS OF THEIR ROLES IN BIM-BASED COLLABORATION

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The inter-organisational collaboration with Building Information Modelling (BIM) is one of the hottest topics in construction sector nowadays. The implementation of BIM is a complex inter-organisational process, and the sharing of information among numerous actors from multi-disciplinary backgrounds may affect the actors' role perception and performance. This study offers insights into the BIM roles of various actors by analysing a BIM-based project carried out by an integrated partnership across many tiers. The analysis identified inconsistencies between the actors' perceptions and their partners' expectations of their BIM roles. Inconsistencies in BIM roles were more related to soft rather than hard (domain- or technical) skills. Mismatches were found in the architect's role, as it was deemed necessary to be more domain- and BIM-related, contrary to their perceptions. Likewise, the suppliers' role called for an enhanced BIM orientation. The paper concludes with set of suggestions for increasing the joint responsibility and supporting the multi-actor collaboration.

Keywords: Building Information Modelling, case study, collaboration, roles.

## INTRODUCTION

Building Information Modelling (BIM) is a subject undergoing intense study in construction management research. BIM entails software applications, tools, activities and procedures for generating, managing and sharing building information among various multi-disciplinary actors. The use of BIM in construction projects has become increasingly popular, due to project benefits, e.g. time reduction, coordination improvement, lower costs and fewer returns for information (Azhar, 2011, Bryde *et al.*, 2013), and collaboration benefits (Barlish and Sullivan, 2012). Whereas BIM may improve collaboration among the various project actors, there is little research how the channelling of information flows in BIM affects the various actors' roles.

Sebastian (2011) provided evidence of changing roles of the clients, architects and contractors from BIM. BIM has penetrated into the professional routines of numerous multi-disciplinary actors. Not only architects and structural engineers but also clients, contractors, and suppliers gradually include BIM in their work routines. Thus, the business models of various construction professionals are transformed by BIM. When collaborating with BIM, actors develop BIM responsibilities at both technical and inter-personal levels (Gu and London, 2010). These transformations might further fragment the existing practices among actors, given that the construction industry is already described as scattered field with low employee satisfaction levels.

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The various national BIM reform agendas instigate a cultural shift towards increased collaboration and consistency of information sharing. This study focused on the changes of BIM roles within Supply Chain (SC) partnerships, which are consensus seeking and non-antagonistic (Gosling *et al.*, 2015). The term ‘SC partnership’ instead of ‘partnership’ is used to denote a partnership extending across all tiers. The paper aims to gain a deeper understanding of how collaboration with BIM is affected by incongruences between one’s own role perception and expectations of other actors.

First, related past work on BIM perception is presented. Then, the research questions follow. Next, the research methodology was reported. After presenting and analysing the data, the findings were discussed and compared to literature. The paper concluded with a summary and suggestions for construction practitioners to overcome the gap between incongruence in emerging perceptions and expectations in BIM-based teams.

## BACKGROUND

### The impact of BIM on the project lifecycle and actors

#### *Benefits of BIM*

BIM is a promising set of technologies for consistently sharing building information among various actors. BIM is as a ‘multifunctional set of instrumentalities for specific purposes that will increasingly be integrated’ (Miettinen and Paavola, 2014). BIM’s ‘ready packed’ capabilities are likely to be accepted, due to their immediately shown benefits (Jacobsson and Linderoth, 2010). The built-in features of BIM applications have options for visualisations and quantity take-off (Eastman *et al.*, 2008). BIM can facilitate design with fluent visualisations, fast shop drawings, fast coding and precise interference detection (Azhar, 2011). Such benefits greatly alter the work of engineers, e.g. architects, structural engineers. The built-in cost estimating features of BIM tools facilitate the work of quantity surveyors and contractors (Azhar, 2011, Bryde *et al.*, 2013). Thus, most BIM benefits apply to operational and informational aspects.

The impact of BIM does not only pertain to *hard*, operational and informational, but also implicate relational aspects, e.g. commitment, trust. BIM also induces various *soft* gains related to shared information, such as coordination improvement, fewer returns for information (Azhar, 2011, Bryde *et al.*, 2013), and collaboration benefits (Barlish and Sullivan, 2012). Whereas BIM adoption rises in employees, firms, and countries, BIM implementation and collaboration are in flux. Succar and Kassem (2015, p.65) defined BIM implementation as a combination of readiness, capability and maturity that firms need to develop to have BIM successfully implemented. Thus, the involved project actors might vary in BIM readiness levels. Since collaboration involves to a multi-actor network, delving into the emerging BIM roles of various actors is needed.

#### *Extant challenges and transformations from BIM*

The use of compatible Information Systems (IS) has been deemed essential for the information exchange among various actors (from designers to suppliers) and could be used to integrate the design and construction phases (Dulaimi *et al.*, 2002). BIM is an IS, that allows the involved actors to use their preferred systems, meanwhile exchanging compatible information in Industry Foundation Classes (IFC) format, currently the main open data standard (Berlo *et al.*, 2015). BIM deeply affects collaborative processes by transforming the information exchange and inciting denser interactions. Thus, the roles of the clients, architects and contractors are likely to change due to the use of BIM (Sebastian, 2011). The changing roles from BIM pertain not only to domain-related and technical skills but also to relational managerial issues.

Dossick and Neff (2010) studying the interaction among Mechanical, Electrical, Plumbing (MEP) engineers, found BIM to enhance transparency by showing the connections among them. However, BIM did not foster closer collaboration across the firms. The changing nature of the (shared) deliverables and integration across professional roles carries implications for construction actors who might engage in roles beyond the disciplines in which they were originally trained in (Jaradat *et al.*, 2013). Davies *et al.* (2015) stressed that a 'combination of personality, experience, and training or education' is necessary to develop social competences for collaboration, communication, conflict management, negotiation and teamwork with BIM. An investment in social competences could, thus, support the emerging BIM-related roles. These social competences could be added to the traditional technical skills, including the technical skills that BIM use requires. In the context of this paper, the *soft* competences that could accompany BIM collaboration are defined as the skills do not require domain expertise or BIM-related technical nature, unlike the *hard* skills.

#### *The impact of BIM from an inter-organisational perspective*

Adopting and implementing BIM is thus a multi-faceted challenge. Its implementation induces various project-based, intra-organisational and inter-organisational changes. BIM not only affects the knowledge-based, technical nature of construction work but also affects the soft and intangible aspects of communication and collaboration, thus the team's relational management. According to Orlikowski and Gash (1994) the concept of 'technological frames' signifies that actors may have varying 'assumptions, expectations, and knowledge' (skills) about the use of IS, e.g. BIM. Thus, it might be useful to investigate the actors' perceptions and expectations in respect to the use of BIM. Yet, most BIM-related studies exclusively focus either at the designer (Son *et al.*, 2015, Ding *et al.*, 2015), or the facility owner (Giel and Issa, 2016, Korpela *et al.*, 2015), or the contractor (Ahn *et al.*, 2016) or the engineers (Dossick and Neff, 2010, Gu and London, 2010), neglecting the impact of BIM on the work of sub-contractors and suppliers. There is a lack of understanding about what BIM means to the actors in a multi-actor project network, and how BIM influences their role perception.

The construction industry could thus be considered a supply-demand network (Christopher, 2005) with multiple "action-reaction" relations among its actors. One more important characteristic of construction industry is the project-based focus, which due to its autonomy and discontinuity impedes learning and reduces possibilities to standardise (Jacobsson and Linderoth, 2010). Thus, an analysis of the meaning of BIM implementation within structured inter-organisational teams, and particularly in contractually bound SC partnerships with long-term relations could provide insights into the changing roles upon the introduction of BIM. Such insights are important, as BIM-based collaboration needs better-structured teams (Dossick and Neff, 2010). The study therefore addressed the following research questions:

- What are the perceived roles of actors in a BIM-based project?
- What are the expected roles of the various actors in a BIM-based project?
- What are the implications of the mismatches between the perceptions and expectations of roles in a BIM-based project for construction practitioners?

## **METHODOLOGY**

### **Research background and rationale**

The study explored the emerging BIM roles of actors who were contractually bound in SC partnerships. The Netherlands is an appropriate research setting for cultural reasons,

for its ubiquitous consensus-seeking, ‘*poldermodel*’ culture that fosters close collaboration among project actors. Winch (2002:25) describes the Dutch construction industry as a Corporatist type System where the “social partners”, - like trade unions - are keen to negotiate instead of seeking confrontation to optimise benefits to the Dutch workforce and the society at large and to reduce the costs and risks.

The empirical context of the study was a set of actors organised in a SC partnership initiated by the contractor. The partnerships not only provided a structured setting for the study but also enabled the data collection process and the unobstructed access to information, given that all SC partners saw value in further researching their relations. Moreover, this non-antagonistic setting could serve as a ground-up approach for BIM implementation. After all, many national mandates, e.g. The Egan Report and the Publicly Available Specifications (PAS) 1192 in the United Kingdom (UK) have been envisaging the integration of the supply chain, triggered by close collaboration.

The study used case study methods to explore the research questions. The case was a real-world building project and involved various actors. The case study was selected over isolated interviews with construction firms, to avoid impression management and retrospective sense-making that often arises in interviews among isolated interviewees (Eisenhardt and Graebner, 2007). The study was interpretative and focused more on information richness, sense, and meaning (Yazan, 2015), than generalisation.

### Case study protocol

#### *Data collection and analysis*

The roles of the various professionals were explored as to both BIM-related and inter-organisational aspects. The data were collected from in-depth interviews with nine multi-disciplinary actors of the BIM-based case. The interviews were semi-structured, lasted about one hour, and had consistent preparation and data handling. Before the interviews, all interviewees had the same information about the study goals. Question hand-outs were used in the interview. The interviewees conversed in Dutch and with their permission they were recorded to aid the transcription and translation, by research assistants. The transcripts were analysed with qualitative analysis software, using free codes. The interviewees agreed on using their input for research, but opposed to publishing their details. The authors are not affiliated with the firms.

#### *Interviewees and the nature of the questions*

The interviewees were asked to reflect on their newly emerging roles in a BIM-based project. Table 1 contains their domain, function and whether they used BIM. The interviewees were first asked to describe their position, the project, the motivation for using BIM, and their roles. Apart from reflecting on their roles, the interviewees were encouraged to reflect on the changing roles of their partners. No probing techniques were used to receive feedback about all expected roles. When no information about any actor was received, it was an indication of a not content-based relation between them. The roles were analysed as to domain expertise skills and emerging BIM roles.

*Table 1: Interviewed firms and employees for the case.*

Actor	Function/position in the firm	BIM
Contractor	Site Engineer/BIM Coordinator in training	x
Architect	Project Architect	x
Structural Engineer	Lead Engineer	x
Mechanical Electrical Plumbing (MEP) Engineer	Tender Manager	
MEP Engineer	Site Engineer	x
MEP Engineer	BIM Modeller	x

Sub-contractor	Project Leader	
Supplier	Director	
Supplier	BIM Modeller	x

## CASE DESCRIPTION AND ANALYSIS

### Case description

The case concerned the construction of a housing tower, with 83 housing units in South Holland. The tower was developed over a pre-existing shopping arcade, and there were high technical and logistical challenges. The contractor held long-term contracts with the architect, the structural engineer, the steel sub-contractor and some suppliers. BIM was used from initiation and “as-built” BIM would be delivered. About ten firms used BIM, which was requested by the contractor and not by the client, to increase project quality, via a clause in the framework agreements.

The partnership was formed by 'dyadic' relations initiated by the contractor. The architect had an exclusive relation with the contractor. The contractor also had an exclusive relation with the structural engineer, but not reciprocal, i.e. the structural engineer also worked with other contractors. The contractor had agreements with some other suppliers, his 'preferred partners'. The preferred partners were firms that were already culturally aligned with the contractor. The final selection of the preferred partners was made considering the availability of selected individual employees.

### Case analysis

The narratives from the case actors were organised (1) according to their own perceptions of their emerging roles in the BIM-based project and (2) around their expectations of the other actors' roles. Given their existing long-term SC partnership, the narratives witnessed experiences stemming from previous collaborations. The next paragraphs present distinctive and thought-provoking quotations from selected actors.

#### *Architect: Perceptions and expectations*

The architect acknowledged the importance of their domain expertise-related input in the project: *'Funny enough those responsibilities did not change that much. You're still responsible, whether it is an architectural model or a drawing. That actually has not changed that much'*. She also added that they felt particularly *'responsible for a good architectural BIM model and to encourage the collaboration'* among the various parties. For this reason, they were proactively seeking input from their partners in various ways, e.g. through co-locations, emails, and phone calls. The partners deemed the architects' input highly important, because it defined *'the form and space in which partners had to operate'* (Contractor-Site Engineer). Most of the emphasis from the actors was given to the architect's domain expertise and technical-based skills. They did not address the architect's social competences.

#### *Structural Engineer: Perceptions and expectations*

To the structural engineers, coordination skills were considered as important as their domain expertise and technical-based skills. Whereas their primary role is the design of the structural BIM model, requiring good mastering of BIM skills, they additionally *'monitor all other suppliers, especially if it has a connection to the structure'*. At the same time, they adjusted their mode of communication to the BIM process: *'We now increasingly communicate only with BIM models instead of drawings and details'*. Other actors held the structural engineers responsible for retaining long-term interactions with the architect to share knowledge and were seen as complementary disciplines: *'they always have to sit together'* (Sub-contractor-Project Leader).

### *MEP Engineers: Perceptions and expectations*

The MEP engineers considered their roles to require more domain-related skills than soft competences. They stressed that the BIM-related activities are a *'joint responsibility'* and a matter of everyone being *'respectful to each other'*. Other actors expected the MEP engineers to more frequently engage in proactive knowledge sharing and informal communication by email and co-locations, to avoid the contractor *'just playing the postman between'* (Sub-contractor-Project Leader).

### *Contractor: Perceptions and expectations*

Aside from domain-related tasks, such as *'reducing the cost of failure'*, the contractor's project leader perceived his role as a set of soft skills to inspire *'a whole different way of working together (...) talking about partnering but not price-hunting'* and *'to roll out the whole story about the BIM-culture in the chain, and to get everyone excited'*. He aimed to engage in a transparent way and from an early stage onwards with the other actors in the project. Moreover, he emphasised that he was responsible for taking on the role as the BIM coordinator: *'basically I need to be the communication link among them (...) to ensure that the errors are accordingly communicated'*. The suppliers had underscored the importance of a permanent BIM coordinator from the contractor's firm being on the construction site. This was probably the motivation for the contractor firm to train the Site Engineer as a BIM coordinator. The other actors expected the contractor to have *'planned the occasional moments where everyone sits around the table'* (MEP Engineers-Tender Manager) and prepare BIM agreements. *'For the contractor the role changed. And that really concerns both the process and planning. They much earlier think ahead, thinking about the accountability of other involved parties'* (Architect-Project Architect). The architects also expected that the contractor became *'all of a sudden responsible for the whole BIM model'*, thus becoming responsible for the full coordination.

### *Sub-contractor: Perceptions and expectations*

For the concrete sub-contractor, the main domain-related responsibilities, e.g. *'schedule (...), delivery on time and been attuned to all parties, has not really changed'*. However, because of the strategic decision to outsource the development of BIM to a BIM drafting firm, this major impacted their work, as the lack of an in-house BIM engineer at the sub-contractor was considered a draw-back by the other actors. The Architect-Project Architect stressed: *'that can also be a sign that their knowledge around the BIM model stops as they just hire a BIM drafting firm'*. In contrast, the sub-contractor emphasised relational or soft skills, such as being collaborative and flexible *'we sit together in the office and that is very handy. If we need to go together to the contractor's office building, I have each time to consult with the BIM drafting firm (...) but to me that is very flexible'*. The sub-contractor was also very keen to engage in informal communication: *'the communication is basically with all the parties'* and advocating a relational or soft-competences view about BIM: *'I still find a strong point in using BIM is making you think about the other disciplines'*.

### *Supplier: Perceptions and expectations*

According to the steel supplier, the perception of their role responsibilities was acknowledging and respecting the BIM-related and contractual agreements, rather than the domain expertise. He used BIM to look up others' work: *'BIM has a big advantage, you can quickly see what everyone is doing'*. They also engaged in informal communication to support the BIM process: *'we always work with the same standards. We want to provide good quality, so they (contractor) created standards. We have to coordinate because each has its own way of working and especially in BIM'*. However, not all suppliers in the project used BIM and therefore, the architect mentioned that:

*'some suppliers are accustomed to the contractor checking everything in detail. And the control is now moved to them and that they find it inconvenient (...) they find it very scary. (Architect-Project Architect).*

*Table 2: Occurrences of the perceptions and expectations of the various actors' BIM roles.*

Actor	Perception of own role	Expectations from other actors
Architect	BIM technical skills, seeking consensus, and engaging in informal communications	Domain-related expertise and engaging in early discussions
Structural Engineer	BIM technical skills, coordination, domain-related expertise and engaging in informal communications	Ensuring long-term relations
MEP Engineers	Domain-related expertise and showing respect	Engaging in informal communications
Contractor	Engaging in early discussions, meeting the formal agreements, coordination, and BIM technical skills	Domain-related expertise and ensuring long-term relations
Sub-contractor	Domain-related expertise and engaging in informal communications	BIM technical skills and ensuring long-term relations
Supplier(s)	Meeting the formal agreements and engaging in informal communications	BIM technical skills, discipline-related expertise, and coordination
Client	N/A	Engaging in early discussions and informal communications
Multi-actors	N/A	Communication across all tiers, seeking consensus and displaying joint responsibility

Whereas the client did not participate in the interviews, they were expected to play a more dominant role during the early project phases. A collective expectation was that all parties assumed the client to show more responsibility, seeking for consensus and informally communicating with partners across all tiers. Table 2 summarizes the recurring concepts across all interviewees. The concepts are organised according to the actors' own perceptions of their BIM roles and their expectations of the other actors' BIM roles. Table 3 reports the frequencies of the perceptions and expectations of roles into soft and hard aspects and therefore shows the mismatches associated with the changing BIM-related actors' roles.

*Table 3: Summary of the frequencies of soft and hard concepts related to BIM roles, throughout the perceptions and expectations of the various actors.*

Actor	Perception of own role		Expectations from other actors	
	Soft competences	Hard skills	Soft competences	Hard skills
Architect	19	16	11	17
Structural engineer	25	27	6	2
MEP engineers	5	5	8	1
Contractor	26	9	36	13
Sub-contractor	16	7	9	6
Supplier	5	2	15	22
Client	N/A	N/A	6	4
Multi-actors	N/A	N/A	76	38
Totals	96	66	167	103

## DISCUSSION AND IMPLICATIONS

The findings revealed various BIM-related roles among the multi-disciplinary actors as well as some mismatches in their perceptions. Overall, more *soft* than *hard* dimensions were identified during the discussions about BIM collaboration (Table 3, *Totals*). This finding corresponds to results of others showing that soft competences were mobilised within the context of BIM (Dossick and Neff, 2010, Gu and London, 2010, Davies et al.,

2015). Mismatches were observed between one's own perceptions and expectations from actors for BIM roles, particularly between the architect and suppliers. This is consistent with Orlikowski and Gash (1994) that delving into shared perceptions about BIM is important in assessing its impact on construction firms.

The largest inter-organisational mismatches concerned the architect (Table 3). The architect considered their BIM roles to emphasise collaboration and soft skills and less domain expertise (see Table 2), whereas other actors' expectations stressed the importance of domain-based skills. This incongruence might be explained from the traditionally central role that the architect plays in construction projects, which with the rise of BIM, tends to become more instrumental rather than being responsible for the building product. The other partners' expectations are consistent with results from studies about the importance of the architectural model in developing the BIM process (Jaradat *et al.*, 2013). Similarly to past studies, the role of the client in fostering innovation, i.e. BIM, was deemed crucial (Jaradat *et al.*, 2013, Sebastian, 2011). The findings about the MEP engineers contrast with the results of Dossick and Neff, (2010). This difference may stem from the MEP firm in the present study offering integrated design and installation services, whilst in the former study MEP services were delivered by various firms. Finally, the findings offer suggestive evidence of a shift in the role of the suppliers. With BIM, they seem to acquire a larger responsibility, with an additional need for social skills.

Although the focus of the study was inter-organisational, some unexpected intra-organisational observations could shed more light on BIM implementation. A typical combination of complementary BIM functions in firms included a BIM modeller, a BIM-knowledgeable project manager, and a BIM-enthusiast project leader (see Table 1), depending on the firm size. Such contrasts with firms having BIM not included in their business plans. They hired BIM drafting firms (see the sub-contractor's analysis). The latter echoes long-standing strategic dilemmas in innovation change management, about outsourcing or training in-house staff to new technologies, as in the contractor's firm (see Table 1 and the contractor's analysis). The above discussions on varying functions and BIM-related business models carry implications for construction (management) professionals how to disseminate BIM.

A potential limitation is that the study concerned a SC partnership. Such partnerships across all tiers of the construction industry are quite popular in the Netherlands. They feature shared decision-making, consensus-seeking and self-organising project teams and may rely on cultural traits being typical to the Dutch culture. This might indicate that the collaborative culture is a promising way forward in enriching BIM implementation with soft aspects by circumventing hierarchies, seeking consensus and collaborating beyond contracts and prices. Indeed, the findings seem to provide supportive evidence that BIM-based projects need better-structured inter-organisational teams (Dossick and Neff, 2010), and provide suggestive evidence of integration across the supply chain, as aspired in the Egan Report in the UK.

## CONCLUSIONS

This study investigated the emergence of changing roles due to BIM. The analyses were performed along the axis of inter-organisational relations and aimed to reveal discrepancies in actors' perceptions and expectations of BIM roles. Results showed that informal interactions, communication across all tiers and desire for long-term relations were soft competences supporting BIM. Interestingly, and unlike his perception, the

architect's BIM role expectations emphasized domain expertise and BIM skills. Other actors expected suppliers to develop a stronger responsibility for their work and BIM deliverables, and take their share in BIM collaboration.

Acknowledging the differences in the perceptions and expectations of BIM roles could contribute to BIM dissemination. BIM influences the organisation of firms, by requiring complementary BIM roles at operational and strategic levels. It seems that whether a firm adopts BIM by training engineers or outsources the BIM functions affects them being perceived as equally capable partners. Successful BIM implementation requires domain expertise and BIM-related skills as well as soft collaborative skills and clear intra-organisational BIM objectives.

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# UNDERSTANDING THE CREATION OF ICT-VALUE IN THE BUILDING AND CONSTRUCTION INDUSTRY

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ICT (Information and communication technology) creation of business value has become - for few reasons- a topic in need of closer scrutiny. Numerous governmental initiatives originate from a belief that digitization would improve the performance of the building and construction industry. But, there are evidences that expectations of positive effects of use of new ICT, for example BIM, may be too optimistic. In Information Systems research (IS), ICT creation of business value presents one of the main concerns. Accordingly, by drawing on the literature on ICT value creation and characteristics of the building and construction industry, the aim of the paper is to outline a conceptual understanding of ICT value creation in the building and construction industry. The analysis will take the point of departure in three perspectives on ICT-value creation: the resource-based, the process and capability building, and the multiple-firms perspectives. When ICT-value creation is analysed, a paradox is uncovered. In the industry, customer value is co-created due to the need for a wide array of competencies and resources. But, at the same time there are very weak incentives for firms to co-create ICT-value due to existing governance systems and institutionalized role systems. Research is needed in order to uncover facilitators for building more long term relations among firms that in turn creates conditions for processes of building capabilities for creation of ICT-value.

Keywords: ICT-value, co-creation, capabilities, resources.

## INTRODUCTION

In countries like Great Britain and Sweden, governmental initiatives are taken to increase the digitization of the building and construction industry. This is often expressed by promoting an increased use of BIM (Building Information Modelling) that is believed to improve the efficiency of the industry. Also in the literature, BIM is claimed to be one of the most promising developments in the industry that is expected to introduce significant changes for all stages of the construction process (see e.g. Eastman *et al.*, 2011). However, despite the optimistic predictions on BIM's positive effects on the industry, a number of challenges are identified. Demian and Waters (2014), and Linderoth (2010) argue that the temporary nature of construction projects create challenges when BIM use diffuses to consecutive projects. Fox (2014) claims that expectations of BIM benefits may be too optimistic, Kang *et al.*, (2013) question whether claimed benefits of BIM have been fully achieved, Vass and Gustafsson (2014) state that BIM professional do not see any business value from BIM today, but it might appear in the future, and Becerik-Gerber and Rice (2010) claim that benefits of BIM use are difficult to evaluate with quantitative measures because claimed benefits are often intangible.

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However, the creation of ICT (Information and communication technology) value is not a unique concern for the building and construction industry. ICT creation of business value presents one of the main concerns in IS (Information Systems) research. There is a longstanding stream of research examining ICT business value, however, mostly focuses on studying the relationship between ICT investments and organizational outcomes of performance and productivity. Recently, this stream has been expanded to include other facets of value and recognized that ICT business value occur in varying degrees (Luo *et al.*, 2012). The repertoire of ICT business value has been hence expanded to include not only productivity enhancement, profitability improvement but also cost reduction, competitive advantage, inventory reduction, new organizational capability among other factors. Research showed that for ICT to create business value, it has to influence a firm's dynamic capabilities and strategic processes as these have been identified as important components that shape the firm's ability to perform value creating activities (Sambamurthy *et al.*, 2003).

The extent and dimension of the created value are dependent upon internal and external factors, including complementary organizational resources of the firm and its trading partners, as well as the competitive and the macro environment (Melville *et al.*, 2004). This view departs from the singular firm perspective on ICT value creation, where more contemporary research suggests a multiple-firm perspective of ICT value creation. The latter recognizes the fast moving market conditions that organizations currently face and the organizational needs to collaborate to acquire and utilize resources (Grover and Kohli, 2012). It also recognizes that firm's resources might span firm boundaries, and may even lie in its relationships with other firms (Dyer and Singh, 1998). This co-creation of ICT value has been recently highlighted as a critical theme for future IS research and IS researchers are strongly encouraged to understand how multiple partners in multi-organizational relationships co-create and share ICT-based value (Grover and Kohli, 2012; Kohli and Grover, 2008).

Thus, it can be argued that the building and construction industry meet some of the requirements for (co)creating ICT-value. Basically, the building and construction process can be seen as a process of co-creating value, because in order to accomplish a building or construction, several firms with a wide array of competencies co-create the final product. But at the same time, firms in the industry have been using ICT more for controlling and monitoring their own processes, instead of using ICT for creating value with regard to what is best for the project (see e.g. Jacobsson and Linderoth, 2010).

Against this background, the aim of the paper is to outline a conceptual understanding of ICT-value creation in the building and construction industry. This will be achieved by reviewing the literature on ICT value creation and presenting a few models of how ICT-value creation can be understood. The central concepts in the models will be discussed with regard to conditions in the building and construction industry in order to identify constraints and facilitators for ICT-value creation in the industry.

## **ICT VALUE CREATION**

In management literature, organizational value creation could be understood along three value disciplines: operational excellence, customer intimacy and product leadership (Treacy *et al.*, 1993). In the IS-literature, ICT value has been studied from at least three different perspectives with different theoretical approaches. Traditionally ICT value research focused on examining ICT's financial impact on productivity and firm performance. This stream of research applied economic theories to statistically examine and directly trace IT investment to firms' financial metrics of internal and external

performance or what Barua *et al.*, (1995) defined as first order effect on operational level variables and higher level variables such as market share and profit. This stream of research has produced mixed results that invited research to consider mediating factors. Research increasingly find that the relationship between ICT investment and firm performance is mediated by many factors. Devaraj and Kohli (2003) also found that actual usage is the missing link between ICT investment and its impact on organizational performance and showed that the driver of ICT impact is not the investment in the technology, but the actual usage of the technology (*ibid.*).

A second stream of research applies theories from strategic management literature, mainly the resource-based view of the firm to understand the ICT impact on firms' competitiveness. It explores how ICT resources change business operations and create value. ICT resources has been described in terms of a firm's ICT infrastructure, human ICT resources comprised of technical and managerial ICT skills, and ICT-enabled intangibles such as knowledge assets, customer orientation, and synergy (Bharadwaj 2000). However, in a recent study this direct link could not be established and further research was called for to study the role of a firm's resources and dynamic capabilities as mediators between ICT resources/capability and firm performance (Chae, *et al.*, 2014).

Based on theories of capability and dynamic capability, a third stream of research focuses on the role of ICT in developing firm's capability and dynamic capability. Wang *et al.*, (2012) suggest that in stable environments, creation mechanism for ICT value is primarily resource structuring while the primarily mechanism in dynamic environments is capability building. Tallon and Pinsonneault (2011) uncover a positive link between ICT alignment with business strategy and firm's agility, and between agility and firm performance. In this context agility is the ability to detect and seize market opportunities with speed and surprise, and is considered to be an imperative for business success (Brown and Eisenhardt 1997; D'Aveni 1994). Tallon and Pinsonneault (2011) also showed that agility has a greater impact on firm performance in more volatile markets.

Recently, studies on value creation recognized the multifaceted, subjective and intangible nature of value creation. Kohli and Grover (2008) highlight the need to consider and assess the intangible value and rather subjective nature of value as they state: "businesses and customers are the final arbitrators of value creation, and by over emphasizing pure financial post hoc metrics or even ex ante market value, we underreport the true benefits of ICT to these stakeholders (Kohli and Grover, 2008:33). Researchers have tried to inquire into the dynamic and multi facet context of ICT value creation. It is recognised that IT "does not create value in isolation" (Kohli and Grover 2008). It is part of a business value creating network that involves complementary IT and organisational processes (Melville *et al.*, 2004; Wade and Hulland 2004). IT and organizational processes include management, policies, routines, structure, culture, organizational knowledge and learning processes play important role in IT value creation. In this regard, understanding the business value creation network would be of particular importance in understanding how ICT creates value and in assessing the value of a particular system.

### **Three perspectives on creation of ICT-value**

Melville *et al.*, (2004) draw on resource-based theory and propose that creation of ICT business value can be understood through three layers: 1) The focal firm; 2) Competitive environment; 3) Macro environment. In the focal firm the deployment of technology- and human ICT-resources, and complementary organizational resources in a business process generates ICT business value and improves organizational performance. But the generation of ICT business value influence by the competitive environment. Industry

characteristics shape the way in which ICT is applied in the focal firm, at the same time as trading partners' resources and business processes has an increased impact on generation of ICT business value for the focal firm. Finally, resources in the macro environment, for example the level of development of basic infrastructure, education, research and development investments, culture etc. has an impact on the opportunities of ICT value creation.

This view connects the macro and micro of value creation at different levels of analysis. It is therefore useful for strategic thinking in terms of policy making, industry analysis and market evaluation.

In the second perspective, Sambamurthy *et al.*, (2003) focus on the focal firm and consider ICT value creation in terms of competitiveness and financial performance from a capability and processes perspective. They argue that firm performance is influenced by a nomological network of three significant organizational capabilities and three strategic processes. The three organizational capabilities are: agility, digital options and entrepreneurial alertness. Agility is the ability to detect opportunities for innovation and seize those competitive market opportunities by assembling requisite assets, knowledge and relationships with speed and surprise. Digital options are described as a set of IT-enabled capabilities in the form of digitized enterprise work processes and knowledge systems. Entrepreneurial alertness, is the capability of a firm to explore its marketplace, detect areas of marketplace ignorance and determine opportunities for action. Two specific capabilities describe entrepreneurial alertness: strategic foresight and systemic insight

The three strategic processes are: capability building, entrepreneurial action and co-evolutionary adaptation. The capability building process integrate ICT and business resources into organizational capabilities. The capabilities are built by a firm's strategic decisions to invest in ICT and the blending of ICT with organizational processes and knowledge (Barua and Mukhopadhyay, 2000). The entrepreneurial action process is consistent with the logic of opportunism and underlies the creative combinations of agility and entrepreneurial alertness for the launch of competitive actions. The co-evolutionary adaptation process refers to the fact that firms learn over time and through experience as they develop digital options and agility and launch a variety of competitive actions.

The third perspective is built on recent research that has recognized that value is increasingly co-created among multiple partners in multi-organizational relationships (see e.g. Kohli and Grover, 2008; Sarker *et al.*, 2012). As markets and digital infrastructures are changing, it became more difficult for the single firm to create business value in isolation and value is increasingly co-created in networks of organizations. Accordingly, ICT co-creation of value has been articulated as a critical theme for future IS research (Kohli and Grover, 2008). By drawing on a relational view, proposing that a firm's resources might span firm boundaries, and even may lie in its relationships with other firms (Dyer and Singh, 1998), Grover and Kohli (2012) outline four layers in the co-creation of ICT value namely; the asset layer, complimentary capability layer, knowledge sharing, and governance layer.

Value creation in the *asset layer* can only be achieved when partners' resources, for example manufacturing technologies or other physical assets, are combined, and network facilities create new value in form digital or physical products and services. In the *complimentary capabilities* layer, the focus is identification and exploitation of resources/capabilities among the partners in order to identify sources of value that that a

partner not can build on its own. This could be an IT-based resource or a skill provided by a network partner that leverages other partners' resources. In the *knowledge sharing* layer the focus is on the sharing of information and expertise that can inform decision making for co-creating new and better products (Dyer and Hatch, 2006).

In this layer IT-infrastructure and processes for sharing knowledge are means these can enhance absorptive capacity, or abilities to recognize, assimilate and exploit external partners' information (Cohen and Levinthal, 1990). However, it is important to note that right incentives must be in place if firms should share their knowledge for a collective good (Grover and Kohli, 2012). Finally, *the governance* layer can be viewed as the layer integrating assets, complimentary capabilities and knowledge exchange layers, by setting up a control structure that reduce transaction costs and incentivizes new value co-creation. This is typically done through contracts, but social and informal controls (trust) can play a major role and be less costly in facilitating co-creation of value (ibid.). Moreover, it is assumed that the governance layer has an even greater significance when several firms are engaged in a loosely coupled network with the intention to co-create products and services when conditions are conducive (Dhanaraj and Parkhe, 2006).

The proposed framework expands value creation from the focal firm to value creation in network of firms. They highlight one condition for value co-creation which is that firms need to be willing to form cooperative bonds and to co-create value by using ICT in a thoughtful way (Grover and Kohli, 2012).

### **ICT value creation in the building and construction industry**

Taking the point of departure in the focal firm perspective (Melville *et al.*, 2004) and the perspective of processes and capabilities in the focal firm (Sambamurthy *et al.*, 2003), constraints and facilitators for ICT-value creation can be identified in the building and construction industry. With regard to technological ICT resources, larger building and construction companies has for almost a decade used ICT in order to coordinate and manage information flows at the same level as companies in other industries (see e.g. Molnar *et al.*, 2007). With regard to human ICT resources is the situation more mixed? Larger building and construction companies have their own IT-functions with IT-staff, but the IT-function has traditionally been a branch of the accounting and finance department, that may be one explanation for that ICT mostly has been used for calculation and control purposes (see Jacobsson and Linderoth, 2010).

Thus, it is foremost the financial dimension that has been in focus for ICT-value creation. However, a major constraint for creating ICT-value is probably the complimentary organizational resources. Successful application of ICT is often supported by significant organizational changes, including workplace practice, organizational structure, rules and policies, and organizational culture (Brynjolfson and Hitt, 2000; Melville *et al.*, 2004). The need for significant organizational changes has been prevented by industry characteristics, for example identity (see e.g. Löwstedt and Räisänen, 2014) and trading partners, foremost the clients (see e.g. Linderoth *et al.*, 2011). However, in a long term perspective resources in the macro environment, e.g. education and culture, may facilitate the creation of ICT-value in the industry. The major argument is that new generations habits to use ICT in their daily life, but also the fact that different forms of ICT, like BIM, is becoming a more significant component in the education of the industry's future workforce.

When analysing conditions for creating ICT-value from the perspective of processes and capabilities in the focal firm, both obstacles and facilitators can be identified. In one

sense it can be argued that agility is a characteristic of the industry that originates from a need for local adjustments at site. This adjustment is a consequence of three uncertainty factors: lack of complete specifications, lack of uniformity and an unpredictable environment (Dubois and Gadde, 2002). It can be argued that these uncertainties have facilitated a capability of solving problems, or to innovate. Due to a combination of time pressure and lack of complete specifications a capability of finding immediate solutions to a problem has developed among actors in the industry. This can be one reason for the fact that managers on all levels describe themselves as doers (see Löwstedt and Räisänen, 2014). However, this kind of agility, or innovative behaviour, being more a doer more than a thinker (*ibid.*) does effectively prevent other essential capabilities to be built and strategic processes to be developed. In the process of capability building, ICT- and business resources are integrated into organizational capabilities (Sambamurthy *et al.*, 2003). Thus, in a context where people identify themselves more as doers than thinkers, and the focus is on solving problems here and now, it would be difficult to imagine the need for significant organizational changes in order to achieve a successful application of ICT. Instead, digital options, described as a set of IT-enabled capabilities in the form of digitized enterprise work processes and knowledge systems (*ibid.*), will be exploited in manner that immediately makes sense for managers. This is, off site managers exploit digital options when there is a potential for increasing control over projects, and site managers exploit digital options when there is potential of facilitating the keeping budget and deadlines (see also Jacobsson and Linderoth, 2010). Thus, in the entrepreneurial action process, that underlies the creative combinations of agility and entrepreneurial alertness for the launch of competitive actions, actions are, explicitly or implicitly, directed at the financial side of ICT-value creation. This observation is consistent with Love *et al.*'s (1998:381) observation:

1. ...each discipline has become dedicated to the optimization of its own function, with little regard to, or understanding of, the construction process

Finally, it can be argued that the co-evolutionary adaptation process is constrained by the focus on single projects and the strong reliance on competitive tendering. In the co-evolutionary adaptation process the IT-competence and capability building process are reinforced when firms learn over time as they develop digital options and agility, and launch a variety of competitive actions. It can be argued that this process is continuously interrupted by a strong reliance on competitive tendering, which is supposed to promote efficiency (Cox and Thompson, 1977). A project consists of a constellation of actors who happened to have the lowest bid and in the next project there is another constellation of actors working together. Therefore, are there little incentives for creating ICT-value in the project network, because actors do not know who they will work with in the next project?

Thus, this condition will have implications when analysing conditions for creating ICT-value from the multi firm perspective, or perspective of co-creating value. In this perspective four layers in the co-creation of ICT value were out-lined: The asset-, complimentary capability-, knowledge sharing-, and governance layer (Grover and Kohli, 2012). The asset layer and complimentary capability layer can be seen as cornerstones for creating customer value in the building and construction industry. In order to create value for customers' partners, resources, for example manufacturing technologies or other physical assets, need to be combined, as well as partners' complimentary capabilities. Thus, with regard to how operations are organized in the industry, the only way to create customer value, is by co-creation. By drawing on the resource based- and capability perspective it can be claimed that partners have capabilities of co-creating value. However, due to the interruptive nature of the production process, these capabilities are

built on quite standardized role systems associated with strong cultures and value orientation that should facilitate the interaction with other professional groups (see e.g. Björklöf, 1986; Kadefors, 1995).

It can be claimed that the institutionalized role system constrains the development of new capabilities, but also the will to share knowledge. Söderholm (2006) claims that a varying sets of principles, rules, knowledge domains, etc. in professional groups has implied difficulties in co-operating. What finally might hamper the co-creation of ICT-value in the industry is the governance layer. This layer would integrate assets, complimentary capabilities and knowledge exchange layers, by setting up a control structure that reduce transaction costs and incentivizes new value co-creation. However, the industry's governance layer has not promoted an integrative behaviour facilitating co-creation of ICT-value. Instead has the competitive tendering shaped market based, short term interactions between independents businesses (Gann, 1996).

## CONCLUDING DISCUSSION

It can be concluded that basic resources and capabilities are present for the co-creation of ICT value in the building and construction industry. As stated is the co-creation of customer value a corner stone in the industry, because actors cannot create customer value on their own. Instead they have to create value by contributing with their unique assets and complimentary capabilities. At the first glance these conditions seem to be a promising ground for the co-creation of ICT-value. However, a basic condition for value co-creation is that firms need to be willing to form cooperative bonds and to co-create value by using ICT in a thoughtful way (Grover and Kohli, 2012). This condition is, however, more or less absent in the industry due to lacking incentives to co-create ICT-value.

As has been described, firms are more focused on optimising their own processes and when ICT is used for value creation, it is foremost in situations where the value is immediate and possible to link to financial outcomes. The reason behind this behaviour can at the first glance be found in the competitive environment and the industry characteristics if an explanation is sought from the resource based perspective (see Melville *et al.*, 2004). This is, the industry is characterized by being market based and have short-term interactions between independents firms (Gann, 1996). But the deeper underlying explanation can be found in the multi firm perspective's governance layer. A lowest price tender policy in combination with organizing operations by projects have reinforced the market based, short term interactions (Linderoth *et al.*, 2011). This condition has in turn constrained the creation of long term relations where informal controls (trust) can play a major role and be less costly in facilitating co-creation of value (Grover and Kohli, 2012).

Moreover, ICT value creation occurs in networks where the internal and external conditions and capabilities of each organisation need not only to be developed but also developing each other. In this context, boundary spanning becomes an important activity to support organisational learning and capability development internally and in relation to each other. More effort need to take place to enhance this boundary spanning activities and the role of public and private institutions that could support them. Enhancing the understanding of the co-creation of ICT value in the building and construction industry requires more research and empirical investigations. Further research is needed to uncover facilitators for building more long term relations among firms that in turn creates conditions for processes of building capabilities for creation of ICT-value.

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# CHALLENGING DESIGN PERCEPTIONS IN IMMERSIVE VIRTUAL REALITY ENVIRONMENTS?

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The potential and use of immersive virtual reality (IVR) technologies in performing design and construction activities has been widely addressed in the literature. However, research is only just beginning to emerge which examines the role of these technologies in use in 'real-life' practice situations, and seldom if ever addresses the way surprise and novelty impact both experience of these technologies, and of the designs they are representing. Adopting a practice based perspective to understanding the effect of immersive technologies on construction design work as used in concrete 'real-life' settings and as perceived by the practitioners involved, this study draws a specific focus on the concept of 'surprise' around using these technologies. The empirical case examined is a 'real-life' construction design project for a new hospital in the UK wherein a CAVE environment was used performing design review sessions during the bid preparation stage. The methodology draws on accessing participants' view on their surprise emerging in the CAVE through reflective conversations oriented to engage the participants in retrospective reflection on their CAVE design experience. The analysis reveals that the element of surprise encountered by the participants both within making sense of the newly experienced technology, and within orienting to the design in the immersive environment played an important role in performing design review in the CAVE. The findings indicate that using CAVE as design media is not only enhancing or adding to an existing understanding of design through paper based or non-immersive digital representations, but it is also, and perhaps most significantly, challenging the participants' understanding of the design as they experience the immersive, full scale version of it.

Keywords: CAVE, immersive virtual reality (IVR), design practice, surprise

## INTRODUCTION

The potential and use of immersive virtual reality (IVR) technologies in performing design and construction activities has been widely addressed from a number of approaches (Kahkonen 2003, Whyte 2002). The themes addressed in this literature range from immersiveness, experience, complexity, spatial perception and cognition, problem solving, decision-making, collaboration, user engagement, to value and cost or time. Overall, these studies suggest the potential of IVR technology as visualisation and collaboration environments to support the creation, communication, development and understanding of design through supporting and extending other design procedures (Whyte, 2002). However, most of the literature focusses on developing/ testing technology in experimental studies, or examines the practical use of immersive technology preponderantly from quantitative perspectives based on standard metrics. Research is only just beginning to emerge which examines the role of these technologies

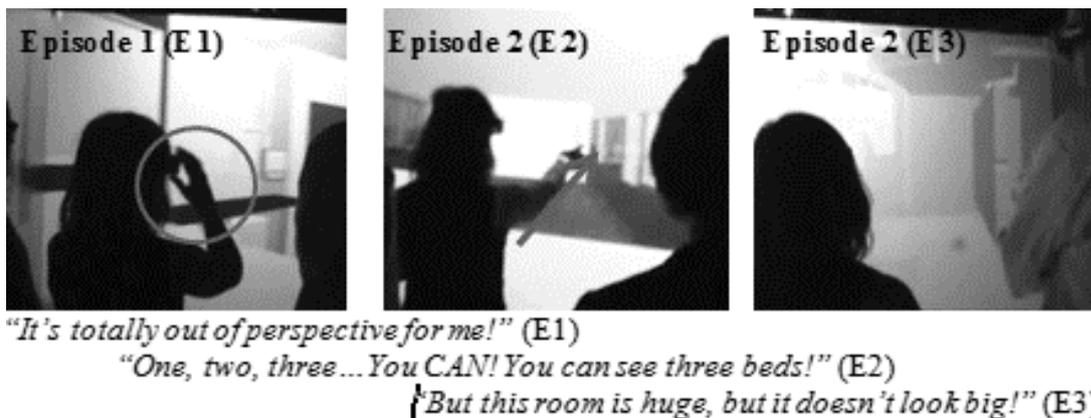
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in use in ‘real-life’ practice situations, and seldom if ever addresses the way surprise and novelty impact both experience of these technologies, and of the designs they are representing.

Therefore this study questions: How might IVR be impacting on broader design practice? The paper addresses this question by taking a practice based approach to examine the use of IVR in a real-life construction design project through focussing on how the actors and materials bound up in the situated design process and by accounting for the participants’ perspective on their design activities performed using the IVR. The empirical material is drawn on the early design of a new hospital project wherein design and contractor teams used a particular type of IVR, a CAVE (Cave Automatic Virtual Environment) set up in the University of Reading to demonstrate particular design requirements to the client and to perform design review meetings. The study builds on previous research which examined the use and implications of the IVR for design activities (Maftai and Harty 2012, 2015) by drawing on direct observation and video recording of design meetings held within the CAVE. Detailed examination of naturally occurring interactions emerging in the CAVE sessions revealed the issue of surprise as distinct feature playing an important role in the design process. Building on insights of the former video study, this paper takes surprise as an unexpected phenomena emerging in the CAVE design processes and unpacks the phenomena by reflecting on the participants’ retrospective insights on these surprises.

*A glimpse of design practice in the CAVE: introducing the idea of surprise*



*Figure 1. Instances of design practice in the CAVE (16th November 2012)*

Episodes E1-E3 (Figure 1) illustrate empirical examples of design interactions occurring in the CAVE.

In Episode 1, examining the hospital patient room in the virtual model, a designer expresses her difficulty in evaluating the space because of the distorted perspective: “I can’t tell anything, it’s totally out of perspective for me!” (E1).

Episode 2 illustrates the participants’ surprise and excitement around noticing that their model unexpectedly confirms compliance with the clients’ visibility requirement on the visibility towards the patients’ beds: “You CAN! You can see three beds!”(E2).

In Episode 3, the participants are reviewing the operating theatre and question their expectation around the size of the space -“This is huge!”; “But this room, is huge, but it doesn’t look big!” (E3).

The fragments illustrate surprise around the newly encountered technological setting (E1), discovering unexpected issues about the model (E2), or noticing disconfirmation of

previous design assumptions (E3) and building up new understanding to further develop their design. Taking surprise as interesting phenomenon characterising design practice performed using IVR, this study further examines literature around the aspect of surprise, and analyses the CAVE participants' view on their surprises.

## **LITERATURE REVIEW**

The aspect of surprise is scarcely considered in the literature on IVR for design. Some experimental studies (e.g. Rahimian *et al.*, 2014) indicate the potential of IVR to enable simulating unexpected events and to support learning by doing and stepping outside routine, enhanced decision making, creativity and understanding of construction design problems. However, this work obscures the processes whereby practitioners perceive and address the surprise and challenge of designing in immersive settings. There is, however, a well-established interest around the issue of surprise in areas including design cognition and creativity, organisational management and learning and use of technology/ information systems in organisational settings, as well as broader studies of social practices or psychology studies of social cognition, cognitive emotion and behaviour. Drawing on a broad identification of two main perspectives in this literature 1) scientific rationality/cognitive and 2) qualitative/ experiential, this paper next reviews how the issue of surprise is treated across these areas.

### **Cognitive treatments of surprise**

Building on a cognitivist (information retrieving and processing) and cognitive psychology orientation, the first strand of studies treats surprise as connected to a degree of expectancy disconfirmation and as affective reaction to unexpectedness linked to 'causal thinking' and indicates surprise as central to sensory processing, adaptation and learning, attention and decision making (Reisenzein 2000:268). These studies aim for an abstract theorising of surprise by developing and/ or testing rational models of surprise in experimental studies in controlled laboratory situations.

Within design, surprise is mostly addressed from a cognitive perspective and it is mainly discussed in relation to its impact on aspects of design creativity and on the perception and framing of design problems. For example, some studies on design creativity (Grace and Maher 2015) consider surprise as a metacognitive (thinking about thinking) process and focus on the impact of surprise on design problems, goals, requirements formulation and relatedly on design creativity. Pointing the iterative nature of the process of problem and solution formulation and indicating the reasoning about the cause of surprise as relevant for changing design goals, this experimental work identifies taxonomies of surprise and responses to develop cognitive and computational models of surprise (programming computers to measure surprise).

Other studies on improving design methods, tools and approaches to foster creativity (Becattini *et al.*, 2015) focus on the cognitive processes emerging in relation to the perception of surprise around a new design product by treating surprise as constituted through human interpretation rather than as effect of measuring novelty. Other studies (Chen and Lai 2014) address the impact of unexpectedness on the communication effect of design by taking an information retrieving perspective focussed on the emotion aspects. The role of non-routine contexts is also highlighted in relation to the impact of the design experience on creativity (Rahman and Jonas 2010). These cognitive studies draw on experimental work to develop/ test rational models of surprise based on measuring novelty and unexpectedness by using standard metrics.

In a different vein, Dorst and Cross (2001) develop a cognitive model of design creativity by connecting with reflective practice treatments of surprise as interruption of routine and as essential for triggering reflection in action. Stressing the role of surprise in stimulating the framing and reframing, in terms of shaping and changing the view of the problem, these studies find that creativity in design processes is linked with the designers' identification of surprise in the 'problem space' which triggers their reflection, enabling the seeing of things in new ways and stimulating the process. This understanding accounts for designers' views of the terms and relationships underlying the design activities, views based on their previous experiences and knowledge, as well as their perspectives of addressing them within a situation. Overall, the literature engaging with the issue of surprise from cognitive perspectives develop rational models and abstract theorising based on experimental studies rather than looking into the actual processes whereby individuals experience and respond to surprise and unexpectedness in practice.

### **Qualitative driven studies of surprise**

Contrasting this generally abstracted understanding of surprise, the second strand of literature -drawn on qualitative approaches- treats surprise as situated, by turning attention to the practice as performed in everyday life, inherently realised in situated social and material interaction and stressing the connection between knowing and doing instead of focussing on the cognitive aspects. These studies build on various theoretical standpoints including practice based approaches, reflective practice, or sensemaking perspectives. These studies, across organisational management and learning, the use of technology/ information systems as change in organisations, and design practice, intersect in recognising the role of surprise as a social, generative phenomenon through triggering practitioners' attention to and reconsideration of the underlying mechanisms of practice.

From a reflective practice perspective (Schön 1983), surprise is central in performing (design) practice by triggering reflection and action to address and engage with unique, conflicting, uncertain, puzzling situations of practice by mobilising appreciations drawn on existing repertoires through both individual and collective conversation with the materials. Surprise is discussed as triggering 'new ways of seeing things' and leading to 'questioning assumptions that had been built into practice' (Schön 1992:131,136). The practitioner's 'ability' of responding to the 'surprise', contradictory, unfamiliar states perceived in the 'back-talk' of a design situation is mediated through 'seeing' the situation in new ways, in association with familiar elements of previous experiences, which guides the process of shaping the situation by employing action and driving further accomplishment of practice.

Similarly, from a phenomenology oriented practice based approach to change in organisations, the issue of surprise as breakdown is treated as means to encounter the 'world' suspending, even if briefly, usual attitudes and expectations (Ciborra 2001: 28). Applying this perspective to study the use of technology in organisations, Ciborra indicates the processes of bricolage ('make do') and improvisation employed by practitioners to "find fixes to the plans and deal with surprises" (Ciborra 2004:20) and points out the phenomenon of drifting i.e. "deviating from planned purpose for a variety of reasons often outside anyone's influence" (Ciborra 2001:4). This kind of phenomenological approach indicates situations of discontinuity and disruptions related to the use of novel technologies and points out practitioners' reconsideration of existing assumptions built into practices (Lanzara 2009). Surprise is treated as a complex of "features that defy our understanding, descriptions and planning abilities", addressed through a range of constructive activities globally conceptualised as 'bricolage' i.e.

encompassing “practical experiments, local readjustments and repairs, extemporaneous improvisations” employed to respond to surprises, novelties, and other puzzling phenomena interrupting/ rupturing repertoires of practice routines (Lanzara 1999:334, 135).

From a sensemaking perspective, surprise (particularly understood as interruption of routine and/or as ambiguous event) is seen as “consequential occasion for sensemaking” (Weick 1995:105) and it is often discussed in relation to improvisation and making new sense to restore interrupted activity (e.g. Weick 1995; Sandberg and Tsoukas 2015). Intersecting with other areas of literature, this perspective acknowledges that interruption and recovery (Weick 2009) drive accentuation of consciousness and meaning of experiences. This approach to surprise is also indicating the role of the repertoires of previous experiences and understandings on which new sense is built in non-routine situations.

These studies also intersect in discussing surprise as triggering practitioners’ shifting from subsidiary to focal awareness around the practice elements, leading to (re)opening (reflective) inquiry (e.g. Yanow 2015). From a sensemaking perspective, ‘jolts’, surprises and other types of disruptions trigger interpretations and “expose tacit, taken for granted assumptions” (Weick 1992:101). In various ways, these studies indicate the idea that through surprise and novel circumstances characterised by interruption of routines, ‘elements’ of practice taken for granted may begin to be questioned, sometimes through a change of focus of awareness and attention. Surprise is discussed as relating to new types of awareness- more focal forms of attention employed to address disruptions: “When routine practices are interrupted by surprises, these disturbances produce a caring, a mattering –an affective state- that focuses awareness and attention” (Yanow and Tsoukas 2009: 1351). Unexpectedness may trigger changed ways of engaging with the elements involved in a practice situation, which may shift from being ‘transparently available’ (Yanow and Tsoukas 2009) to being brought under focus of deliberate attention. Surprise may trigger changes in the degree of awareness around these constituents, focus on their properties, and beginning of reflection on the underlying ‘mechanisms’ of practice.

In various ways, this literature highlights the relevance of surprise in performing social practices. This study draws on the second strand of literature on surprise by taking a practice based approach to examine the surprise phenomenon around the use of IVR in design work through focusing on the participants’ perspective.

## **METHODS**

The case study is based on a real-life 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 an IVR environment - a CAVE facility set up in the University of Reading. This was to be used to demonstrate to the client that the rooms were of an appropriate size.

Building on insights of former research based on observation and video recording of multiple design meetings performed using the CAVE (Maftei and Harty 2012; 2015), the methodology here draws on follow up discussions with the participants involved to access their views on the surprise emerging in their CAVE design experience and the implications on the design process. The research conducted retrospective conversations

with the participants by playing back video clips of the CAVE design events and engaging them to reflect on the use of the technology and on their design review experience. The discussions were conducted nine months after the last CAVE design session and they consisted of four individual interview sessions (30-60 minutes) with participants having various roles in the design team: visualizer (REVIT modeller), project director, 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 draws on the participants' retrospective reflection on the CAVE design review experience to unpack their views on the surprise and challenge encountered in the immersive simulation of their models.

## FINDINGS

### Surprise around the technology

The participants' retrospective insights on the CAVE design experience indicated the surprise encountered in the technicalities of using the immersive environment and provoking ruptures in the routine performance of a design review.

Relating back to the example illustrated in Episode 1 earlier in the paper, the Medical Planner's retrospective reflection on using the CAVE indicates the disruption caused by the technicalities of the environment: "it was exciting but it was a bit daunting" and points the source of breakdown in the distorted viewing perspective, relating to the lack of using the head trackers: "you have an expectation [...] but [...] the perspective of what I was looking at was completely wrong". As firstly encountered, the CAVE was perceived as unusual and surprising in reference to participants' repertoires of design experiences and procedures: "it was a bit daunting because, it's something new and you have an expectation". The participant's comments indicate the surprise around the conflicting relation between the expectations drawn on previous work and repertoires of usual representations (like REVIT/ CAD models visualised on computer screens) - "this space that I've designed, this was my layout"- and the CAVE version of the model as perceived from the participant's viewing perspective: "what I was looking at was completely wrong".

Together with noting the disruption caused by the technicalities of the CAVE as newly experienced design setting (distorted viewing perspective), the participants reflected on the use of the CAVE on a more frequent basis, suggesting familiarisation with the specific procedures of navigating and using the model:

Let's just assume we've been in the CAVE for 15 times, that newness is of [...] Wow, that would be really powerful, [...] 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 comment suggests that through repeated experiences in the CAVE designers would familiarise with the technical particularities of the setting and points that a more routine way of performing design in the immersive environment would lead to diminishing the novelty. These insights indicate the eventual extinction of surprise around the technology, whilst also pointing the potential of the CAVE as design medium to better enable designers' noticing design surprises, disconfirmed expectations and supporting discovery of new issues about the design.

## **Surprise around the design**

### *Visibility requirement*

The participants' comments indicated their perception of surprise around their design while they experienced it in the immersive, full scale simulation in the CAVE. For example, relating back to the instance illustrated in Episode 2 earlier in the paper, the CAVE model revealed surprise around the design conformity with the clients' requirement on the visibility towards the patients' beds from the nurses' station area.

[...] one of the big issues was observation of the bedrooms from the staff base and that [the CAVE] was really good validation of our design because we could see more beds than we thought we could so that was very exciting. (Medical Planner)

By triggering the participants' discovery that they "could see more [beds] than [they] thought [they] could, and that was very exciting", this is a case of surprise not as interruption, defied understanding or disconfirmation but instead as excitement through discovering an unexpected realisation of previous design intention. The participants' view on the CAVE design experience shows that surprise occurred not only as unconfirmed expectation, but also as unexpected confirmation. This circumstance of surprise through satisfactory excitement contrasts the literature tending to discuss surprise as connected to negative feelings (Giddens 1999 in Sandberg and Tsoukas 2015:17).

Beyond driving excitement on the unexpected conformity of their design with the visibility requirement, this surprise emerged through designers' physically immersive exploration of their design within the CAVE connected with their increased awareness of the actual use of their design, triggering reflection on the clients' requirement and leading to reframing:

I remember saying [to clinicians] you've given us this criteria [...] to see 60% of the rooms from one single point, and I said [...] is that really necessary, [...] do people really stand like that? And I just walked one step one way, one step the other way and I said, if I did that I can see a lot more. So is it such a concern? (Project Lead)

The Project Lead's reflection on the surprise around the visibility requirement connects with the literature point on surprise as relating to an affective state, a 'mattering', a 'caring' (e.g. Yanow and Tsoukas 2009) which focusses awareness on the practice elements. In this case, the surprise connected with designers' reflection on the client's requirement and on the actual usability of the designed space. Summing up, the participants' view on the surprise experienced in the CAVE around the visibility requirement shows that in this case surprise triggered: 1) excitement through discovery of their design's unexpected conformity with the requirement; and 2) inquiry into the requirement itself, and relatedly a 'caring', a 'mattering' about the use of their design and increased awareness of the actual usability of the space, and reconsidering the requirement together with the client.

### *Spatial size and relation with the equipment*

Another circumstance of surprise and challenge indicated by the participants' comments on their CAVE design experience is the conflict between their expectation and assumption on the spatiality and functionality of the operating theatre as designed through mundane procedures and the outcome perceived in the CAVE model. This example relates back to the instance illustrated in Episode 3 earlier in the paper.

The participants' view on their surprise encountered in the CAVE around the spatial size and relation with the equipment in the operating theatre indicates the breakdown as sourced in the lack of realisation of design intention - although designed of sufficient size, the room looked overcrowded with the equipment. Discussing with the participants

revealed the connection between their various roles in the project and focus of concern in the CAVE simulation and their attention on particular aspects around this surprise and distinct strategies of addressing them. For the Visualiser, the surprise emerged around the representational impact of the equipment in the operating theatre, triggering reflection on the representation and driving changes to the model: “looking at it [the operating theatre] from that [the CAVE] perspective [...], seeing the equipment and how crowded rooms were [...] was a way of us saying [...] it’s better if we strip some of it out so they [the client] can understand the space better.”

For the Medical Planner, the surprise perceived in the unsatisfactory relation between the spatial size and equipment in the operating theatre triggered her attention on the actual use of the space, leading to questioning and reframing the client’s requirement: “[...] we were concerned that there was so much [equipment] in that space that it wasn’t necessarily workable despite [...] that they had asked for everything in there.”

This case resonates with what the literature discusses about surprise as trigger for questioning assumptions built into practices, by turning focal attention on the client’s requirement which shifts from being ‘transparently available’ (Yanow and Tsoukas 2009), or taken for granted by the designers to becoming ‘apparent’ and subjected to scrutiny, through a ‘caring’ about the use of the space: “[...] it’s too much stuff for you to move around. How do you even work in this space?” (Medical Planner).

The participants’ comments show that the CAVE design experience challenged existing understandings and procedures by not confirming expectations of former design intentions and assumptions based on previous experience (the size of the operating theatre) or by revealing new issues about the design (unexpected discovery of their design conformity with the visibility requirement). These surprises emerging in the CAVE provoked interruption of the routine performance of the process and triggered designers’ reflection on the medium, on their understanding and on the ways of addressing these unsatisfactory issues perceived in the design. The designing process built up on such disruptive aspects, through participants’ making sense of and addressing these surprises to accomplish their practice. The participants’ discovery of unexpected issues about their design triggered changes on the design and affected the process: “to see the spaces in the CAVE [...] was very useful and we certainly used that experience in our thinking later on in the process.” (Visualiser).

These findings indicate that the design surprises in the CAVE triggered new ways of making sense of the space and seeing things in new ways, which impacted on the process through informing further design decisions and the design development.

## **DISCUSSION AND CONCLUSIONS**

The analysis revealed that the element of surprise encountered by the participants both around the CAVE as newly experienced technology and around the immersive version of their design played an important role in the design process. The study indicates that using the CAVE as design media is not only enhancing understanding of design as suggested by the prevailing VR literature, but it is also, and perhaps most significantly, challenging the participants’ understanding of the design as they experience the immersive, full scale version of it. The findings also showed that 1) the surprise around the CAVE as newly encountered technology is susceptible to fade out through practitioners’ familiarising with the setting through repeated experiences in the CAVE and; 2) when the technology is no longer novel, surprise and the unexpected may still be central in the process, triggering

new ways of seeing and making sense of the designs with impact on further design development.

Reflecting back on the main strands of literature on surprise these findings indicate the relevance of adopting a practice based, situated approach to examine the surprise phenomena focussing on the particular participants' experience i.e. their making sense of and addressing surprise in practice situations. Connecting with the qualitative/ experiential driven studies of surprise, the study points towards surprise triggering reflection, discovery, and driving changes to the design. Design surprises encountered in the immersive setting impacted on participants' reconsideration of assumptions based on previous expectations and procedures (e.g. despite of having been designed of sufficient size, the operating theatre appeared too cluttered in relation to the equipment in the space) and making new sense of the design situation by refocussing awareness and questioning assumptions (e.g. reframing the client's requirement around the visibility from a single spot; the need of all the equipment at a time). Of particular relevance to design practice, these findings highlight the role of surprise as design discovery in the CAVE, through leading to design changes/ refinement and guiding the further process. By rupturing repertoires of previous understandings and procedures and challenging expectations based on former assumptions, these design surprises encountered in the IVR setting triggered reflection, renewed awareness and reconsideration of taken for granted assumptions previously built into practices, leading to adjustments and repairs and informing the further process.

These findings contribute to the (design) literature on surprise and extend current understanding around the surprise and challenge in immersive VR design settings by revealing insights on the actual impact of the situated use of IVR technology on design practice. The study also enhances current understanding around and supports integrating the practical consequences of using CAVEs in design activities by indicating that immersive technologies might be useful for design practice and practitioners through extending and challenging designers' own understandings of their previous work.

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# TRANSLATING BUILDING INFORMATION MODELLING: A STUDY OF THE BIM IMPLEMENTATION PROCESS AT A LARGE SWEDISH CLIENT ORGANISATION

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Building Information Modelling (BIM) is currently widely discussed within both the construction industry and the academia. There is a view that it is a new paradigm presenting possibilities to address the slow increase in productivity currently perceived in the construction industry. Around the world many governments and public client organisations are developing their implementation processes for BIM. In this paper the largest infrastructure client in Sweden is studied. Based on a Case study, the BIM implementation process at this actor is described. These results serve as an empirical example of how BIM is being implemented in order to improve both productivity and innovation in the construction industry. These results have been analysed inspired by theory of 'sociology of translation'. This study concludes that the main tool used to enrol actors into BIM use is demanding model based delivery of project information. However, less emphasis is put on how these models will influence work practices for both the client's project organisation and contractors and consultants in the projects.

Keywords: Building Information Modelling, BIM, sociology of translation, implementation

## INTRODUCTION

The construction industry has for many years been considered as having problems with low increases in productivity, lagging behind other industries (Egan, 1998 and Gallaher *et al.*, 2004). The general perception is that this industry is slow in adopting new and better ways of working and incorporating innovations from other sectors (Harty, 2008). Over the years many different innovations have been presented to address the problems found in the construction industry. Currently BIM, Building Information Modelling, is by many presented as “a new paradigm” and it is argued that, with proper implementation, it can enable substantial benefits to the construction sector (Azhar, 2011). However, the BIM implementation has been perceived as slow within the industry (Gu and London, 2010; Smith 2014). Even though many case studies have shown extraordinary results from BIM implementation there are still voices expressing that BIM have not yet shown its promised benefits (Gustavsson *et al.*, 2012; Jung and Joo, 2011; Fox, 2014). To increase implementation rates the role of client organisation have been emphasised in many studies. Client organisations in general and public clients in particular have been described as being a vital player in successful BIM implementation (Wong *et al.*, 2010,

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Wong *et al.*, 2011). There is also a view that the industry has to be convinced of the importance of BIM in order to achieve the sought after benefits. Following this movement many government initiatives for BIM implementation can be found around the world. In the UK, for example, it has been stated that all public contracts awarded from 2014 demands that all project participants will work collaborative through the use of BIM (Cabinet Office, 2011). Similar to this initiative the Swedish Transport Administration, the largest infrastructure client in Sweden, is implementing BIM in its projects.

There is currently much research presenting case studies of BIM implementation on a project level. However, not as much is known of how the large public client organisations, which is presented as the needed driving force for BIM, is implementing BIM in their organisations. In this paper the BIM adoption process at a large public client organisation is studied. These results are analysed taking inspiration from “sociology of translation” described by Callon (1984) in order to explain the change process linked to BIM. The BIM implementation at the Swedish Transport Administration presents an empirical example of the process of BIM implementation at large public client organisations. This study provides insight in how the organisations suggested to drive BIM adoption organises their BIM implementation.

## **LITERATURE REVIEW**

### **Implementation of BIM**

Earlier studies on BIM implementation have mainly focused on how to enable and improve BIM-use in the construction industry. By mapping and presenting solutions so barriers for BIM implementation, such studies aim to support the implementation. The BIM adoption currently perceived as slow within the construction industry (Gu, 2010, Smith 2014) and there is a view that practitioners needs to be convinced in order to increase BIM adoption rates (Khosrowshahi and Arayici, 2012). The role of Client organisations in general and public client organisations in particular is widely discussed in research related to BIM adoption (Wong *et al.*, 2010; Wong *et al.*, 2011; Smith, 2014). It is argued that these client organisations are both the actors who are the greatest benefactor of BIM implementation and also the actors empowered to demand BIM-use from contractors and consultants (Linderoth, 2010). It is often stated that these organisation should use their power and demand BIM in their projects in order to influence the industry and increase BIM adoption (Eadie *et al.*, 2013; Wong *et al.*, 2011; Khosrowshahi and Arayici, 2012). In many countries these types of implementation initiatives are taking place. Public actors are involved in supporting BIM implementation in for example: USA, many Scandinavian countries, Singapore and Hong Kong (Wong *et al.*, 2010). During the last years an increase in BIM adoption rates has also been observed and it has been argued that government directives are effective as a driver for BIM (Smith, 2014).

Many studies present suggestions for how these client actors should design their implementation process. Wong *et al.*, (2011) presents six steps for BIM implementation which they argue must be taken by the government to promote BIM. Mainly the government should establish a policy of BIM use in all new projects (Wong *et al.*, 2011). But it is also important to regulate the information, specifying open formats and promoting collaborative use of project related information, enabling the collaborative benefits with BIM (Wong *et al.*, 2011). Interoperability between software and formats is identified as a major issue and governments have been shown to be able to drive the development towards more open standards thereby increase interoperability (Porwal and Hewage, 2013). Khosrowshahi and Arayici (2012) argue the importance of education and

awareness about BIM as a critical way of addressing resistance to change. It is also argued that there is a need for a certain degree of involvement of researchers before higher levels of BIM maturity can be reached (Khosrowshahi and Arayici, 2012).

### **Innovation in construction**

Even though not often referred to in BIM related research the subject of innovation in construction is a well discussed topic. In a study of implementation of virtual reality (VR) Whyte (2002) makes comparisons to the previous innovations such as CAD and how it often took longer than expected to introduce such systems. This implementation was often lead by technical staff at mid management level and generally at newly created departments (Currie, 1989). In order to achieve successful adoption of IT Whyte (2002) argues for the need for both strategic decision-making by top management and input from technical managers to coordinate both on project and business level. Harty (2008) describes the concept of relative boundedness for innovations which effects extend beyond the control of a single implementer. In construction many actors different are involved which are influenced by the innovation. Innovation that is aimed towards changing the ways actors in construction operate must therefore be implemented across this inter-organisational landscape (Harty, 2008). Therefore, when studying implementation of innovation in construction it is relevant to trace networks of association, the actors included (and excluded) in shaping the implementation process and study how they influence this process (Harty, 2008).

### **Sociology of translation**

Actor-Network theory (ANT) is not unheard as tools of describing the implementation of information systems or other situations concerning technical innovation. By analysing both human and non-human elements (actors) ANT can address the social-technical divide in the implementation process (Tatnall and Gilding, 2005). This approach to studying the adoption of BIM makes it possible to map the actors needs and motives for being enrolled in the networks where BIM is being implemented (Linderoth, 2010). Within the field of BIM related research, it is commonly argued that BIM adoption will require substantial changes to both business and work practices, together with many other changes in the culture of how projects are conducted (Mihindu and Arayici, 2008; Succar, 2009; Tylor, 2007). How the technology influences, changes and defines roles among the actors in the network is made possible by an actor network perspective (Linderoth, 2010). Callon (1984) identifies four moments of translation in the process of a driving actor to impose themselves and their definition of the situation on others. These steps are:

- **Problematization** - The process of identifying the actors related to the sought after change process. In order to enrol these actors there is a need to understand their goals and needs. The problematization stage also enables the definition of an obligatory passage point, a set of issues that is needed to be resolved in order to succeed.
- **Interessement** - This is the process by which the actors identified are linked together and given roles which the driving actors propose.
- **Enrolment** - a set of strategies orchestrated by the driving actor to make the other actors take and accept the roles proposed.
- **Mobilisation** - The methods used to ensure that the spokes persons for the different actors are able to represent their respective actors and that they are not later betrayed by these groups.

This models works as a method for mapping the process in which the driving actor imposes themselves on others. By analysing the interplay between the different actors

identified it can be revealed how they are linked to this network and which influence they all have on the process where BIM is being implemented.

## **METHOD**

This paper builds upon a case study of the BIM implementation process at the Swedish Transport Administration. In the case study analysis of documents produced throughout the implementation process has been done. The case study is supplemented with a series of semi-structured interviews. A total of 11 interviews have been made, 6 with participants and managers driving the BIM implementation and 3 with project managers in projects currently using BIM together with 2 interviews with the project manager for one of the two BIM implementation projects. The results have been analysed by the theory of sociology of Translation by Callon (1984). The results have also been related to earlier research on BIM implementation with the focus of client organisations and their role in supporting BIM implementation.

### **Delimitations**

This study does currently not present results of how this change process has been accepted in actual projects. That is to say, the question of how successful the translation process has been is not currently included.

## **RESULTS**

The BIM interest at the Swedish Transport Administration was initialised by individual project managers around 2010. These project managers got inspired by the buzz around BIM and tested it to various degrees in their projects. The project managers grouped themselves in a 'BIM network' to share experiences and develop their use of BIM. This network was not managed centrally but was rather an unstructured forum where these project managers could exchange BIM knowledge. In this network were several of the largest infrastructure projects in Sweden. At that time, the Swedish Transport Administration went through a lot of turmoil. The organisation was established in 2010 and was the result of a combination of two predeceasing organisations: the Swedish Road Administration and the Swedish Railway administration. During this reorganisation the leadership was unclear. According to one of the more influential project managers in the early BIM projects, this lack of guidance enabled the BIM developments as resourceful project managers had a large degree of freedom to take action and start new initiatives.

The Swedish government authorised a committee to analyse the public client organisations measures to increase productivity and innovation in the infrastructure branch of the construction industry. This committee started their work in 2009 and resulted in a Swedish Government Official Report in 2012 (SOU, 2012:39). This report suggested that the Swedish Transport Administration should drive implementation of BIM in the industry. Some of the project managers connected to the 'BIM network' were directly involved in the writing of this report and thereby had an impact on it. Based on this Report, the General Director for the Swedish Transport Administration decided that BIM should be implemented in this organisation.

### **The problematisation stage of BIM implementation**

The initial step in the BIM adoption process was taken in the loosely connected 'BIM network'. The focus in this network was to find ways of taking advantage of the new possibilities with the technology. After the decision by the general director the BIM initiative gained legitimacy and the 'BIM network' was reorganised into a 'BIM Initiation project'. This project was obliged to pave way for the BIM implementation at this

organisation. Many of the project managers linked to the 'BIM network' continued working with this project, either directly with the project or as project managers in pilot projects linked to the 'BIM Initiation project'. The 'BIM Initiation project' was initiated in late 2013. Within the boundary of this project a BIM strategy for this client actor was developed. This document describes BIM as: "the use of information models in a continuous flow through the main processes connected with a constructed facility". Further it is expressed that the object oriented information could be used for multiple purposes, such as: clash control, analysis of different design alternatives, cost calculations and time scheduling. Combined these benefits is expected to result in a more efficient project process.

In order to achieve the benefits presented in the BIM strategy the 'BIM Initiation project' formulated question in relation to how BIM should be implemented, addressing implementation barriers like interoperability and other technical aspects of adoption. Apart from those issues, the main question was how to influence projects to use BIM, influencing them to adopt the new possibilities.

#### *Identification of actors*

The actors related to the BIM adoption process is brought in by the stated questions. These actors are not expressly defined in the 'BIM Initiation project'; however it is these actors that are addressed in the implementation process. The actors have been identified as: Projects at the Swedish Transport Administration, Third party users and the BIM technology.

- The projects at the Swedish Transport Administration – It is in the projects that the actual changes are made. If BIM is going to be used, it is going to be used in construction projects. The projects are however not a perfectly homogenous group. Most prominent is the difference between projects conducted in the different branches of the Swedish Transport Administration, 'investment' and 'large projects'. The projects all have their own possibilities with different project goals. However, the projects and their project managers are addressed as a united group in the BIM adoption process.
- Third party users – These are the contractors, designers and consultants in the projects. In order to adopt BIM it is these actors that need to deliver project related information in new ways. It is also the ambition that the BIM implementation will influence these actors to change and thereby change the Swedish construction industry.
- The BIM technology – The BIM technology was tested in several pilot projects, however it can be used very differently. Depending on how it is used it has different requirements. More advanced collaborative uses of BIM requires more advanced models and higher levels of interoperability. The level to which BIM should be used in projects will have to be addressed in the implementation process. Infrastructure has not been in focus in the development of BIM tools and currently there are problems in expressing drawn out objects, like roads and railways. Standardisation has also not been taken as far as in house construction and especially the issue of road alignment have been identified as a problem in relation to developing models based on open formats.

#### *Definition of obligatory passage points*

In order to achieve BIM adoption and thereby succeed in the implementation a few steps was identified in the work of the 'BIM network' and later the 'BIM Initiation project'.

- To know the extent to which BIM should be used. In other words know how the technology should be used in the projects and thereby how it should influence work practices.
- Ensure that the actors are convinced and they realise the benefits with allying around the BIM implementation process.

### **Interessement stage of BIM implementation**

The projects previously connected to the 'BIM network' were after the start of the 'BIM Initiation project' used as pilot projects. Many of these projects were still running and delivered experiences and results from their projects to the 'initiation project'. Several new pilot projects were also connected to the 'initiation project'; these however used BIM to a very limited degree, if at all. Especially one of the pilot projects, currently the largest infrastructure project in Sweden, had a major influence on the outcomes of the 'initiation project'. This project developed the first draft of the demand document later implemented in the whole organisation. In this process the understanding of BIM present in the BIM networks were formalised and accepted as the general BIM view by the 'BIM Initiation project'. In this way the issue of BIM was not only relevant for a small group in the 'BIM network' but rather something relevant for the whole organisation. The BIM issue was also presented to the different branches of the organisation on several occasions on so called 'BIM days'. In this process the BIM strategy was presented to other parts of the organisation together with possibilities with the new technology.

### **Enrolment of the actors**

At its conclusion in late 2014 the 'BIM Initiation project' delivered a total of 32 documents. These documents contained proposed changes to then current guidance documents and new documents setting up guidelines and demands for BIM usage in projects. The documents went through a referral process and got a lot of internal critique. After major rework all these documents had been implemented in the mid-2015. Among these documents is the demands on Object Oriented Information Model (OIM) which describes the demands on how object oriented information should be produced and shared within projects. This document was implemented 2015-06-01 and is referred to by guidance documents describing how projects should be procured. As the main deliverable, the documents makes up the central part in the enrolment of the actors found the problematisation stage. These documents address all these actors and the barriers linked to them that were found as a result of BIM pilot projects.

- The projects at the Swedish Transport Administration – By making changes to guidance documents and procurement templates, object oriented models (BIM models) is introduced as an alternative or the preferred choice of medium for project related information. When accepted, these documents demands that the deliverables from contractors and consultants in projects should be done in coordinated models. It is also these documents that describe how the models should be produced and managed in the projects. The majority of the changes to existing documents contained the change from "drawing" to "model". These documents do however not describe how the internal project organisations at the Swedish Transport Administration should make use of the models and change their work practices.
- Third party users – This actor is enrolled by the demands for BIM described in the new procurement templates. The details of how these actors should use BIM are not defined, as that would be in conflict with other initiatives by the organisation. Rather, it is only demanded that coordinated models should be delivered back to

the Swedish Transport Administration by the main contractor. That is to say that the models should contain information from all disciplines together. This is thought to incentivise the main contractor to demand collaborative BIM use in the project as that would simplify the creation of these coordinated models.

- The BIM technology – How the models should be produced and managed was identified as a major issue in the implementation process. Problems with interoperability and software were identified as problematic in the pilot projects. To address this the guidance documents relates to .dwg/.dgn file formats which is far from the object oriented information initially aimed for but that cannot currently be done in the infrastructure sector.

### **Other development initiatives**

Simultaneous to the development and implementation of BIM, the Swedish Transport Administration worked with another development process, a change towards an ‘unmitigated client organisation’. This initiative strives to establish the Swedish Transport Administration as a client organisation, procuring contractors and consultants to conduct the design and construction of projects. Following this initiative the Swedish Transport Administration should avoid putting demands on the work practices of other actors. Instead demands should be specified on the function of produced facility, not on the facility itself. The purpose of this initiative is to increase innovation and lowering costs by giving contractors and consultant’s larger degrees of freedom. The work with an ‘unmitigated client organisation’ and the BIM implementation is somewhat contradictory. BIM-usage is generally relating to new work practices, focusing on collaboration around the joint development and use of models. Because of this possible contradiction the general director’s decision to adopt BIM specifically states that the BIM-usage should be in line with ‘unmitigated client organisation’ concept. As a result the ‘BIM Initiation project’ could not demand BIM centred work practices. Instead, incitements for BIM supported collaboration was presented in the demands for coordinated models.

### **Mobilisation of allies**

After the completion of the ‘BIM Initiation project’ in early 2015 the BIM implementation process was continued as two BIM implementation projects. These two projects were initiated in each of the two branches of the Swedish Transport Administration conducting construction projects, ‘Investment’ and ‘Large Projects’. The ‘Investment’ branch collects the main bulk of projects, everything from small improvement projects to larger road or railway construction. This branch works relatively standardised with projects managers conducting multiple projects simultaneously. ‘Large projects’ collects the largest and most complicated of the Swedish Transport Administration’s projects. These projects are driven more independently from each other and have larger internal support structures.

Following the start of the implementation project at the ‘Investment’ branch the templates and guidance documents concerning how projects should be conducted was changed. The template for how mission statements should be prepared in the procurement process was changed in 2015-09-09 (UB-mall 7.0). This document refers to the document presenting requirements on how project information should be produced, exchanged and delivered within projects. Thereby the demands on object oriented information were active in all projects following the implementation of this template in September 2015. The impact these changes can have on project are however very limited. The implementation process is not allowed to be an extra cost on projects. That is to say, no new roles are allowed to be added to increase the internal project organisation.

The BIM implementation at 'Large projects' have been somewhat different. These projects are driven more independently with larger support structures. This makes the BIM use in these projects more diverse. Some of the projects have acted as BIM pilot projects for the 'BIM initiation projects' trying out new possibilities with the technology. In these projects there are larger margins for developing new work practices within the project and this have been done in the pilot projects.

To support these two implementation projects, the 'BIM initiation project' was reorganised in the form of a 'BIM Area of Competence'. In this group, many of the individuals working in the 'BIM initiation project' continued and thereby are the link from the original group of project managers in the 'BIM network'. This Area of Competence continues with the development of the guidance documents and further supporting the BIM implementation at the two branches of the Swedish Transport Administration.

## **DISCUSSION**

The story of BIM implementation at the Swedish Transport Administration is the story of how a group of early adopters translates their understanding of BIM to the whole organisation. It is the 'BIM network' and its descendants that lead the translation process. Even though the general director for the organisation made the formal decisions, this decision was heavily influenced by this group of project managers. The project managers' views of BIM and the hardships relating to successful implementation are well in line with current research on BIM. The confidence that a change towards BIM supported work practices can be achieved by demanding models can be found in both in research and in the 'BIM network'. The extensive focus on technological issues and how to bridge them is also prominent among them both. The sought after benefits described in the BIM strategy is very much in line with how researchers present benefits with BIM. However, most of these benefits correspond to the work of contractors and consultants tied to the projects. Therefore there are direct conflicts with the 'unmitigated client organisation' initiative, as it limits the degree to which the client should influence the work practices by these actors. The 'BIM network' has distanced itself from this conflict in their implementation process. This conflict does however come up when the guidance documents starts to get implemented in the organisation. Especially in relation to the Investment branch of organisation these conflicts have arisen. This branch works more standardised with projects and is more tightly governed by other, now conflicting, guidance documents. It should also be noted that the third party users have not been included in the translation process, but are only affected by the new procurement templates.

This implementation process for BIM is similar to how other studies have described the change process in relation to other innovations. Both Currie (1989) and Whyte (2002) found that middle management were responsible for achieving sought after results from technological change. Even when the decision is made by the CEO Whyte (2002) found a lack of direct involvement by board level involvement after this decision. This can lead to implementation problems, bad coordination between different parts of the organisation and a short-sighted focus in relation to the benefits of the technology. Even though these two studies observed CAD and VR respectively, the results are very much reproduced in this study.

## **CONCLUSION**

The Swedish Transport Administration follows the understanding of BIM adoption presented by the main body of BIM related research. Their main way of enrolling actors

is by demanding delivery of models instead of drawings. By the implementation of new guidance documents the obligatory passage point has been past and BIM is now supposedly implemented in the organisation. However, the enrolment of some actors has been problematic. The BIM technology is not as developed for infrastructure as for other construction, which have influenced the demands on the models. The projects supposed to adopt BIM have several conflicting directives to take into consideration making their enrolment more problematic.

Implementation of innovation is not a new phenomenon in construction and it has been studied for decades. This knowledge is however seldom used in relation to implementation of BIM. This case study has found several similarities to the implementation of other innovations. By not using prior knowledge similar problems are bound to present themselves and this is what we can find in relation to the BIM implementation of today.

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# **CLIENTS AND CAPABILITIES**



# COOPERATION IN CONSTRUCTION: THE ROLE OF VALUES

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The study presents a building project executed by a major Danish construction company, where cooperation and its staging were essential for achieving high productivity and competitiveness. The form of this cooperation is the main theme for the article. The contractor actively changed the communication and sociological values of the actors involved and saw it as essential for their way of cooperating. The cooperation included and combined elements of traditional industrial building production, with concepts and initiatives that had to be understood by means of sociological analysis. Tentatively the companies in the case can be understood as possessing a social capital which is enforced and united by initiatives of the main contractor. The social capital was built up and maintained through the actual constitution of cooperation already in the initial phase of bidding before the building process. The management logic of the main contractor is interpreted as based on a sociology-inspired understanding focusing on norms and social values rather than on contractual (law) and functional (engineering) logic, which had hitherto been prevalent in Danish construction management.

Keywords: mode of communication, shared value, cooperation, social capital, normativity

## INTRODUCTION

For years it has been discussed how value-based production might stimulate the building process in terms of higher productivity, cheaper buildings and better health and safety on the work site. Winch (2012) connected the value concept with capital and discussed how value in construction could be viewed as different kinds of capital for actors. In a Danish context Kristiansen (2006), based on user perspectives, delivers an analysis of how the concept of value in construction has been used in recent years. As with Winch, Kristiansen mainly discussed in which way the result of construction, namely the buildings, could contribute to value for groups of users or for society as such. With a background in sociology, Kristiansen mentioned an alternative meaning of value, namely the social notion of values as a base of norm for social groups, norms which have intended or unintended regulating effects on social behaviour. It is such a sociologically rooted understanding of value that we refer to in our article.

Management of innovation and production in construction are increasingly subject to a number of complex challenges related to the staging of work and cooperation processes across companies and organisations (Bougarin *et al.*, 2014). In Denmark this development can partly be attributed to the last 10-20 years of increasing implementation and use of cooperative construction contracts and contract forms (Forman and Laustsen 2009), which has gained ground in the wake of fierce criticism of the construction price, quality and productivity development. In a UK context there has been a critique of

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"under-socialized" theories of the firm already in the '90'teens and social capital (Edelman *et al.*, 2004) has been used as a framework for analyses with a more socialized perspective. Here it is important to note that it is a main challenge to develop a common social capital across team and firms especially in project based firms as is the case in Construction (Bresnan 2005, Edelman *et al.*, 2004). It is one of aims to understand how the case company dealt with this problem.

The analytical focus in the paper will be on the construction industry's cooperative problem in a social capital perspective, and further how the company establish a common platform between the cooperating parties for the development of a social capital which would stimulate cooperation and do it early in the building process, further our interest is on management of social norms and values.

We have done a dialog based single case study of a major Danish construction company which targets the role of values inhered in subcontractors in the construction projects already in bedding phase and consolidated later in the building process. In the paper we describe the cooperation in the tendering-bidding phase, and we look into how this cooperation apparently forms a development platform for enhancing the social capital between both the subcontractors themselves, and between them and the main contractor.

## REVIEW OF LITERATURE

Danish housing construction firms have implemented a number of projects where cooperation in one way or another had a prominent role. Focus has varied both in theme (productivity, innovation, quality, health and safety etc.) and in actors (firms, managers, teams, persons etc.). From the 1990s and onwards, there was a strong focus on lean construction and on partnering (Gottlieb 2010). Further there was a strong focus on cooperation and the ability to increase productivity without compromising the working environment. This was similar to much of Scandinavian research and development work in productivity and work life (Hvid and Hasle 2003) with a focus on the work organisation of production combined with a basic assumption that employee involvement and participation can, at the same time, both give rise to new, more productive production processes as well as a better psychological and physical working condition. Seen as a representative of the Scandinavian industrial sociology this is opposed too much of the Anglo-Saxon Labour Process industrial sociology (Thompson 1989) seeing the two issues as an either or situation.

The Scandinavian research on cooperative production concepts has included an extensive series of empirical studies, (Sandberg 1987, Sandberg *et al.*, 1992), renowned developmental tests at Volvo back in the 1980s and 1990s (Ellegård *et al.*, 1992), and a number of other projects supported by the Swedish programme funds. Not least the Swedish governmental "Arbetslivsfonden" who supported 25,000 development projects in Swedish jobs between 1990 and 1995. In Denmark, there were corresponding activities. In the 1990s, the Danish Confederation of Trade Unions promoted (with inspiration from the Swedish sister organisation) "the stimulating work. However, it was characteristic that the construction industry was seldom represented in these empirical studies. The project based organisation with cooperation across the value chain separated the construction sector from other industries. A few development projects took place in the Danish construction sector, a major one was BYG-SOL (2003 - 2007), which included the establishment of an early cooperation between the parties with a focus on cultural factors, (language and mores), joint meetings, introduction to the construction site kick-off meetings, social events, common lunch locations and commitment to mutual plans (Hall-Andersen, H 2007 and Egebjerg 2006). Forman and Laustsen (2009) reviewed five

building projects, with elements of both partnering and lean construction. They found a large overlap between the specific initiatives and activities used whenever it was cooperation based on partnering, lean construction, strategic partnerships or the autonomous building site.

The interest in new cooperative construction contracts and contract forms has developed into instrumental regulations and tools, without focus and reflection on the relationship between these regulations and local practices. The concept of social capital can include some of the factors related to the rationality discussed above and throw light on some of the conditions important for social interaction. Social capital was introduced by Bourdieu (1986) who distinguished between economic, cultural and social capital. In principle, these forms of capital are exchangeable, but Bourdieu focused on the mechanisms that maintain social affiliation. Putnam (2000) and Woolcock (1998) changed the focus to an organisation level and developed the concept to deal with the traits of an organisation that promote coordination and cooperation for the common good. Networks, norms and trust are key parameters. In the Danish white paper on social capital and working environment, social capital was defined as the quality that enables an organisation's members to jointly address the organisation's core tasks (Olesen, KG, and *et al.*, 2008).

The ability to cooperate is essential. Trust and the belief, that justice is done, favour cooperative ability (*ibid.* 8). There are thus at least three processes that are important: the ability to tie together a group (bonding), the ability to connect groups with each other (bridging) and the ability to connect across the hierarchies (linking). Social capital is unique in its form and strength from company to company. In this context, it means that companies who each possessed a solid social capital, would not necessarily have the ability to quickly establish a good and binding cooperation. For the construction industry, this might pose a problem because production is project-oriented (Gann and Salter, 2000) which imply that partners and cooperation often change from building site to building site. Due to change in context, attempts in Construction to exploit social capital become more problematic (Bresnen *et al.*, 2005). Danish experience with the companies' social capital, has mainly been based on case studies from industry and government jobs. There is scarce knowledge about the relationships between social capital and the psychological work in project-based companies, which characterise the construction sector.

The Danish Construction Association (2011) conducted a study of social capital in eight Danish companies. The analysis identified a potential that focus on social capital could increase competitiveness in Danish construction, but it was reluctant to identify guidelines on how to achieve this. With the concept of social capital we can describe the overall nature of relations as trust, justice, interpersonal skills, but the concept is difficult to connect to the practical coordination of workspaces. Gittell's (2004, 2009) theory on "relational coordination" gives a proposal of how in-depth relationships should be understood in companies. The key term "relational coordination" describes how the interaction between "quality of coordination" and "quality of communication" in the organisation's relationships affect the organisation's performance. Gittell is based primarily on Dutton and Heaphy (2003), who works with the quality element in social connections / relationships.

They rely on three psychological inspired descriptions of how individuals in high-quality relationships: that they feel "alive"/vital, valued and as a member of the mutual relation. In the case of construction projects, "relational coordination" will both cover the relationships in the individual construction company and the relations between the companies participating in the cooperation on the construction site (the primary partners

are here the building team and the construction management). Gittell and Weiss (2004) suggest that organisational practices influence the level of relational coordination, which includes central coordination mechanisms controlling the information flow within the company across functions.

On basis of other scholars Edelman *et al.*, (2004, p.560) divide social capital in a structural dimension, a cognitive and a relational dimension. The relational aspects of social capital, is concerned with “the underlying normative dimensions that guide exchange relationship behaviours”. In project-based businesses, relational coordination represents an opportunity to operationalise social capital in terms of both integrative activities and coordination mechanisms. The coordination mechanisms are transversal sets of procedures and routines, interoperable information and meetings (formal and informal) as well as the tasks and operations that employees perform. Integrative activities are the company's use of incentive systems, control mechanisms, interdisciplinary performance measurements and supervision (Gittell 2009, Gittell and Weiss 2004).

Social capital may exploit a new type of rationality. It could be in the form of normativity, based on 'negotiated agreement' (Jessop, 2003) or 'communicative action' - inspired by both Weber and Habermas (Nørager 1985) - that challenges the tradition-bound procedural and goal-oriented normativity's (Sørensen and Vogelius, 1991) which have dominated in construction. This opening to a value-oriented rationality can also be seen as an establishment of a new social order through a 'removal' of traditional structures, rules and roles - and thus as an establishment of a new space for action, enabling new types of interaction and coordination between the parties.

## **METHOD**

Empirically, the project is a single case study which was based on an ongoing discussion (in the period August 2009 to mid-2011) between the researchers and the project manager in a division of the Danish construction company MTH Construction (Division of Zealand and Copenhagen) concerning new management issues with an outset in experiences from specific projects. This dialogue process was followed by interviews of one of the major subcontractors (plumbing and HVAC) who had participated in the construction projects managed by MTH Construction. Finally, other data from the case were used, such as minutes of joint meetings between MTH and subcontractors as well as returned questionnaires sent by MTH Construction to the trade contractors about their perception/evaluation of the cooperation (Vogelius 2014). Our approach was a type of action research which in a Scandinavian context is named dialogue research. In dialogue research, input from the research directly/simultaneously affects the project being studied, but the research part has no responsibility for the process being researched and is financially independent from the project studied Storgaard (1991) Storgaard (1998).

## **THE CASE**

In the period 2009 to early 2011, MTH Construction built the housing estates 'Magnet Dwellings' in Frederiksberg, part of Copenhagen, for a public housing client with 42 flats (MTH 2012). The total construction cost was approximately DKR 50 million, MTH Construction had the turnkey contract and also undertook the design. A number of firms were hired as sub- and trade contractors, the most important of which were heating / ventilation, roofing, painter works, carpentry works and electrician works. The building project, which was characterised by high good quality and a design based on a well-defined user profile, was a pilot for trying out new value-based forms of cooperation

conducted by MTH Construction. The new cooperation model was based on the establishment of a common understanding between subcontractors and main contractor, and besides the contractual economic agreements, there were some straightforward mutual decisions on how to act and cooperate on a daily basis (the case is described in detail in Vogelius 2014). Two value themes related to the construction process were central to the agreement, “Dialogue” (dialogue and cooperation rather than conflict) and “Interaction” (a civil tone at the workplace). It was decided to add two more themes, namely product (creating products you are proud to produce) and common explicit value and profit-sharing (agreed profit-sharing based on goals set in value areas such as health and safety and quality of the built). In other projects, common explicit value also refer to themes outside the building sphere, e.g. charitable purposes, e.g. to combat a certain type of disease.

### **Tendering**

As early as during the preparation of a bid in the tendering phase, a model based on confidence and trust was used. At the main contractor’s (MTH) request, the network of potential sub- and trade contractors worked through the tender documents in an open discussion, where considerations of quality, total contract sum and price for various subcontracts were estimated. On this basis, the first bid was developed for internal use. The pool of potential sub- and trade contractors was subject to competition in the process in order to get a competitive bid. If it turned out that someone outside the circle was cheaper, the subcontractors had in advance accepted that this party could be involved if a re-evaluation of prices did not reach a competitive level.

Compared with traditional procurement, the difference is that cooperation is already openly established in the tender process. It was an important feature in this phase that the logistics planning across the involved firms became part of the bidding process which opened up for significant cost reductions. The early planning also gave better opportunities for planning a better working environment and an effective use of the skills of the total workforce across the subcontractors at the site. The early joint logistics planning applied not only to labour, but also to an effective use of supplies across the parties with agreements on joint use of cranes, hoists etc. Hereby optimisation was obtained and overlap avoided. The overall planning already at the tender/bid phase ensured that readiness among the single parties was raised, with reduced starting-up time as a result.

### **Design**

Client, consultants and contractors held meetings with the purpose to decide rules for the actual cooperation processes in the project. In particular, the focus was on:

- Formulating an objective for the project
- Establishing and formulating success criteria; Decisions on how the teams in the working process could meet and measure the criteria
- Establishing consensus about that “together we will construct a building to be proud of” and what this meant regarding quality standard (besides the specifications in the tender documents)
- Agreeing on an extra profit to the parties when the targeted goal was reached. This might involve an agreement for donations to charitable activities/institutions

## **The building process**

Contracts were formed as an ordinary general contracting / total contract form, but had an added condition: all contractors had to accept to enter into a joint management across all trades on the building site. The joint leadership was realised through a mutual coordination planning directly between sub- and trade contractors. The main contractor did not in advance prepare a common detailed master plan. Instead various specific planning tools were established on site, e.g. manning tables and diagrams for progress. These tools were completed and negotiated directly between sub- and trade contractors and with the operative crews performing the functions. It was this common management of these tasks, which secured the responsibility for the internal coordination in relation to gangs and teams across firms and organisational affiliation. It was a basic rule at all levels, that there must be a civil tone at work - everybody had to "talk nicely with and to each other." Mutual agreement on what was labelled "Conflict-solving at source" instead of appealing up in the organisational system. Week-meetings for foremen and managers were established and five week plans were worked out at the site meetings. Corrections of tasks and design - as built - was ongoing and in dialogue with all levels (construction management, team/gang, design, consulting). The planning and management initiatives of the building process may be summarized to:

- Establish and enforce ownership by craftsmen and management of the already agreed targets
- Create new sub-targets with all subcontractors
- Create success criteria at the operative level in gangs and teams and their management in a common plenum in order to achieve the objective
- Establish rules for sharing a profit by compliance. A portion of the profits may be used for non-profit purposes
- All contractors (head, professional, and subcontracting) join in a common management team that is responsible for the overall management of the site (but with MTH as moderator).
- Establishment of norms for communication: a civil tone!

## **Delivery**

A key instrument to achieve a good final product was the "master statement". A master statement was a demand from the head-contractor to the sub-contractors to document the process and partly to guarantee (by signature) the delivered quality. The review should be made by the master himself. Master statements were also agreed with suppliers. They had to take construction responsibility of the control of the installations. This ensured that guaranties for products were valid. Master examination took place the last 2-4 weeks before delivery. Deficiencies were corrected by special teams within 2 weeks.

## **ANALYSIS**

An opening question for the analyses, can be formulated as a question of whether MTH Construction with the new concept had built a practice for establishing a social capital across the involved actors, which already before the project, namely in the phase of tender and bidding, had created the conditions for the "special cooperation" in the following project phases of design and production.

The new cooperation may be seen as an innovative development of partnering and lean where dialogue on values in product (high quality, to be proud of e.g.) and process (civil tone, conflict solving, e.g.) plays a crucial role in the consolidation of cooperation

between the actors (Gottlieb 2010). Many of these activities actually occurred in the MTH Constructions project. Seen in this light, elements of the MTH Constructions concepts were therefore seen before (as described in the Review section), but the combination and focus were changed, and they did not have the pronounced/ massive form, we saw in MTH projects. Instead of relying only on a legal and economic logic, the cooperation in equal degree also relied on a dimension of especially social values. This value concept may be seen as the axis around which the cooperation between the different actors and the related interests were moderated in the building process especially the establishment of an agreed code of communication - civil tone, conflict solving on location and common management across parties, was seen as effective. This may be seen as an establishment of a specific mode of social capital characterized by high potential for bonding in the teams, for cooperation between the groups and partners as well as across the hierarchies. The relational coordination involved integrative elements and coordination elements those are seen in terms of common managements across partners, high quality (to be proud of the delivered product), extra profit sharing and donation to charitable activities, civil tone in communication etc.

Based on an overall evaluation of the performance of the delivered building etc., MTH Construction experienced that the approach worked and they profited from it. It is our interpretation that MTH Construction performed a new form of participatory collaboration between contractors and subcontractors, a form of relational coordination, which already started during work in the bidding phase and that the cooperation continues during the building process, where the realisation of all benefits for the construction project finally takes place.

The close coupling of a value-based coordination at the bidding/tender stage and the insistence that the cooperation can be utilised and realised in the production process has proven to be a profit-giving business. Value-based cooperation seems to contain paradoxes in relation to the way cooperation between the parties has previously been perceived. How is it, for example, possible to get subcontractors to accept decreasing prices for their bid, increased productivity and better quality and close cooperation of all involved? It creates more competition - and increased cooperation, where one would otherwise expect increased competition at the expense of a good working relationship. The regulation between MTH Construction and sub-contractors was built on different fields of management, ranging from the management by contract over functional/operational management, to management by norms and values. The first two focus areas are inherently traditional in building projects and are a familiar part of the building management, whereas the latter is a new field attracting greater attention. Theoretically the case may be characterised as an example of how "co-operated and construction contracts and contract forms" represents a (new) emerging value rational normativity or action horizons in construction. A normativity that through "negotiated agreement" (Jessop, 2003) or "communicative action" (Nørager, 1985) challenges the tradition-bound, procedural and goal-oriented normativity.

The previous dominant form of cooperation has over time been naturalised in such a way that it seems as 'the' way to cooperate and has been installed as a traditional normativity which is not a subject for discussion, the (often limiting) rules, which also regulates the behaviour of players, (Sørensen and Vogelius 1991) is a normativity, based on contractual regulation and frequent conflict that often ends in court.

Habermas emphasises precisely the language and the wider communication as a coordinating factor - in fact, Habermas points out that normativity of modern creation lies

in and with the language (Nørager, 1985). Here it is worth to recall that one of the basic initiatives in the MTH Construction concept is precisely the requirement that players must change their linguistic game with each other - in brief, they are forced to speak nicely to each other. This work on the language is opening up to another rationality (value based) which at the same time is an opening up and changing of a time-honoured and vested social order, through a dismantling of the traditional structures, rules and roles - to an establishment of a new space for action, enabling new types of interaction and coordination partners in between. A new type of cooperation based on social values including mutual trust, low conflict and better coordination, and resulting in higher productivity, higher quality and better safety and health. As mentioned before, this is not a democratic and free dialogical situation, but a situation based on the structure of power between contractor and subcontractors. It is a process that is subject to and supported by the use of discourse based on shared values of cooperation and production, as well as traditional management tools on many different levels.

## CONCLUSIONS

With the implementation of the new concept, we initially raised the question whether MTH Construction has established a practice for creation of a special cooperation, which is rooted early in the phase of tendering/bidding. The ambition was to understand how, based on values, norms and a mode of communication, the establishment of binding cooperation between the participating actors already in the bidding process created cooperative relationships resulting in a more efficient cooperation later on in the project - in the designing/construction phase and - most important - in the executing/production process on the construction site itself.

What we can see is that apparently mechanisms of coordination were established through the establishment of the trust-based, transparent process early in the building process, which was used to increase and form social capital across the sub- and trade contractors as a means to improve collaboration and productivity on the construction site. The coordination mechanisms have the characteristic that they manage to incorporate the strengths of social capital as a mean for development of cooperation that creates high-quality solutions, higher productivity, and better economy for the involved contractors and a better working environment. In this way, cooperation in the tendering/bidding phase can be regarded as a way to create relational coordination already prior to the actual production taking place in the project. Literature tells that it is complicated to enhance social capital in project based organisations; the early initiatives observed in this case, is regarded as crucial for the good result. In light of the initiatives and measures used in the various phases of the participatory, value-based construction production, it seems likely that these local examples of management must be understood as (new) management rationality in construction. The blueprint combines two different (in the sociological sense) forms of governance, namely a technical rational management and a management by values and norms.

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# **SAFEGUARDING PUBLIC VALUES BY PROJECT-BASED CONSTRUCTION CLIENTS: LEADS FOR FUTURE RESEARCH**

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In an environment with large interdependencies like the construction industry, project-based public construction organisations are challenged to seek for 'new' ways to safeguard public values and project outcomes. Public bodies increasingly depend on private parties to achieve public values. Hence, due to the character of their tasks, they remain social-politically responsible. In order to find leads for future research into safeguarding public values by construction clients, an explorative literature study was conducted. The fields of institutional logics, public organisation science and public value management were used to gain insights in relevant multi-level organisational concepts considering the meaning of public values in the daily practice of public clients. Hybridity was found as characteristic of public-private partnerships. Furthermore, the management of institutional complexity as a central task for public construction clients implies the importance of monitoring ambidexterity and accountability. Future research into the understanding of safeguarding public values at all levels of public construction clients must centralise these concepts in order to contribute to the professionalization of public construction clients.

Keywords: project-based organisations, hybridity, ambidexterity, accountability

## **INTRODUCTION**

Due to their social-political responsibilities, public clients are expected to actively contribute to the innovation and improvement of the building sector. Today's 'public' understanding of inefficiency, ineffectiveness, frantic salaries and attention to scandals (Entwistle and Martin 2005) have however made many actors in the construction industry falter. The Dutch construction sector recently experienced a severe case of construction fraud and financial abuses in the semi-public sector. In Rotterdam, the purchase and renovation of a historic cruise ship by a housing association from a commercial standpoint led to a substantial financial loss, causing a nearing bankruptcy of the organisation endangering the living conditions of thousands of people. Also in other countries, problems with Design-Build-Finance-Maintain -Operate contracts are no exceptions, since quality standards are often not reached and finances are incomplete.

Over the last couple of years the public sector has been subject to some major movements. In public service delivery of the built environment, such as infrastructure, real estate and urban development, a trend called 'socialisation' is most crucial (van der Steen *et al.*, 2013). Socialisation led to a transition from top-down privatisation and citizen participation initiated by the government towards bottom-up active citizenship and

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social entrepreneurship. Public service delivery in construction (often) takes place by so called project-based organisations; a variety of organisational forms that involve the creation of temporary systems for the performance of project tasks. These can either be entire firms or multi-firm consortiums or networks (Sydow *et al.*, 2004). Public organisations are increasingly depending on private parties to achieve their goals entering in public-private collaborations. These goals concern public values if the public body is ultimately responsible (WRR 2000). Public values are embedded in different ways from sector to sector. In the construction industry public values, for example, manifest in procurement principles of transparency, objectivity and non-discrimination.

Public clients enter in public-private partnerships for expediency reasons and to create added value (Eversdijk 2013). The heterogeneous nature of these networks, alliances or partnerships is flexible by nature, constituted by different dimensions in hierarchy, formality (regulations) and collaboration. However, they also introduce competing market and community logics and thereby conflicting demands (Reynaers and de Graaf 2014, Fossetøl *et al.*, 2015). Public-private partnering reshapes principles of public administration using a certain contracting approach.

The debate about whether or not public values are safe in private hands and how and to what extent private parties can be held accountable for achieving public values is relevant in studying the daily practice of construction clients. Public actors are challenged to align their organisation with their changing role. They need to find appropriate management logics, skills, methods, mechanisms and strategies to create public value in various (collaboration) 'structures' between public and private parties. As public actors don't have many examples to follow due to the complexity and specificity of most construction projects, they are faced with questions like 'To what extent and in which circumstances is outsourcing possible and desirable?', and 'To what extent can private parties be held accountable for achieving public values when they are carrying the risks?'

A multitude of studies has been executed in the area of public administration and public service delivery. However it remains unclear what the meaning of public values is in the daily practice of public construction clients and how it might be measured (Mills *et al.*, 2009). Furthermore, we know little about how public (construction) actors deal with public value conflicts (de Graaf *et al.*, 2014). We know that hybridity is pursued to be flexible enough to manage institutional complexity. Hence, we know little about the actual deployment of this hybridity, other than the choice for a certain approach in value trade-offs (Smets *et al.*, 2014). For public parties it is concluded that the socialisation in creating public values implies a major change in their task in the public value process (Bao *et al.* 2013, de Graaf *et al.*, 2014). Yet, it appears that the actual influence of the role change on project-based public clients remains unclear.

In this paper we intend to contribute to the development of construction clients by presenting the main findings from an explorative literature study into safeguarding public values. The fields of institutional logics, public organisation science and public value management are used to gain insights in relevant multi-level organisational concepts considering the meaning of public values in the daily practice of public clients and identify leads for future research in this area.

## **RESEARCH CONTEXT AND RESEARCH APPROACH**

One of the core professional tasks of public clients is to ensure public value, nowadays often achieved by commissioning in innovative public-private collaborative structures (Noordegraaf 2015). Considering the complexity of this task, safeguarding public values

needs to reflect various organizational levels and a diversity of professional fields. The pressure to professionalise has become more complicated in the public domain. Societal changes constrain professionalism and professional powers in multiple respects and opportunities for establishing content are weakened (Noordegraaf 2015). In this context, the construction industry seeks for innovative ways of procuring and stable partnerships to achieve their organisational aims of ensuring the quality of the built environment.

To select relevant research perspectives representing these different levels, an earlier graphical network analysis of the existing literature exploring the field of public construction clients by Eisma *et al.*, (2014) is used. This network analysis 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 and displayed promising links to other scientific fields such as social sciences, public administration, business administration and innovation sciences (Eisma *et al.*, 2014).

The selection of literature perspectives for this study was guided by the relation to the different organizational levels in combination with a certain researcher's judgement on the potential of different perspectives which the explorative nature of this study allows. The following three research fields were selected:

- Institutional Logics, reflecting on the institutional system and culture on a strategic level, discussing different belief systems that shape the cognition and behaviour of actors. This entails an important internal aspect, namely directing policy making, for example expressed in portfolio management
- Public Organization Science, applying organisation science in the context of public administration leading to the discussion about societal problems and critical challenges faced by organisations involved in public value creation. This reflects the strategic level where internal procedures guide the shaping of external interaction, such as risk management by contracts
- Public Value Management, focussing on the management of conflicting values discussing practical implementations of finding the public sector balance in both creating and management of public values. This relates to the operational level where external interactions are managed on a daily basis, for example deploying dealing mechanisms

Next, Scopus was used to select relevant literature from the three research fields using different search queries, starting with the combinations of the different themes and terms as public administration and construction. Specific journals were found to be most informative, such as Construction Management and Economics, Public Administration, Public Management Review, Research in Sociology of Organisations, and Engineering, Construction and Architectural Management. MAXQDA and Atlas.ti were used to structure the literature by coding and to develop an overview of topics (code list) that describe the basic concepts of the themes. Using a snowball method - selecting new search queries from intermediate provisional code lists - an iterative process of selection and analysis of scientific literature was realized. Eventually 82 international (peer reviewed) articles were selected. Then, the final code list was used to map the relationships between the different concepts (codes) coming from the different literature perspectives. This way the binding factors between the perspectives, using safeguarding of public values by public construction clients as the core, were found. Finally, we reflected on the contribution of the different research perspectives and identified leads for future (empirical) research. Figure 1 depicts how the three research fields of institutional logics, public organisation science, and public value management lead to the

identification of three core concepts of safeguarding public values: ambidexterity, accountability and hybridity in public private partnering. In this paper we describe the results of this study.

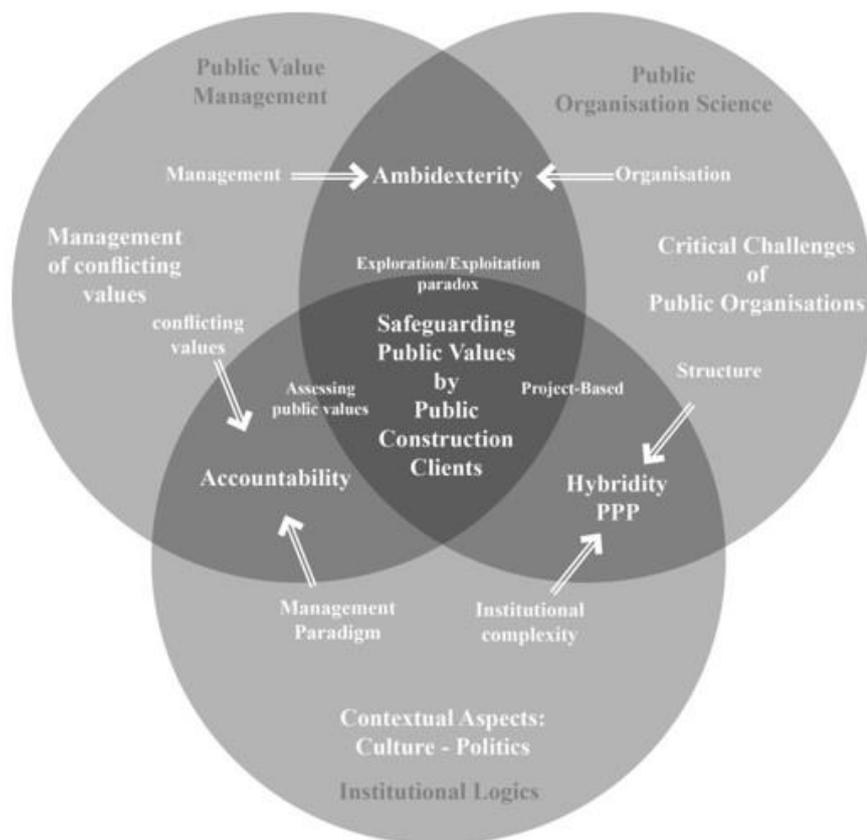


Figure 1. Overview of research fields and concepts leading to leads for future research on safeguarding public values in public commissioning

## FINDINGS

### Hybridity

Public-private partnerships are in line with the public value thinking paradigm, in which the importance of combining logics is recognized (Bennington 2011, Coule and Patmore 2013, van der Steen *et al.*, 2013, Casey 2014). Growing interdependencies in public service delivery cause new dynamics between the public construction client and the contractor. The public client confines itself to drawing up a set of functional requirements, subsequently the market provides solutions. In this collaboration public clients have to deal with clashes and incompatibilities between values in community and market logics. They get faced with institutional complexity as described in institutional logics literature. In market logics the basis for strategy is profit maximization and performance values such as effectiveness and efficiency are dominant (de Graaf and Paanakker 2014, Smets *et al.*, 2014). On the other hand, in community logics, relations of affect, loyalty, common values and personal concern are pursued and procedural values such as integrity and transparency are dominant (de Graaf and Paanakker 2014, Smets *et al.*, 2014). As soon as public actors do not treat values as commensurable they find themselves in a value conflict. In the collaborative public service delivery process these value conflicts are central.

Entering in a public-private partnership public clients are thus confronted with multiple logics. But what does this imply for the structure of public organisations? As we can understand from public organisation science literature, the position of an organisation on the public-private continuum, the 'publicness', is referred to with the concept of hybridity (Smets *et al.*, 2014). This position is (partly) determined by the extent to which organisations are constrained by political control, how organisations are funded and financed and the extent to which organisations perform public and private tasks (Besharov and Smith 2014). Construction clients itself can be internally hybrid, we can make the distinction between government and governed by the public law, these are organisations that are required to use tendering, and semi-public and private, these organisations are not required to use tendering (bron).

The project-based nature of the construction industry brings along another difficulty. Long-term collaborative relationships are needed to develop sustainable approaches to improve project performance (Clifton and Duffield 2006). Project-based organisations are limited by the short term focus of participating. The short-term focus on efficiency, based on exploitation of existing knowledge and technologies, conflicts with the long-term focus on innovation and strategic development, based on exploration of new knowledge and technologies (Eriksson 2013). Therefore public construction clients have to deal with value-conflicts on a daily basis. The management of competing values is referred to as good governance (de Graaf *et al.* 2014, de Graaf and Paanakker 2014). Public construction clients are challenged to balance competing values while honouring the structures of authority and regime (Bao *et al.*, 2013).

### **Ambidexterity**

The second core concept of ambidexterity purely refers to the ability to excel at two contradictory things simultaneously (Eriksson 2013). An interpretation of ambidexterity in (good) governance is the use of multiple management paradigms to approach public value conflicts. Public value management literature describes management paradigms prioritizing certain values above others, choosing one or multiple logics. This choice results in different response strategies to institutional complexity. These response strategies could be related to different types of ambidexterity. These types reflect the way an organisation gets organised, as gets discussed in public organisation science literature. It is about whether or not different rules, for example regarding the priority of certain values, apply for different parts of or groups in an organisation.

A first response is one of reducing complexity by choosing a dominant logic and avoiding, dismissing and ignoring others (symbolically complying) (de Bruijn and Dicke 2006). This response can be related to a structural view towards ambidexterity, separating exploration and exploitation activities in different business units (Eriksson 2013). A second approach to institutional complexity is about navigating and balancing (de Bruijn and Dicke 2006). Logics are separated per task by adhering to them on an individual basis. This response can be seen as a sequential view towards organisational ambidexterity (Eriksson 2013). The temporal separation through focusing on first one type of activity and then the other one (de Bruijn and Dicke 2006).

Due to the project-based nature of the construction industry, many structural and sequential solutions to ambidexterity, which have been found successful in other industries, are not working satisfactorily (Eriksson 2013). In order to improve both exploration and exploitation in construction projects the current structural and sequential solutions need to be combined with contextual ambidexterity (Eriksson 2013). Contextual ambidexterity refers to a capability to simultaneously and synchronously

pursue exploration and exploitation within a business unit or work group (Eriksson 2013). This contextual view towards organisational ambidexterity can be linked to a third response to institutional complexity. A response involving the ability of organisations to integrate different logics into the processes whereby they perform their tasks. In this response, hybridization is the result of the ability to actively- and even creatively – manage the complexity of the various logics.

At project-level, exploration and exploitation are explicitly affected by client's procurement procedures. Contextual ambidexterity is strived for by project teams searching for alternative procurement procedures (Eriksson 2013). The common competitive tendering procedure counteracts itself since the lowest bid price enhances exploitation but hinders exploration. Simply changing contracts from Design-bid-build to Design-build will not solve the ambidexterity problem in construction projects. Where in performance contracts room is left for the contractors to imply the 'how' within the limits of the output specifications set by clients, it might be interesting to look into whether or not this room is utilized by private parties to express their logics and beliefs as well as the managerial influence a client might have to informally shape the collaboration in the execution phase also reflecting their logics and beliefs. By using cooperative procurement procedures different actors and their activities can be integrated in order to enhance contextual ambidexterity (de Bruijn and Dicke 2006, Eriksson 2013). Further research into appropriate procedures and practical implementation is needed.

### **Accountability**

Next, due to the expansion in the use of networks of interdependent public and private parties in public service delivery, the accountability and reliability discussion becomes more prominent (Michels and Meijer 2008). In the discussion of safeguarding public values it needs to be clear which values should be secured. This needs to relate to the one to account to. As public construction clients are both politically and socially responsible for value standards in the living environment there are multiple accountholders. This means dealing with multiple views, thus different often conflicting values, as described in public value management literature. In order to deal with conflicting demands, the public client can choose a management paradigm, suiting the institutional logic, to guide constellation of values and the choice for certain safeguarding strategies in public value management. The traditional, vertical, hierarchical mechanism of accountability no longer adequately fits the current social and administrative developments (van Wart 2013). In addition, more horizontal, informal, mechanisms of accountability should be deployed. Both mechanisms can together form a hybrid accountability arrangement (Michels and Meijer 2008). Public accountability can then be safeguarded, but only if a number of requirements have been met. In the first place, the horizontal accountability arrangements must fit the type of government structures. Moreover, horizontal forms of accountability, just as vertical accountability, must meet the requirements of the democratic constitutional state, that is, transparent responsibilities, well defined interested parties, a good information supply, debate opportunities and sanctioning options (Michels and Meijer 2008). Thus public-value trade-offs need to be imitable, decision-making should be transparent.

In order to achieve imitability public construction clients can apply different strategies and mechanisms. Different constellations of values can be made based on interpretations of relationships among the different values, using the 3 dimensions of proximity, hierarchy and causality (Jørgensen and Bozeman 2007). This can result in different compositions, such as procedural and performance values. Or for example between

ethical values, democratic values and professional values (de Graaf and Paanakker 2014). In order to achieve good governance the way certain public values are safeguarded in necessary value trade-offs is important. Safeguarding strategies need to reflect the interdependency of different public and private parties. The interdependencies imply that not one party is able to impose its own views on others, and decision making results from interaction. The essence is that all parties agree about the rules of the game, thus creating a 'negotiated' environment (de Bruijn and Dicke 2006). As there are various accountholders in different public environments - political, juridical, administrative and social - there might be overlapping accountability relationships within various negotiated environments. The question might not be one of safeguarding public values, but one of safeguarding public responsibility.

This can be understood as the network safeguarding mechanisms where decision making results from interaction, consultation and negotiation (de Bruijn and Dicke 2006). However as de Bruijn and Dicke (2006) mention, in reality, a combination with other safeguarding mechanism. For example a free market, where competing on public values is central, or hierarchy, enforcing public values through regulations. This was, for example the case when the Dutch Building Act changed the obligations regarding the mandatory outdoor space. After scrapping the mandatory outdoor space from the national Building Act in 2003 believing in the market mechanism, consumer organisations and municipalities expressed their concerns in 2007 about the future value of the housing stock when the market mechanism proved to be insufficient and after parliamentary questions and a research by an external agency the building act was partially restored. And another example where a disastrous outcome of a fire in a temporary cell-block of the detention- and expand centre Schiphol-East due to a permit given on the basis of limited information and lack of knowledge, deviations in building plans and unrealistic expectations in the emergency plan as well as a lack of alignment between the user organisation and the fire department, led to changes in the building regulations.

## **DISCUSSION AND CONCLUSION**

The aim of this study was to find leads for future research into safeguarding public values by public clients in public-private partnering, today of growing importance because of the increasing dependency of private parties to achieve public goals. The explorative literature study gave insight in relevant multi-level organisational concepts considering the meaning of public values in the daily practice of public clients. Considering the complexity of the core professional tasks of public clients to ensure public value, safeguarding public values needs to reflect various organizational levels and a diversity of professional fields. We explored what the different literature perspectives have to offer in the sector specific public value debate. Relevant because of the dynamics in public service delivery and the accompanied pressure to professionalise as a public commissioning agency. We identified three core concepts of safeguarding public values: ambidexterity, accountability and hybridity in public private partnering.

A first leading concept, hybridity, becomes relevant in discussing the increasing use of public-private partnerships in the construction industry. Growing interdependencies in public service delivery cause new dynamics between the public construction client and the contractor. As the public client only sets functional requirements and lets the market provide solutions its role changes. Managing institutional complexity, combining different institutional logics of public and private parties in achieving public goals, and aligning multiple logics with the right organisational structure, becomes part of the managerial role of the public client. As literature tells us, the flexibility of hybridity can

be used to achieve good governance, combining logics in value trade-offs. But the public value debate on responsibility and accountability issues remains. This is a lead to study the hybridity of networks more specifically on the distribution of operational responsibilities and the tasks regarding safeguarding and creating public values, and the various public roles this entails. In addition the potential of deployment of internal hybridity in the practice of balancing competing management logics becomes interesting.

Another crucial concept, discussing the exploration/exploitation paradox characteristic to the commissioning aspect, is ambidexterity. Contextual ambidexterity on project level was found to be essential in the project-based construction industry where procurement procedures need to be adjusted to the collaborative, interdependent, nature. Where in performance contracts room is left for the contractors to imply the 'how' within the limits of the output specifications set by clients, it might be interesting to look into whether or not this room is utilized by private parties. For instance to express their logics and beliefs. Or the managerial influence a client might have to informally shape the collaboration in the execution phase also reflecting their logics and beliefs.

Departing from the accountability prerequisite of the 'public' characteristic, the assessment of public values relates to the choice of a specific management paradigm following from Institutional Logics and dealing with conflicting values. Findings show the need to achieve a hybrid accountability structure reflecting the collaborative structure. Also the importance of creating a 'negotiated environment' as core from where a safeguarding strategy can be established, is considered. The overlapping of accountability relationships within various negotiated environments makes you wonder if the question should be one of safeguarding public responsibility, instead of safeguarding public values.

In order to provide better insight into the nature and impact of characteristics of public-organisations and actors as determinants of their professionalism as public commissioning entities, we propose the following. To start, look at reasons and motives behind the tactical considerations of the public client in the context of the collaboration, the organisation as well as the project. Next, look into the effect on the operational level with regard to ensuring different public values. After which results can be used to achieve a safeguarding-strategy. A long-term plan for the function of the organization of society in which the organization indicates the objectives it wants to achieve by any means and ways how to achieve these objectives. In studying these strategic, tactic and more operational aspects in the construction industry one should consider two differentiations. The distinction between works- and service contracts. And the distinction between sub-industries, such as civil engineering, utility building and residential building. This might lead to different outcomes due to the specific character of the different types of projects.

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# ASSESSING THE MATURITY OF PUBLIC CONSTRUCTION CLIENT ORGANISATIONS

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The construction sector is changing, and commissioning organisations have to rethink the way they approach the market. This is especially important for client organisations operating in the public domain, because of their role as change agent in the sector and their social responsibilities. The ‘Public Commissioning Maturity Model’ (PCMM), first presented in 2014, was created to raise awareness amount construction clients’ organisations to the range and width of their commissioning task. It provides a means to elicit discussion on the current and desired state of the organisation’s competences, thereby supporting these organisations in further professionalization. As a result of six workshop-based discussion sessions and five panel discussions, the value of the model was determined. In this paper, the validation path of the model in practice is described. The findings resulted in changes to improve the usability of the model for the construction sector, as well as alterations to increase the understanding of the model for workshop participants. Adjustments regarding stylistic issues and elements in the maturity model and supporting materials were also made. Applying the PCMM has proven to enable assessment of the current and desired organisational performance on different aspects of public commissioning by eliciting discussion and raising awareness. It is however not constituted for numerical ranking, sector-wide monitoring or benchmarking purposes, while these needs also exist among client organisations. Furthermore, it was found that the model is less suitable for organisations in the middle of a comprehensive change process.

Keywords: client, commissioning, maturity model, professionalization, public sector

## INTRODUCTION

The construction industry is, together with related sectors, one of the major economic activities in every country. In addition, the construction sector has a significant impact on living standards, the capability of a society to produce other goods and services, and its capability to trade effectively (Manseau and Seaden, 2001). Despite its importance, it has been underperforming for many years (Winch, 2010), and a necessity is felt worldwide to reform the sector. Public and semi-public construction clients have a significant impact on potential construction sector reform (Vennström, 2009; Winch, 2010). They account for approximately 40% of the total construction output in Western European countries, and have a significant influence on the quality of the built environment and the construction process itself. Furthermore, because of their social responsibilities they are expected to actively contribute to the innovation and improvement of the building sector (Boyd and Chinyio, 2008; Manley, 2007; Ye *et al.*, 2013).

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Although the important role of construction clients in the public domain (non-profit and not-for-profit) has been recognized in the literature, the understanding of the actual nature and configuration of public commissioning is limited and data collection is fragmented. Most research is focussed on large projects and new construction, yet most construction activity involves small-scale projects and construction performed by smaller scale public or semi-public organisations (Eisma and Volker, 2014a). Semi-public organisations are private organisations that have statutory duties and/or serve a distinct public interest, and that they are (mostly) financed by the government (Boyd and Chinyio, 2008). Only limited research has been done into the impact of organisational characteristics on the level of professionalism and competences of commissioning entities (Hermans and Eisma, 2015; Hermans, Volker, and Eisma, 2014).

In 2014, the Public Commissioning Maturity Model (PCMM) was developed. The objective of this model is to raise awareness among construction clients' organisations to the range and width of their commissioning task. It provides a means to elicit discussion on the current and desired state of the organisation's competences, thereby supporting these organisations on defining their desired further development (Hermans *et al.*, 2014). In this paper the validation path of the model in practice is described. First, the general concept of maturity models in general and the PCMM specifically are explained. Next the validation path is described, followed by the corresponding findings. Subsequently, the applicability of the model is discussed.

## THE CONCEPT OF MATURITY MODELS

A maturity model focuses on the key elements of a specific organisational quality, and thereby describes an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process (Paulk *et al.*, 1993). The purpose of a maturity model is to provide a framework for improving an organisation's business result. To achieve these improvements, a maturity model identifies the organisational strengths and weaknesses, and possibly, but not necessarily, provides benchmarking information regarding similar organisations (Combe, 1998; Hartman, 1996; Kwak and Ibbs, 2000).

One of the first maturity models was designed for software processes in the late 90's (Paulk *et al.*, 1993), and since then a large number of maturity models for a variety of processes in organisations is developed. However, some have criticized maturity models from a practical perspective. Objections are among others the inflexibility of the models, their emphasis on identifying problems and raising awareness instead of solving problems, and their incapacity to account for the rapid pace of change in firms (Cabanis, 1998; Dinsmore, 1998; Pennypacker, 2001). But despite their shortcomings, they have made a significant contribution to the field (Cabanis, 1998; Dinsmore, 1998; Kwak and Ibbs, 2000). A research on several purchasing maturity models reveals poor empirical validity on the investigated models. Although some of these models are widely known in both practice and in the academic world, they are barely used or applied (Poucke, 2016). Poucke states that, nevertheless, in both practice and in the research community more of such practical knowledge tools are needed.

However, there is a lack of information about the applicability of maturity models in practice. In the paper we present the validation process of the maturity model 'PCMM', and therefore contribute to the knowledge development on applying maturity models within construction organisations.

## PUBLIC COMMISSIONING MATURITY MODEL (PCMM)

### Development of the model

The development of the Public Commissioning Maturity Model (PCMM) has been extensively described by Hermans *et al.*, (2014). First a preliminary set of elements correlated to the concept of ‘public commissioning’ in the built environment was gathered. These elements were mainly based on an international literature survey by Volker and Eisma (2014b), supplemented with more practical viewpoints. Next, literature on maturity models was studied, together with existing maturity models developed for adjacent areas. Then, the development stages and a set of aspects were compiled, which led to a draft version of the model. The draft version was discussed in a structured discussion in four expert sessions, which resulted in an adjusted pilot version of the model. This pilot version is used in the validation phase.

### Content of the model

The Public Commissioning Maturity Model contains the following 10 aspects:

1. Organisational strategy and policy;
2. Culture and Leadership;
3. People and learning organisation;
4. Decision models and portfolio;
5. Stakeholder management;
6. Public role;
7. Public rules of play;
8. Interaction with supply market;
9. Managing projects and assignments;
10. Creativity and flexibility.

The aspects are a combination of basic organisational competences, specific public commissioning related issues and aspects related to the ‘public’ nature of construction clients. The 10 aspects are being assessed according to 5 maturity levels, being: 1. Ad hoc; 2. Repeatable; 3. Standardized, 4. Managed; 5. Optimized.

The maturity level is determined on the basis of four indicators, all carrying equal weight. These indicators concern the extent to which the client:

- Has the aspect on the agenda within his organisation, and how integral their consideration of the aspect is (comprehensiveness)
- Has given itself tangible targets regarding the aspect, and to what extent the client evaluates and is held accountable over these targets
- Has this specific aspect embedded in the organisations, and thus the aspect is known to the relevant employees (embedding)
- Has the processes, methods and tools available to ensure the operations and support for this particular aspect (supporting means)

The resulting maturity model is shown in figure 1.

Figure 1. The Public Commissioning Maturity Model (PCMM)

Maturity level		State of development regarding professional commissioning in your organisation												
		1	2	3	4	5	6	7	8	9	10			
5.	Optimized													
4.	Managed													
3.	Standardized													
2.	Repeatable													
1.	Ad hoc													
		Organisational strategy & policy	Culture & leadership	People & learning organisation	Decision models and portfolio	Stakeholder management	Public role	Public rules of play	Interaction with supply market	Managing projects and assignments	Creativity & flexibility			
		1	2	3	4	5	6	7	8	9	10	Aspects		

### Validation Path

To validate the model and test its applicability, it was used in several cases with commissioning organisations in the public domain. First, a number of structured

workshop-based discussion sessions were conducted, each with one or in some cases two organisations. Secondly, several panel discussions were organized, each with a larger amount of organisations. All cases were conducted with Dutch organisations, in the period of 2015 and 2016.

### **Workshops**

A total of six workshops have been carried out, with four housing associations and the real estate department of a central government organisation. The selection of organisations is made within the network of the university that developed the model. All organisations expressed interest in the model by themselves, intending to use it as a tool in a strategic change process of their commissioning role.

In order to validate the usability and feasibility of the model and the toolkit, we somewhat varied the programme and character of the workshops. In most cases, two workshops of half a day were conducted. In the first workshop the current situation regarding professional commissioning is assessed, after which the results are processed and fed back to the participants. Some weeks later the second workshop is carried out, in which the desired future state of professional commissioning is discussed, based on the results of the first workshop. Some organisations only attended the first workshop, others were based on a mixture of current and future measurements. In all workshops, the final results were fed back to the organisation.

A workshop has between 8 and 15 participants, and is accompanied by one or two facilitators. These facilitators are researchers of the university, working within the department that developed the model. The model is intended to be used by board members and managers, and the participants should be primarily engaged in commissioning, so no advisors or support staff. The organisations are advised to invite both people engaged in managing the portfolio and those involved in new projects and investments, in order to get an image of the commissioning competences throughout the organisation as a whole.

#### *Structure of the workshops*

A workshop starts with a plenary session, with an explanation of the maturity model and some background information. Subsequently the participants are divided into several groups of approximately four people. Each group is assigned a number of aspects of the maturity model, which they discuss successively. They get circa 15 minutes per aspect, in which they have to assess the corresponding maturity level and the reasoning behind it. When all aspects are discussed, participants come together to share the outcomes. In a structured plenary session every group shares their results, with which the maturity model of the organisation is made.

Each of the validation workshops ends with an evaluation of the workshop and the maturity model. During this evaluation the different aspects, maturity levels and the applicability of the maturity model in general are discussed. The outcomes of these evaluations are described in the next section.

#### *Think-aloud*

All discussions are recorded using audio recorders, and the participants are asked to use the think-aloud method during the group discussions. With this method all decision, reasoning and decision-making processes are being made by thinking out loud, and the recordings are analysed retrospectively (Ericsson and Simon, 1980).

### *Quick scan*

All participants receive a so-called ‘quick scan’, approximately two weeks before the workshop takes place. This is a document with the maturity model as displayed in figure 1, equipped with a brief description. Participants are asked to fill in the model spontaneously, for the current state of development in their organisation. They do this based on their first intuitive estimation in a maximum of 15 minutes.

The quick scan serves two purposes: first, it gives the possibility to compare the outcomes of the individually and spontaneously filled in quick scans with the outcomes of the workshops, at which the participants assess the maturity levels through group discussions. The second purpose is a more practical one; since the participants are already familiar with the model, time can be saved during the workshops.

### *Supporting material*

The PCMM is accompanied by a toolkit, containing supporting material. This toolkit contains an accompanying memo with extensive explanation of the model, posters of the model to be used in the plenary parts of the workshops, several prints of the model with brief explanations of the different aspects and maturity levels, and forms to evaluate the workshop afterwards. The explanations of the aspects are equipped with questions for the participants, as a basis for discussion on the issue. This toolkit ensures that the model is being used in the same way in the different organisations. As a result, the usability of the model and its elements is perceived in the same way, and the evaluation of the model is conducted in the same manner.

### **Panel discussions**

In addition to the structured workshops, five panel discussions were conducted. In these panel discussions, multiple organisations assessed their maturity at the same time. The meetings enabled participants of different organisations to share their experiences, differences, similarities and best practices, and on the basis of that they jointly determined the agenda for future improvements. The aim of the discussions within the validation of the model was twofold: recognition of the 10 aspects, and obtaining an understanding of the bandwidth of performance within these aspects. Most panel discussions took about two hours, and therefore were more superficial than the workshops. Nevertheless, they gave a good understanding of the distribution of leaders, mainstream and stragglers regarding public commissioning within the sector.

## **FINDINGS**

### **Elements**

Overall, the experiences are positive. The aspects are being recognized and collectively give a good impression of professional commissioning. The maturity levels are helpful, but can be difficult to grasp at first. Furthermore, correct terminology is of great importance in the model and the toolkit.

In general, the participants considered the selection of aspects very complete. One of the participants commented that he was missing ‘collaboration within the organisation’ as an aspect in the maturity model. This is however covered in aspect 2; culture and leadership. Another participant suggested the aspect ‘customer satisfaction’. Currently this is covered in aspect 5; stakeholder management, since costumers are one of the stakeholders. The costumers and users could be further specified in the toolkit to clarify this. But if they are specified too far, the model cannot be widely deployed, since costumers and users differ for different kind of organisations. The final aspect, creativity

and flexibility, proved to be a difficult aspect to assess. Whether one can be creative and flexible depends highly on the other aspects, according to several participants. Furthermore, it is difficult to assess this aspect according to the specific maturity levels in the model. A possible solution would therefore be to incorporate this element in the maturity levels.

The first maturity level, ad hoc, is often understood in two different ways: ‘not yet available, one does not think about that’, in other words fairly negative, and ‘we are consciously working on it, but at the moment it is still ad hoc’, which is more positive. In order to show such nuances in the maturity model, an arrow can be drawn in the model, showing the upward or downward movement in the organisation. There was some confusion about the third maturity level as well. In the draft version of the model, the term ‘standard’ was used for this level. However, this caused some confusion among the participants, since they associated the term standard in a different way. Therefore, we changed the term to ‘standardised’.

### **Process of using the model**

In all workshops the process was facilitated by one of the developers of the model. Experiences show that (executive) managers occasionally had the tendency to dominate the discussions in the workshop, by talking the most and by steering the discussion. This might influence other participants, especially if they work at a different level in the organisation. Ensuring that the groups of participants are evenly mixed across the organisation, and making sure that every voice is heard therefore belonged to the core tasks of the facilitators during the assessment process.

Approximately 15 minutes per aspect was used. This is a tight schedule, especially for the first aspects, at which one must get used to the process of using the maturity model. Keeping track of time during the group discussions is therefore another important role for the facilitators. Sending the quick scan contributes as well, since it makes the participants accustomed to the maturity model in advance.

As follows from the above, the facilitator plays an important role in the process of using the maturity model. In the validation phase, most of the workshops were moderated by a researcher of the university department that developed the model. However, it appears to be very well possible to use the model autonomously. In that case, it is especially important that the moderator has both experience in the construction industry and experience in facilitating workshops and suchlike. This could be provided by a representative from a university or other knowledge based institution, but it could also be provided by peers in the field.

### **APPLICABILITY OF THE MODEL**

The maturity model proved to be a good way to elicit discussion about professional commissioning in organisations in the public domain. The structured workshop-based discussion sessions raise awareness about the comprehensive side of professional commissioning, and with the PCMM it is possible to assess the current and desired organisational performance on each of its different aspects. By organizing the workshops with participants of all relevant parts of the organisation (such as project management, purchasing, contracting and maintenance on management and operational level), the awareness and possible improvements as a result can be accomplished throughout the organisation as a whole. Furthermore, reporting the results of the workshop contributes to embedding the elements of public commissioning within the organisation.

The model seems to be less suitable for organisations in the middle of a comprehensive change process. In two of the workshops the organisation was going through major organisational changes at the time of the workshop, which had an adverse impact on the results. Although the added value of the model was recognized in the context of the future development, the dynamics of the organisational change had a negative impact on the outcomes of the maturity levels, since the model mainly rewards standing practices instead of future changes.

To truly measure change in an organisation, one should link the outcomes of the maturity model to the actual performance of the organisation. This is for instance done in the EFQM model, a quality management system developed by the European Foundation for Quality Management. In this model, a distinction is made between “enablers” and “results”. In this context enablers can be considered comparable with the maturity aspects of the PCMM, and the results are the actual performances that are being achieved (Vukomanovic, Radujkovic, and Nahod, 2014). However, for the PCMM the focus deliberately lies with the awareness within organisations as a first step towards further professionalization.

### *Benchmarking*

In contrast to some other maturity models, the PCMM is not intended for benchmarking, numerical ranking or sector-wide monitoring purposes (Hermans *et al.*, 2014). Nevertheless, remarks and suggestions in the workshops indicate that there is a demand for comparisons among commissioning organisations. However, as stated before, the aim of the PCMM is to focus on the awareness within organisations first. For this purpose, a supervised workshop seems to be the most appropriate method. Quantitative comparison of organisations on the basis of numerical outcomes of the current maturity model, would give a distorted picture and is methodologically not sound. For benchmarking to be justifiable, the questions and terminology that are being used should always be interpreted in the exact same way, without ambiguity or differing perceptions. This imposes different requirements on the used terminology and supporting material, and is more suitable with, for example, an individual questionnaire or another more standardised method.

## **CONCLUSION AND DISCUSSION**

Only limited research has been done into the role of commissioning clients in the public domain. A strong need therefore exists among public and semi-public clients to develop a scientific foundation about the approach to face the challenges existing in the industry. In order to accomplish this aim, the first step would be to raise awareness among these organisations to the range and width of their commissioning task, and supporting them in defining their desired further development. The development of the Public Commissioning Maturity Model (PCMM) and accompanying toolkit fulfils this need.

After development in 2014, the PCMM has now been validated in a number of cases with public and semi-public commissioning organisations. The model proves to be an effective means to elicit discussion on the current and desired state of commissioning competences among construction client organisations. By doing this, the PCMM adds crucial information to the development of existing body of knowledge on the role of public construction clients. Furthermore, reporting the results contributes to embedding the elements of public commissioning in the organisation.

The results of the validation workshops show that illumination of the specific terminology is of great importance for the general understanding of the material, since some terms can

be interpreted in various ways. The selection of the participants within the organisation and good facilitators also appeared to be essential in the correct use of the model. Limitations of the model include its unsuitability for numerical ranking, sector-wide monitoring or benchmarking purposes. Furthermore, it was found that the model is less suitable for organisations who are in the middle of a comprehensive change process.

It should be noted that there could be some bias in the current selection of organisations, since the organisations in the workshops have expressed interest in the model themselves, and are therefore not selected at random. Supporting material is now being developed for the PCMM to be used without support of university researchers, in order to the model to be more wide spread among client organisations in the Netherlands.

Future research could incorporate the relationship between the outcomes of the maturity model and the actual performance an organisation achieves, in order to assess the rapid changes some organisations undergo. Research could also be aimed at a more solid version of the model, with for example an individual questionnaire instead of discussions, in order to enable benchmarking purposes.

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# CLIENT PROJECT GOVERNANCE CAPABILITIES: UNPACKING THE CONCEPT AND GOVERNANCE MECHANISMS IN PRACTICE

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Globally public sector clients are increasingly being asked to do more for less i.e. produce more public value with fewer resources; at the same time as cost and time overruns on major projects are increasingly highlighted and subjected to public scrutiny. These developments are not lost on the research community and there is now an emerging body of literature that seeks to explore the relationship between how these organisations are structured and resourced and project outcomes. This paper seeks to build on this literature set. It does so through the theoretical lens of organizational capabilities. The particular focus is on project governance and associated governance capabilities. Drawing on an extensive review of the academic literature on project governance from both a supply-side and client perspective, as well as public policy sources, we propose that client project governance capabilities are underpinned by three sets of sub-capabilities: project assurance, project coordination and asset-integration capabilities. We unpack these capability sets with particular attention given to the multiple ways in which they can be deployed. Conclusions are drawn highlighting the importance of a strong owner for the successful realisation of the project and how project governance capabilities are key to achieving this.

Keywords: governance capabilities, public sector clients, project capabilities, project governance

## INTRODUCTION

Infrastructure projects are seemingly fraught with poor delivery outcomes. They consistently exceed budgeted time and cost, fail to deliver expected benefits, and do not meet the demands for which they were built (Flyvbjerg, 2011; Flyvbjerg *et al.*, 2003; Mellow, 2011; Morris and Hough, 1987). In general, issues of poor project delivery outcomes have become the norm rather than the exception, with approximately 90% of projects exceeding budgeted cost and schedule (Flyvbjerg, 2014). Further, the demand and benefit side estimates are typically out of forecast by 20 - 70% (Flyvbjerg, 2011).

The poor outcomes of infrastructure projects have not gone unnoticed (see for example, NAO, 2009, 2012). The government organizations (public sector clients or in the terminology adopted in this paper the project owner) entrusted with project delivery are increasingly being questioned on their capability to deliver projects that provide value and make optimal use of citizen taxes. In general, such project owners are questioned on: their commercial capabilities, i.e. their ability to interact on an equal and professional terms with the private sector (e.g. NAO, 2009); their project assurance capabilities, i.e. their ability to independently and objectively verify whether the project is on schedule,

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within budget and will meet future performance (e.g. NAO, 2010, 2012); and their project delivery capabilities (e.g. LEGCO, 2014). This is despite the fact that these organizations have commonly experienced a reduction in the resources available to them and the inability to develop technical capacity as a result of budgetary constraints, growing welfare schemes, competing demands on public sector finances and adoption of New Public Management principles (Hood, 1991). Thus on the one hand, whilst these public sector clients are being questioned and criticized on project outcomes and being asked to improve performance; on the other hand they are being supplied with fewer resources. In effect, they are being asked to do more for less. Significantly there is now a growing literature that points that the role of the project owner is crucial for the successful delivery of projects (e.g. Miller and Lessard, 2001; Morris, 2013; Rowlinson, 2014).

This paper sets out to study these project owners by focusing on their capabilities, more specifically governance capabilities, i.e. the capabilities through which the owner manages the interface with the temporary project organization set up to deliver project. We start by reviewing the major causes of poor delivery outcomes and the role of the project owner to these outcomes. Attention is then drawn to research that highlights the link between the presence of strong owners and project success. Thereafter, literature on owner project capabilities, a build-up on the strong owner concept, is reviewed with particular attention to the roles of the three sub-capabilities that underpin it. The rest of the paper then focuses on project governance and its associated capabilities. The main focus is on the three sub-capabilities that underpin project governance: assurance, project coordination and asset integration. Various activities that underline each sub-capability, and some challenges they bring with them are also discussed. The paper concludes by arguing that each sub set of capability is essential to success and also project owners need to become strong owners. We further suggest that concepts from dynamic capabilities theory offers an insight into how project owners may use existing resources to develop capabilities.

## **THE PROBLEMATIC CLIENT**

Infrastructure is typically delivered in a project organising domain. Three organizational types usually interact within this domain: the temporary project or programme; the relatively permanent owner and operator; and the project based firm or supplier (Winch, 2014). The project supplier is mainly a project based organization that predominantly undertakes tasks via projects and supplies the human and material resources required on projects; the temporary project or programme is the asset to be delivered; and the relatively permanent owner and operator supplies the capital resources required, charters the project and operates completed assets to deliver goods and services to its customers (Winch and Leiringer, 2016).

The literature on project organizing has over the years focused mainly on the role of the project supplier with less emphasis on the project owner (Winch, 2014). Further, the limited literature usually views project owners as clients interested in the purchase of a service rather than as a strategic actor with roles on the project. In recent times, however, this perspective has started to shift, and there is now an emerging body of literature that has started to focus its attention on project owners. A driving force behind this trend is the realisation that in many cases the causes of poor delivery outcomes lay in areas that are within the remit of the project sponsor (owner) rather than that of project execution by the contractor. Issues such as optimism bias and strategic misrepresentation have, for example, repeatedly been identified as key factors affecting delivery outcomes of

infrastructure projects (e.g. Flyvbjerg, 2011; Flyvbjerg *et al.*, 2003; Flyvbjerg *et al.*, 2009). So too have factors such as clients: inability to manage the front end definition; failure to properly drive the project; inability to shape strategy and cope with political, economic and social turbulence of outside institutions; failure to manage or influence project 'externalities' (e.g. Miller and Lessard, 2001; Morris and Hough, 1987). Such findings have led to the emergence of concepts such as smart clients, intelligent clients (Aritua *et al.*, 2009) and strong owners (Morris and Hough, 1987) among others.

Morris and Hough (1987) recognised the important role of project owners to the successful delivery of projects and thus proposed the concept of a "strong owner". More recently Merrow (2011), based on his research on engineering projects in the oil and Gas sector, has reinforced the strong owner concept and suggests that project owners should have a strong distinct team that will be able to interface interactively with the supply side. Winch and Leiringer (2016) building on this work sought to unpack the concept. Using organizational capabilities as a theoretical lens, they identified three conceptually distinct capability sets which the owner requires for project success. These set of capabilities they dubbed as 'owner project capabilities'.

## **OWNER PROJECT CAPABILITIES**

Owner Project Capabilities is the set of capabilities needed by a project owner to define, implement and deliver its projects and may be broadly classified under into three distinct set of capabilities: strategic capabilities, commercial capabilities and governance capabilities (Winch and Leiringer, 2016). Strategic capabilities is the set of activities that the owner organization uses to successfully implement its investment projects. They mainly relate to activities that define, conceptualizes and outlines the benefits of the project for formal approval. Strategic capabilities, includes activities such as: project selection, project definition, raising capital, stakeholder management, and project portfolio management. Commercial capabilities refer to activities the owner organization undertakes to manage the interface between the owner organization and the project based firm.

Here project owners have the challenge of identifying which supplier is best suited for an activity, what mechanisms may incentivise or motivate a supplier, and how to manage that relationship. Commercial capabilities empowers project owners to manage its relationship with supplier by being able to engage in activities such as: the clear definition and packaging of works to be undertaken by a supplier(s); selecting and motivating potential suppliers to undertake a task at an optimal cost; and making use of appropriate contract mechanisms to engage suppliers. The last set of capabilities, Governance capabilities, is the capability set needed to manage the interface between the owner organization and the temporary project organization set up to deliver the investment. Activities here focus on assuring relevant stakeholders of project progress; managing or coordinating the project during its execution; as well as ensuring that completed projects are integrated into existing operations of the owner. The remaining section of this paper focuses on governance and associated capabilities.

## **PROJECT GOVERNANCE**

Governance of projects relates to the set of activities that the project owner exhibits towards the temporary organization it finances. This set of activities include assessing and reporting progress of work to relevant stakeholders; using appropriate tools and techniques to monitor the project; creating the organizational structure of a project and integrating completed project into operations. To appreciate project governance it is

necessary to first look at corporate governance (Too and Weaver, 2014). Corporate governance is described as that which “involves a set of relationship between a company’s management, its board, its shareholders and other stakeholders. Corporate governance also provides the structure through which the objectives of the company are set, and the means of attaining those objectives, and monitoring performances are determined.” (OECD, 2004: 4). What this suggests is that governance systems, including that of project governance, consist of two main components: the governance framework and the people (management) (Too and Weaver, 2014). While the governance framework sets out the structure of the organization, its roles and accountability processes among others; the management component focuses on decision making and performance monitoring to ensure that objectives are achieved. Effective usage of governance on projects may lead to: the efficient delivery of projects, and ensuring that delivered projects are beneficial to the organization (Too and Weaver, 2014). Project governance consists of a myriad of activities, which may be broadly categorised under three sub-categories of governance (Winch and Leiringer, 2006). These are project assurance capabilities, project coordination capabilities and asset integration capabilities.

### **Assurance capabilities**

Assurance capabilities relates to the ability of the project owner to assess a project, establish that the required elements to deliver it successfully are in place and report project progress to relevant stakeholders (NAO, 2012). Project owners that possess sufficient assurance capabilities and can deploy them are able to assess progress of a project; identify relevant early warning signs likely to cause project failures, and assist mitigate against them; and highlight any breach of time, cost, and quality control limits established earlier at the front end stage (NAO, 2010; Williams *et al.*, 2012).

Project assessments are mainly undertaken via various assessment models. Typical examples of such models include: project reviews - applicable throughout project lifecycle; project health checks - for fraud; benchmarking - for comparison of two projects; project audits - to check executed against standards; and post project evaluations (Williams *et al.*, 2012). Most of these assessment models, including project reviews, are underpinned by stage-gate processes which addresses the “who, when, what” questions of who should make decisions on project progress, when such decisions should be made and on the basis of what information (Williams *et al.*, 2012; Winch and Leiringer, 2016). In terms of occurrence, assessments may be performed at a 'point-in-time' or 'continuous' (regular intervals) throughout the project lifecycle (NAO, 2012).

A drawback of using project reviews and stage gate processes for assurances is that they are lagging indicators, i.e. they report on issues that have already occurred rather than that which may occur in the future. This thus makes them most suitable at the front-end phase where the cost of cancellation is low (Winch and Leiringer, 2016). The use of a mechanism that has the ability to forecast, complementary to stage gate processes, mitigates the lagging indicator effects. An Early Warning Signs (EWS) is such a forecasting mechanism that leads to a proactive response and ensure that problems that may arise are identified and corrected at a stage where its cost effects is lowest.

Two such early warning mechanisms which project owners may make use of when undertaking assessments are: a focus on processes; and informal "gut-feeling" approaches (Williams *et al.*, 2012). A focus on process assists in identifying the more technical and measurable “hard issues” on a project, whilst “gut-feelings” helps identify “soft issues” that are related to attitudes and values which are harder to measure (ibid). For instance, when undertaking assessment at the early stage of a project, a process approach may

bring to the fore, formal issues likely to signal problems such as the lack of a good business plan, lack of a common definition of roles and responsibility and disputed major decisions. Similarly, in using a “gut-feeling” approach, signals such as: leadership issues, uneasy comments and body languages, parties voicing reservations and politically hedging their positions among others may signal the presence of problems on the project.

An issue that arises in project assessment and is of importance is whether the assessor should be independent of the project team or an integral part of it. It is the case that having an assessor that is a part of the project team leads to a scenario where the assessor questions their own work. In contrast having an assessor fully independent of project team leads to a reliance on reports by project suppliers which may not capture issues detrimental to the project supplier. An approach that makes use of the positives of both methods, resulting in findings that are independent, have both an inside and outside perspective, and improves credibility is preferable (Klakegg *et al.*, 2016). One such approach is the three “lines of defence” for assurance (Hone *et al.*, 2011). The "three lines of defence" approach consist of having: 1) effective project controls by the owner team in direct contact with project, 2) internal assurance independent of the project team that is provided by say the programme management office, and 3) an external audit (Hone *et al.*, 2011). The first line of defence may be made up of those directly accountable for the delivery of the project, i.e. the project teams and line management; the second line of defence team may be made up of the programme assurance office supplemented with relevant functional professions; whilst the third line of defence may be constituted of an external audit unit.

### **Project Coordination Capabilities**

Project coordination focuses on ensuring that the various parts of the project organization work in harmony for a successful project outcome, as well as the planning and monitoring of performance. Project coordination can, thus, be described as the ability of an organization to: harmonise the activities of various actors on a project (Hui *et al.*, 2008); plan, monitor (measure and report), take necessary corrective action and also authorise project teams to deliver (Morris, 2013). This ability of the owner organization to coordinate its projects and suppliers and also undertake project control is its project coordination capabilities.

Infrastructure projects consist of work packages that are to varying degree dependent on each other and need to be synchronised. Project coordination serves as the glue that binds the various packages and sub-packages and ensures that there is a smooth workflow among the involved parties. The various work packages needs to be scheduled such that dependent activities are harmonised in terms of workflow. This entails having an overall work plan that considers all aspects of the project, specifies how the various work packages will fit together and delineates roles and responsibilities. Additionally the process of coordination needs to take place throughout the project lifecycle i.e. at the front end, during project execution, and from the construction stage to the operational stage. Such a systematic approach to co-ordination leads to the avoidance of issues such as backlogs, accidents, mistakes, and wastes thereby contributing to successful project outcomes (Merrow, 2011). This ability to undertake co-ordination may however be affected by factors such as the degree of complexity of an activity, procurement method, the number of firms and work packages on a project (Child and McGrath, 2001; Hui *et al.*, 2008).

Project controls, are complementary to coordination. Project control involves planning and monitoring, taking corrective measures and re-planning of projects (Merrow, 2011).

It is initiated with the planning and establishment of baselines in cost, schedule, scope, and quality. Once a project is implemented, current progress is compared and forecasted against the baseline at agreed periods. Results from undertaking the comparison provides basis for either taking corrective measures, re-planning or maintaining existing pace (Morris, 2013; Winch and Leiringer, 2016). Processes that are used for project control include: earned value method, milestone tracking of schedule, use of key performance indicators, critical path analysis, PERT/CPM etc (Hone *et al.*, 2011; Morris, 2013). Additionally the use of qualitative assessment such as project manager commentary on progress and critical issues is encouraged as most of the process tools are quantitative in nature and may not capture issues that need to be described but are important (Hone *et al.*, 2011).

An issue with project control is whether the owner organization has to rely on information supplied by the project supplier or prepare their own set of information for the purpose of project control. Where information for project control is provided by the project supplier, they may not provide information regarding problems they face, unless such problems are at an advanced stage and noticeably by all. An alternative is for project owners to take charge of preparing information for project control purposes themselves. This more high level of involvement in the delivery of projects has been attributed with positive project outcomes (Hui *et al.*, 2008; Merrow, 2011). This, however, requires more resources, which are not always available.

### **Asset Integration Capabilities**

It is not uncommon that projects fail to function or operate properly after hand-over. This is irrespective of whether they have been completed on time and to budget, or over budget and time (Brady and Davies, 2010; Davies *et al.*, 2009). This tendency for projects to experience operational failure arises from the discontinuity between the processes required to deliver the project and those needed at the operational phase (Brady and Davies, 2010). The ability of a project owner to integrate its assets first at the construction stage, and then from the construction stage into existing operations of the owner organization for beneficial use, is its asset integration capabilities (Winch and Leiringer, 2016). Project owners that are able to properly deploy asset integration capabilities ensure that operational failures are prevented post completion. Two mechanisms by which the owner organisation can achieve asset integration are operational readiness and system integration.

Operational readiness in projects deal with the process of ensuring that a project is ready for the functions it was designed for at completion. It is an activity that is undertaken throughout the lifecycle of the project and during the handing over stage. At the early stage of projects, operational readiness may consist of a core operations team incorporated into the project team to give inputs that will make operations post completion easier, and also assist correct errors at a stage when they cost less to resolve. At the latter stages, operational readiness will consist of a series of tests, trial soft openings, simulation of real life scenarios, possible loading of asset to its maximum capacity among others in order to identify any issues which may affect operations after hand-over and also ensure project performs optimally during its operational phase (Davies *et al.*, 2009). Conducting these activities as part of operational readiness also enables the operational team become familiar and confident with the asset and its operations post hand-over.

Systems integration involves the logical coordination of the component part of a system to make it a whole unit. In an infrastructure project, system integration coordinates and

controls the network of contractors and suppliers involved in the design of the infrastructure and specialist work package; construction of the infrastructure and subsystems needed for operations; and integration, testing, commissioning and handover of a fully operational system (Davies and Mackenzie, 2014). It may involve the transition from the construction to the operational phase, or the combination of two different work packages. This activity includes the management, governance and logical co-ordination of the project throughout its lifecycle: planning, design, construction and operational readiness (Davies *et al.*, 2009). The scope of systems integration requires knowledge of the total effort of integrating the whole project that goes beyond any of the contracting parties. This is, however, difficult, and the owner organisation faces the challenge of being able to perform this systems integration function required throughout the project lifecycle with varying capabilities. Three suggested approaches by which owner organizations may undertake systems integration are: 1) internally by having all the capabilities in house, 2) via a prime contractor and 3) as a joint venture between owner organization and other firms possessing requisite capabilities needed (Davies and Mackenzie, 2014).

### **Challenges with Developing Governance Capabilities**

As the above discussion shows, possessing governance capabilities by project owners is essential for successful project outcomes. However, there are challenges that public sector clients encounter in developing this capability set. There are a myriad of governance frameworks all of which are context dependent and have different intended outcomes. For instance, in a case study of governance schemes Klakegg *et al.* (2016) found that the Governance framework of the Norwegian state had its goal as maximizing value for society, and the reduction of costs and increase in cost control; whilst that of the UK was designed to focus more on achieving financial target. Additionally in terms of implementation, whilst the governance frameworks in the UK focused on a “how to achieve” perspective, that from Norway shows a “what to achieve” perspective (*ibid*). The non-generic nature of the governance frameworks makes it difficult for project owners to decide on the type of governance capability set to develop. Added to this is the fact that research is yet to establish what capability set may work well within a particular context and under what conditions they may be effective. Even where these project owners are able to develop a particular capability set, policy changes by government in terms of intended outcomes may render the capabilities ineffective. Project owners will then face the challenge of developing new sets of governance capabilities to match the change in environmental conditions.

Another difficulty that affects the development of governance capabilities is the anchoring and centralisation of governance frameworks at top political levels and Finance Ministries (NAO, 2010; Winch and Leiringer, 2016). The non-localization of such governance frameworks prevents project owners from being able to develop capabilities needed for governance to manage its projects and further transfer knowledge that may have been gained to subsequent projects. The centralization of governance also prevents assurance from being continuous as staff from centralized units (e.g. Finance Ministry) are mainly released to undertake assurances based on their availability. This leads to a situation where the assurance team is not embedded within the project. As a result the assurance team is unable to have an in-depth and up to date understanding of issues affecting deliverability and respond quickly to them rather than at a later stage where effecting corrections might be difficult (NAO, 2010)

In a situation where governance is not centralised and project owners are allowed to exercise localized governance capabilities, it is the case that governance as a whole requires that sufficient resources are dedicated to the project. In most cases, however, this is lacking as most of these project owners have faced cut in resources due to the adoption of principles of New Public Management and budgetary constraints (Hood, 1991). This suggests that these project owners need to be able to make use of existing resources and modify such resources during the project lifecycle. How they can do this is less explored. It is here that the concept of owner project capabilities - with its origins in the dynamic capabilities literature (Winch and Leiringer, 2016) - comes into play. It offers an insight into how these project owners may adapt or modify their resources to changing environmental conditions so as to develop required capabilities (see Helfat *et al.*, 2007; Teece *et al.*, 1997).

Additionally very little is known of how governance arrangements work in practice. Studies of governance from a project owner perspective have mainly focused on governance mechanisms at the front end (see Klakegg *et al.*, 2016; Williams *et al.*, 2012; Williams *et al.*, 2010). There is less focus on governance mechanisms such as coordination and operational readiness. This makes it difficult to determine what mechanisms work effectively in practice or otherwise and within what context.

## **CONCLUDING REMARKS**

Infrastructure projects, despite their importance to the economies of countries, consistently experience poor project outcomes. The focus of the literature in improving project outcomes has mainly been on the project supplier, despite the fact that the project owner has been identified as a major cause of project failure. This paper contributes to the emerging literature on project owners and their importance to the success of a project as strategic actors. In particular, we argue for and reemphasize the need for strong owners from an organisational capabilities perspective. This requires project owners to be involved in defining, interacting with its suppliers and managing the delivery of the project throughout its lifecycle.

The focus on governance capabilities shows that simply defining the project by way of strategic capabilities, and procuring the project supplier will not be enough to ensure success. The owner organization has to be involved in the project during actual implementation to assess the progress of the project, monitor progress and report to relevant stakeholders. This process serves as a check on the project supplier and provides insight to stakeholders on what needs to be done and when it has to be done. Further, it is also the case that completion of a project does not mean it is successful as projects completed within time and cost may nonetheless encounter operational failures. The owner needs to be able to integrate the completed asset into existing operations in order to operate and derive benefits from it. We have introduced project assurance, project coordination and asset integration as three sub-sets of governance capabilities and argued for how they form one part of the necessary owner project capabilities. Here we do acknowledge that project owners face resource constraints in being able to develop these capabilities. As a result we have suggested the use of the dynamic capabilities theory as a useful theoretical lens for understanding how public sector clients can develop the needed capabilities. This theory focuses on how organizations create new resource configurations using existing resources in pursuit of improved performance.

We have, through this paper, started to unpack the concept of project governance capabilities for an infrastructure owner. However, this only forms a baseline for further development of the construct, and we recognize that these may not be the full range of

mechanisms. There is the need for further research especially on how governance mechanisms work in practice, what context they are most suitable, and how operational readiness for instance occurs on projects.

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# PROJECT ALLIANCING: THE CASE OF ROAD INFRASTRUCTURE PROJECTS IN NEW ZEALAND

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In recent years, alliance contracting has emerged as a popular procurement route for large complex infrastructure developments in many countries. As part of a wider study to understand the extent of alliance contracting in the New Zealand construction industry, the basic features of an alliance, the alliance development process, the risk/reward compensation framework, and the governance structure of the alliance are discussed based on three case studies. Representatives from each case were interviewed and relevant documents were referenced as part of the data collection. The analysis revealed differences in the reasoning why a particular alliance approach was implemented, how the alliance selection process was conducted and what kind of structure was adopted for the governance of the alliances. Interestingly, a number of unique and innovative practices to alliancing were also highlighted, such as the construction phase starting during the interim project alliance agreement (iPAA) phase, alliance partners being chosen extremely early in the process and working as part of an interim alliance from the option development phase and, finally, the alliance manager not being from one of the consortium members but is instead an independent. The findings provide a basis and platform for discussion, especially for academics and practitioners, to gain more understanding in managing different alliance contracting projects in the construction industry.

Keywords: case study, project alliance, infrastructure, New Zealand.

## INTRODUCTION

Issues associated with the fragmentation of the traditional contracting approach, in the construction industries of both developed and developing countries, have led to recommendations to move towards a more collaborative and integrated delivery methodology (Egan, 2002). In response, a collaborative procurement approach, notably alliancing contracting, has been introduced to ensure the integration practice in delivering construction projects (Sakal, 2005; Walker and Lloyd-Walker, 2015).

An Alliance is a collaborative way of working, typically on large complex projects, that involves the integration of diverse organisations to overcome the project challenges. The alliancing method has been widely used in different continents, across different sectors and in different types of organizations (e.g. Chen *et al.*, 2012; Walker and Lloyd-Walker, 2016). Particularly in New Zealand, more collaborative approaches to construction procurement designed to achieve significant improvements in performance are now

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gathering pace in the industry (Ibrahim *et al.*, 2015). The emergence of project alliances over a decade ago has contributed to its significant establishment, specifically in infrastructure road development. Since then, thirteen road infrastructure projects, estimated at approximately \$4 billion have been successfully delivered or are being delivered as alliances (Ibrahim *et al.*, 2015).

The significant growth of alliances in New Zealand clearly represents a breakthrough in the development of alliancing and, hence, the exploration of its implementation is timely. Although many countries, for example Australia, are quite advanced in project alliancing procurement approaches, it remains a growing area for research in the New Zealand context. Similar to Australia, the New Zealand alliancing experience has also made a significant contribution to the body of alliance knowledge (Walker *et al.*, 2015). With the exception of a limited number of studies, particularly in Australia and a few other countries (e.g. Hauck *et al.*, 2004; Laan *et al.*, 2011; Jefferies *et al.*, 2014), the examination of practical evidence based on real-life project alliances remains elusive. Hence, the objective of this paper is to report on three real-life case studies of highway infrastructure projects procured under the alliance model. Owner and Non Owner Participant's (NOPs) representatives from different organisations were interviewed and relevant documentation for the cases was reviewed. Most importantly, essential features of alliances from these comparative case studies in relation to any similarities and differences are presented and discussed herein.

## **PREVIOUS CASE STUDIES ON PROJECT ALLIANCING**

The increasing attention placed on the project alliancing approach due to its successful implementation (for example, see Walker and Lloyd-Walker, 2016) has led to a number of case studies by academic researchers in this subject. For instance, the ACA (1999) reported how the first alliance project in Australia, the Wandoo B Offshore Oil Platform project, adopted collaborative contracting together with an alliance culture to achieve outstanding success. In another study Walker *et al.* (2002) reported on a case study of the National Museum of Australia constructed under the project alliance delivery approach, and highlighted differences between project partnering and project alliance that occur in the selection process, management structure and the risk and rewards mechanism. Walker and Keniger (2002) discussed the quality management system adopted on the same project in the context of integration of selection criteria and performance measures, and how these can deliver best for project outcomes. Hauck *et al.* (2004) also studied the same building to determine the extent to which project alliancing incorporated collaborative processes and concluded that project alliances for commercial buildings offer many advantages, especially in terms of the levels of collaboration among the project team when compared to traditional project delivery systems. In another study, Lingard *et al.* (2007) evaluated the impact of the compressed work week upon employees through work life balance in a case study of a dam project in Australia. It was found that the project alliance provided an ideal environment in which a good work life balance can help to create high performance work. In addition, Rowlinson and Cheung (2005) identified the critical success factors; trust, teamwork and collaboration as crucial drivers for successful alliance projects based on a case study of a wastewater treatment plant project in Australia. Finally, Jefferies *et al.* (2014) classified the project success factors (e.g. an integrated alliance office, project specific KPI's) based on water services project in Australia.

In addition to the above case studies in Australia, there were also attempts at studying project alliancing based on the case study approach in other countries. For example, in

the UK, Bresnen and Marshall (2000) focussed on an oil and gas project delivered under an alliance to explore the economic, organizational and technological factors that encourage or inhibit collaboration in practice. In another study, Laan *et al.* (2011) provided an insight into the establishment and maintenance of cooperative, trusting relationships under an alliance in a railroad project in the Netherlands. Vilasini *et al.* (2014) established a framework to streamline improvements in processes in a viaduct replacement in New Zealand. Finally, Plantinga and Dorée (2016) investigated the reasoning behind the development of the ‘project alliancing’ delivery system on rail infrastructure in the Netherlands. They indicated that the results (i.e. reasoning during the development processes based on a typology of the shared domain) in their study could help practitioners to reflect upon their motives and logic especially on the shared and pain/gain structures.

Based on previous studies, summarised in Table 1, it is clear that project alliancing studies from Australia are more prominent in the literature, compared to other countries. In terms of the themes of the research, the majority of the studies are focused on a wide range of topics from the concepts and principles, through to the implication of project alliances, with less focus on the features and structure of project alliances. In contrast, a recent study conducted by Walker and Lloyd-Walker (2016) set out to learn about the rationale for choosing an alliance through the involvement of experts from several countries. In addition, although there are established guidelines on the features and structure of project alliances available for reference (e.g. Ross, 2003), they are considered only as a basic guideline, as modifications on the agreement, features and structure of a specific procurement approach are expected to accommodate the challenges and complexity in managing the construction projects.

*Table 1: Summary of Previous Project Alliance Case Studies*

Authors	Focus	Country	Cases
ACA (1999)	Relationship contracting	Australia	Oil and Gas
Bresnen and Marshall (2000)	Building partnership	UK	Oil and Gas
Walker and Keniger (2002)	Quality management system	Australia	Museum
Walker <i>et al.</i> (2002)	Difference between project partnering and alliance	Australia	Museum
Hauck <i>et al.</i> (2004)	Collaborative process	Australia	Museum
Rowlinson and Cheung (2005)	Critical success factors	Australia	Wastewater treatment plant
Lingard <i>et al.</i> (2007)	Safety	Australia	Dam
Laan <i>et al.</i> (2011)	Relationship behaviour	Netherlands	Railroad
Jefferies <i>et al.</i> (2014)	Identifying critical success factors	Australia	Sewage infrastructure stations
Vilasini <i>et al.</i> (2014)	Framework for process improvement	New Zealand	Road Infrastructure
Plantinga and Dorée (2016)	Analysing the range of applications of the concept of project alliancing	Netherlands	Rail infrastructure

Given the increased popularity of alliance contracting in the development of large complex infrastructure projects, especially in New Zealand where they resulted in considerable cost and time savings (Ibrahim *et al.*, 2015), an exploration of its implementation is timely to see if there are any significant learnings to be taken from their continuing evolution. Consequently, this study intends to add to the above growing literature on project alliancing by reporting the findings of a research project designed to explore the use of project alliancing in New Zealand.

## **RESEARCH METHODOLOGY**

In this study, a comparative case study was selected as the most appropriate way to achieve the objectives of the research. It was also seen as the best way of capturing a wide range of views and opinions of respondents selected from an industry that is project driven and made up of many types of organizations and businesses (Yin, 2003).

Project alliancing in New Zealand was examined as the unit of analysis. The case study projects were identified in collaboration with the New Zealand Transport Agency (NZTA), who have been instrumental in promoting alliancing contracting in the New Zealand construction industry. Three case studies, referred to as Case 1, 2 and 3, are highway infrastructure projects that were currently being undertaken or were recently completed under an alliancing procurement approach at the time of this study. The cases selected are not individually identified, for confidentiality reasons, although the characteristics of the projects are described in Table 2.

*Table 2: Characteristics of the selected case studies*

	Case 1	Case 2	Case 3
Approx. Target Outturn Cost (NZD)	150 million	340 million	630 million
Brief description of project	Earthworks, Expressway and Bridges	Motorway, Urban Tunnel	Motorway, Bridges and Tunnel
Type of Alliance	Competitive	Pure	Pure
Numbers of NOPs	Two	Five	Six
Location	Hamilton	Auckland	Wellington
Phases during the study was conducted	Construction	Completed	Planning

### **DATA COLLECTION**

The main method of data collection was via semi-structured interviews. Questions focussed on the reasons for adopting an alliance procurement approach, as well as the processes and features embedded within the alliance. Examples of questions asked included; what were the main reasons of adopting the alliance approach? What kind of governance structure has been adopted in the alliance? How does the limb 3 pain/gain arrangement work in the alliance? Accordingly, the views of different stakeholders, including owner and each NOPs representative were sought. In this case, 16 representatives including owner, consultant and main contractor across the three cases were selected for interview (on average, 5 interviews were conducted per case). The interviewees within each case were selected according to the importance of their role in managing the project (ranging from Project Alliance Board (PAB), Alliance Management Team (AMT) and Wider Alliance Team (WAT)) and their experience and knowledge in project alliancing. The interview session with each interviewee was conducted at the project site office and lasted for about one to two hours.

In addition to the interviews, secondary sources of evidence were examined in order to verify the interviewee's statements. They provided relevant documents including the project's scope of work, in-house guidelines for implementing the alliance approach and relevant project reports. The documents were examined before, during and following the interviews. Secondary sources of evidence were used to support the primary source and minimise bias in data collection during interviews.

## DISCUSSION

Four key features were identified from the case studies to form the basis of the presentation and discussion of the data, as shown in Table 3.

Table 3: Summary of the four key features

Key features	Case 1	Case 2	Case 3
Motivation behind choosing an alliance	Lack of Designation and Consent, Need for Speedy Delivery	Project Complexity, Need for Speedy Delivery	Lack of Designation and consent, Need for Speedy Delivery, Complex Stakeholder issues, Environmental Issues
Alliance development process	Typical Competitive Alliance selection process	Standard Pure Alliance selection process Construction works started earlier, before the PAA was signed	Adopting 'early contractor involvement' Formation of alliance team prior to concept design
Risk/Reward Compensation Framework	Social Environmental Economic	Safety Environmental Stakeholder Relationships Quality Time Budget Supply chain engagement	Responsiveness Consent Conditions Quality of Engagement with Key Stakeholders Alliance Health
Alliance Governance	Standard three levels of governance (PAB – AMT –WAT)	New level of governance was introduced - Wider Leadership Team (WLT) – in addition to standard levels.	Local council part of Alliance and has a seat in PAB Alliance Manager is an independent member

### **MOTIVATION BEHIND CHOOSING AN ALLIANCE**

It is evident that there are significant differences between these three cases in terms of why the alliancing approach was implemented, how the alliance selection process was conducted and what kind of structure was adopted for the governance of alliances. In terms of the reasons for choosing an alliance model, it can be seen that the lack of designation and consent for necessary approval is one of the main reasons. For example, in Case 1 the Alliance Manager stated “They (the owner) had so many problems to deal

with. They didn't have a designation, they didn't own the land and there were a lot of uncertain things". In Case 3, the Alliance Approval Manager described "having the alliance team deal with planning and approval and to get it confirmed as early as possible was one of the main reasons for adopting the alliance". In addition, project complexity, need for speedy delivery and complex stakeholder issues due to high intensity of population, traffic and cultural heritage areas were also recognised. Finally, environmental issues were also cited where the project traverses areas of high-value ecological habitats. As explained by Walker and Lloyd-Walker (2016), internal (e.g. Best value, relational) and external (e.g. risk, competitive resources) pressures are known to be determinants that resembles an alliance.

#### ***ALLIANCE DEVELOPMENT PROCESS***

As for the alliance development process, it can be seen that across these three cases, two have been developed under a pure alliance and one under a competitive alliance. The findings indicate that, in general, there are no significant differences between how the pure and competitive alliance are implemented apart from the obvious - having one proponent in a pure alliance, compared to two proponents in a competitive alliance competing in the interim Project Alliance Agreement (iPAA) phase to determine the target outturn cost (TOC) of the project. However, interesting deviations from the norm were found in Case 2 and Case 3. In Case 2, it was found that the construction works started early, before the Project Alliance Agreement (PAA) was signed, due to the urgency to start the work because of the constraint of time and characteristics of the location (e.g. Surrounded by high intensity development). According to the Alliance Manager in Case 2 "the alliance team also advanced physical works at the same time as working up the TOC, whereas in normal alliance practice the construction phase doesn't start until the TOC is agreed". Thus, due to advancement of work while still finalising the TOC, an early works agreement (EWA) was established as part of the payment and insurance scheme. The Design Manager in Case 2 explained that "construction started during iPAA through effectively an early works agreement (EWA) which is a vehicle for payment and insurance. Everything done in early works got transferred over to the PAA". Typically, in a project alliance, the construction phase starts after the PAA is signed and all the necessary design and technical investigations have been completed, as seen practiced in Case 1.

In Case 3 the 'early contractor involvement' concept was taken to a new level of alliancing practice. The project alliance was formed prior to concept design, prior to Resource Management Act (RMA) public consultation and prior to approval made by the Environmental Protection Authority (EPA). This decision was taken by the owner (i.e. NZTA) in order to resolve the difficulties due to anticipated stakeholder opposition to the proposed expressway. There was consistent feedback from the interviewees that the need to manage the critically important relationships with local council and community in order to reconcile a complex set of values and issues including cultural environmental impacts and impacts on Māori-owned land led to the early establishment of the alliance. The Alliance Approval Manager and Design Manager in Case 3 argued: "[...] there were challenging issues particularly around the community and political issues [...] it definitely helped, giving the community certainty and client certainty to be able to move quickly in this public engagement phase". The Construction Manager in Case 3 also explained: "[...] it will bring us the advantage of understanding and gaining local knowledge in the area thereby eliminating a lot of second guessing and assumptions". The early involvement of the alliance team in the planning phase made a significant contribution to the stakeholder management and in establishing relationship bridges to

achieve breakthrough outcomes which are expected to benefit the further development of the project.

#### ***RISK/REWARD COMPENSATION FRAMEWORK***

The compensation frameworks adopted in the Case 1 and 2 alliance projects have the same alignment of project cost risk/reward based on sharing profits/loss between the owner and NOPs on a ratio of 50:50. As for Case 3, the official commercial arrangement had not been discussed at the time of the study. However, a special mechanism had been put place for the iPAA compensation structure. In principle, the interim alliance were paid its actual costs (limb 1) and corporate overheads (limb 2) incurred in providing the iPAA services. However, due to the fact that the PAA had yet to be signed, there was no mechanism for the pain/gain arrangement (limb 3). The Senior Manager in Case 3 maintained the view that since there was no pain/gain arrangement during this iPAA, all the pain, if there is any, will be borne by the NZTA if any unexpected issues occurred. Nevertheless, due to the importance of ensuring that this interim alliance is behaving like an alliance over a very long period (almost 3 years), a mechanism has been introduced to incentivise and motivate the performance of the interim alliance . One of the main attractions of alliancing is the ability of the commercial model to incentivise the alliance participants with non-cost KRAs that represent value to them (Ross, 2003). In addition, of the three limbs that form an alliance's overall compensation framework, the risk/reward model (limb 3) element appears to exert the most influence on team behaviour (Love *et al.*, 2011) . Alliance participants agreed to have a series of KPI to incentivise the performance of the alliance team during the iPAA phase. The Senior Manager and Design Manager stated that a “series of KPI to incentivise the team has been developed and a fee was set aside [...] we do have some KPIs, trying to give the team some incentives and motivation [...] these KPIs help breed the collaborative way of working” . As for the non-cost risk/reward model, every project has different types of KRAs with different values of bonus payment or penalty based on actual performance measured against non-cost KRAs. Depending on the needs of the individual project, the owner will decide what types of incentive to include to influence the performance of the team.

#### ***ALLIANCE GOVERNANCE***

In terms of the alliance governance structure implemented, all three cases use the typical three levels of governance, although in Case 2 an additional level called Wider Leadership Team (WLT) was introduced with the aim to distribute the leadership. The establishment of the WLT, featuring clearly defined roles and responsibilities and reporting lines to and from the Wider Alliance Team (WAT), was desirable due to the complexity in managing an urban tunnel project.

While the alliance governance structures appear to be reasonably similar, the representatives involved in the PAB and the designation of the Alliance Manager in Case 3 are worth noting. Regarding the former, the local council is represented on the PAB, although at this stage their role and involvement is still evolving. There was an agreement on the opinions from interviewees that it was taught that the involvement of local council was to indicate that the alliance team is embracing the concept of empowering the council to achieve the consultation outcomes which will maximise benefits for the respective community and stakeholders. Regarding the latter, it was found that the Alliance Manager in the early phase was independent (not from any of the NOPs) and had no construction experience, but he did have a successful track record in managing complex relationships with multiple stakeholders including local and national governments and agencies . Traditionally, the Alliance Manager comes from the main

contractor. Based on the investigation, it is believed that the main purpose of having an Alliance Manager as an independent was because the main focus during this early stage was to shape the relationships with the multiplicity of stakeholders, so that any designation and consenting issues can be finalised and lodged with the EPA within the time planned.

## **KEY FINDINGS FROM CASE STUDIES**

The investigation across these three cases has identified four unique elements to it which indicate significant modifications from the normal alliance practice. The first element is that the construction phase started during the iPAA phase, while the real cost of the project was still under development. This indicates the flexibility of the alliance agreement to adapt to a situation where continuous improvement and change in process are significant (Walker and Lloyd-Walker, 2016). The second element is that the Alliance partners were chosen extremely early in the process and will be working as part of an Interim Alliance during the early phases (e.g. Option development, scheme assessment report, statutory approvals, lodgement with the Environmental Protection Agency (EPA)). Early involvement of partners is the norm in an alliance, where the Alliance Partners would be selected after a recommendation is made by the EPA and the Interim Alliance formed thereafter with the Alliance proper formed in advance of construction. However, the Case 3 project takes the 'early alliance involvement' concept to a new level of alliancing practice. In this case, the external pressures of public engagement as well as issues related to consent and stakeholder, contributed to the decision to have interdisciplinary and inter-firm organizational arrangements in one entity. The third element and fourth elements are related on the governance structure. The third element is that the Alliance Manager, for the above interim alliance, was not appointed from one of the consortium members but is instead independent. The final element is that the local council are an Alliance partner, although at this stage their role and involvement is still evolving. The final two elements came about to response to complex engagement issues relating to key stakeholders and the community at large.

A comparative analysis of these three cases provides a multi-perspective view of the basic features in an alliancing implementation. As this paper reveals, the unique practices identified indicate that alliancing contracting is evolving to suit client and project needs for driving the delivery of complex roading projects with outstanding outcomes. A project alliance, in this context, allows consideration of a wider range of potential solutions as the owner and NOPS are not fixed on any particular project solution to meet strategic goals and are open to suggestions (Walker and Lloyd-Walker, 2016).

## **CONCLUSIONS**

The volume of projects recently completed and still on-going under the management of NZTA clearly represents a breakthrough in the development of alliancing in New Zealand. While typical alliance practices are innovative compared to practices in other procurement types, the maturity of organizations, particularly the owner and NOPS, have taken this a step further by hosting a new generation of procurement methodologies tailored to the needs of a particular project. These innovative practices have brought the alliancing concept to a new level of practice in New Zealand. For example, working in an interim phase over a very long dynamic period, while at the same time behaving like an alliance to ensure the success of the project. In addition, innovation is evident in the appointment of an independent Alliance Manager, as well as taking the local council on board as part of the alliance, in a situation where public engagement issues are significant. The findings show how the concept of alliancing and the flexibility of the alliance

agreement can overcome barriers and improve construction players' ability to manage complexity in different alliance contracting projects.

The findings from this study also have the potential to provide an opportunity for public and private organisations, both nationally and internationally, to understand how these practices could be a point of reference for the purpose of overcoming extreme challenges and achieving “breakthrough” results, where “business as usual” performance would not be sufficient. Finally, it is suggested that further research should be conducted in the context of a longitudinal study to examine the effect of these innovative practices towards the project outcomes.

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# OWNER PROJECT CAPABILITIES IN INFRASTRUCTURE PROJECTS: UNPACKING COMMERCIAL CAPABILITIES

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This paper investigates how the public sector organisations charged with the definition and delivery of large infrastructure projects are structured and resourced, and how they undertake the definition and delivery of the projects they promote. The paper locates its contribution in the theoretical literature on dynamic capabilities and its roots in the resource-based view of the firm. We take as our point of departure the emerging literature on client side project capabilities for infrastructure development - termed as owner project capabilities, referring to the dynamic capabilities that are required by public sector clients to develop infrastructure assets and deliver public services. More specifically, based on an extensive literature review, we focus on the owner project capabilities needed to develop and maintain commercial interfaces with the project-based firms which supply the human and material resources - which we dub commercial capabilities. Examples of such capabilities include, but are not restricted to, packaging capabilities, contracting capabilities, and relational capabilities. The conclusions lay bare the importance of rejecting the notion of project management as a best practice toolkit, which is always applicable and useful, to instead direct attention to which sets of capabilities should be deployed.

Keywords: public sector client, owner project capabilities, commercial capabilities

## INTRODUCTION

Many countries are presently facing the need for massive investments in social and economic infrastructure development - the so called 'infrastructure gap'. It is reported that an estimated value of US \$5 trillion per year in global infrastructure investment will be needed to support a future global population of 9 billion people by 2030, with an annual financing gap of about \$1 trillion (World Economic Forum, 2015). The economic role of social and economic infrastructure in modern societies is well understood (Stevens *et al.*, 2006); and the many contemporary pressures put on the scarce resources available, such as citizens' rising expectations, ageing infrastructure, urbanisation, and sustainability are well rehearsed. Cost and time overruns on major infrastructure projects are, however, prevalent. For example, research has shown that close to 90% of these large projects are subjected to cost escalation, and cost overruns of up to 50% are relatively common (Flyvbjerg, 2014).

To achieve satisfying project outcomes, three types of organisations take principle responsibilities in the project delivery process, the temporary project or programme organisation, owners and operators who invest in the project, and the project-based

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firms who supply human and material resources to the project (Winch, 2014). The project supplier's main job is to implement a project as required achieving goals of schedule, cost, and quality, while the project owner is responsible for choosing the right project and ensure its successful delivery (Merrow, 2011). All construction projects begin with an owner, who is responsible for instigating the project. For the infrastructure project, the owner is often a government or public sector organisation. Around the world these public sector clients are increasingly being questioned regarding their ability to achieve value for money in the projects they deliver and services they provide, and face the grinding pressures of improving infrastructure project delivery while cutting administrative costs. Rather ironically they are being asked to do more for less, i.e. produce more public value with fewer resources.

Concomitantly, the 'New Public Management' agenda (cf. Hood, 1995) promoting decentralization, disaggregation, outsourcing and downsizing has persuaded many that public sector clients do not really need to be able to engage in the project implementation process (Haque, 2007). There is, however, an increasing body of evidence that the process of capability outsourcing has gone too far, and that many owners now have too little capability to manage the projects they promote (cf. Hui *et al.*, 2008; Winch and Leiringer, 2016). For example, recent research in Hong Kong (Rowlinson, 2014) shows that most of the factors that have driven cost escalation in the Hong Kong construction sector resides firmly within the remit of the public sector clients. Therefore, this paper takes as its point of departure that public sector clients need the capability to manage the projects that they promote and invest. In other words, they need the competences and capabilities to define, manage and deliver the infrastructure projects efficiently and effectively. Given that most public sector clients will also have a stake in the operation of the built infrastructure asset, albeit that it might not be the same part of the organisation, we dub such capabilities 'owner project capabilities' (see Winch and Leiringer, 2016).

To acquire owner project capabilities, public sector clients need to develop and maintain in-house skills, competencies, and abilities to engage with the supply chain. Our particular focus lies in the commercial relationship between project owners and their suppliers or project-based firms. This is a topic that has received much research interest over an extended period (e.g. Pryke, 2004, Winch, 2010), in particular from a supply side perspective. For project suppliers, it is critical to have client-specific capabilities (Ethiraj *et al.*, 2005, Wethyavivorn *et al.*, 2009), which are built on repeated interaction with the owners over time and across various projects. Here we argue that, as the investors and operators of infrastructure assets, public sector clients also have continued interaction with suppliers; procuring services and products from them for the design, construction, and maintenance of infrastructure facilities. Hence, they in similar fashion need to develop supplier-specific capabilities. The importance of developing such commercial skills and competences when delivering complex projects has been widely acknowledged (e.g. Morse, 2009, Caldwell and Howard, 2010). These skills and competences needed to deal with the commercial relationship with project suppliers are here labelled as commercial capabilities.

This paper mainly focuses on the important role of developing 'owner project capabilities' for infrastructure development, with particular attention on commercial capabilities. We argue that public sector clients need owner project capabilities, especially commercial capabilities, to manage and deliver infrastructure projects. We take as our point of departure the concept of project capabilities (Davies and Brady, 2000, Brady and Davies, 2004, Davies and Brady, 2016) which is rooted in the

resource-based view and organisational capability view of organising. We then introduce the term ‘owner project capabilities’, and argue for how these can be understood as a set of dynamic capabilities. We then move on to the sub-sets of commercial capabilities and put forward an argument for the importance of developing, managing and maintaining commercial relationships with the project suppliers. We divide these commercial capabilities into three high-level sub-sets, packaging, contracting, and relational capabilities. We conclude by highlighting the importance of owner project capabilities, particularly commercial capabilities in ensuring project delivery. In doing so we reject the notion of a generic project management or management of projects toolkit. Instead we point towards the need to think about how different capability sets can be configured in different contexts.

## PROJECT CAPABILITIES

In the domain of strategy management, the essence of the resource-based view of the firm is that a firm's competitive advantage originates from its tangible and intangible resources and capabilities (Barney, 1991). To be capable of something is to have a generally reliable capacity to bring that thing about as a result of intended actions. Organisational capabilities are commonly referred to as the particular combination of skills, knowledge, competences, resources, routines, and behaviours, which enable effective organisational performance and competitive advantages of firms (Zollo and Winter, 2002). These capabilities are usually divided into two types: ‘operational capabilities’ which capture the day-to-day, month-by-month ability of the organisation to deliver on its mission and make a living; and ‘dynamic capabilities’ which capture the ability of the organisation to change and develop in order to meet new challenges (Zollo and Winter, 2002, Winter, 2003, Helfat *et al.*, 2007).

A sub-set of the vast and varied capability literature is that of ‘project capability’ introduced by Davies and Brady (2000), which stems out of research on innovation in complex product systems and project-based firms. This construct refers to the specific skills, knowledge and experience required by the project-based firms to develop bids and implement or execute projects, including pre-bid, bid, project, and post-project activities. This work has subsequently been developed in a number of publications (e.g. Brady and Davies, 2004, Davies and Brady, 2016) and has also influenced research work elsewhere. For example, client-specific capabilities and project management capabilities are identified as important in the software services industry (Ethiraj *et al.*, 2005). In the construction industry, Wethyavivorn *et al.*, (2009) identified six types of organisational capabilities which are essential to the performance of construction firms, such as procurement capability, construction capability, etc. Furthermore, Miozzo and Grimshaw (2011) analyzed the organisational capabilities (project capabilities) needed in outsourcing of IT services firms. Hence, there is a growing literature on project capabilities, which applies them on studies of the performance of project-based firms and in continuation the projects they work on. However, research on project capabilities has mainly focused on the project supplier side, rather than the owner side.

Building on the work on project capabilities and the realisation that investment projects are fundamentally about change in the owner organisation - either extending in scope its existing operational capabilities or resource base or creating new ones to meet challenges - it is possible to view project capabilities from the owner side as the permanent owner (client) organisation's ability to mount temporary projects. Indeed, what are operational capabilities for the supplying firm may well be dynamic

capabilities for a purchasing organisation (Winter, 2003). Owner project capabilities, thus, can be understood as the dynamic capabilities that are required to extend, improve or reconfigure operational capabilities or existing resource base to develop infrastructure assets and deliver public services.

For public sector clients in charge of providing infrastructure assets to the public, it is necessary to make good use of their limited resources (Pablo *et al.*, 2007). We argue that acquiring appropriate owner project capabilities is a good way to do so. Indeed, prior research has identified the importance for public sector clients to develop and deploy project capabilities. The term of 'intelligent client' (see for example Aritua *et al.*, (2009)), emphasizes the critical skills, competences, and capabilities needed by the public sector clients in the delivery of projects and programmes. Extensive reviews of UK National Audit Office reports and relevant interviews have found that for most public sector organisations, owner project (management) capability is an indispensable factor and can help facilitate better management of public projects (Cha *et al.*, 2015). Research has, indeed, shown that project owners with higher levels of owner dominance could lead to a higher chance to achieve better project outcomes (Hui *et al.*, 2008).

We take this argument a step further by unpacking the different sets of owner project capabilities. Corresponding to the three domains of project organising (Winch, 2014), owner project capability is made up of three distinct sets of capabilities, strategic capabilities, commercial capabilities, and governance capabilities (Winch and Leiringer, 2016). The term - strategic capabilities - refers to the capabilities the owner needs to manage its investment projects within its own organisation. Governance capabilities are those which are needed to manage the interface between the relevantly permanent owner organisation and the temporary project organisation. Commercial capabilities mainly focus on the interfaces between the permanent organisations, the owner organisations and the project-based firms or project suppliers who provide resources into the projects. The rest of the paper will particularly focus on the role of owner commercial capabilities.

For large infrastructure projects, it is rarely possible for public sector clients to undertake the whole project within its own organisation. Instead, they rely on resources from the project-based firms. Hence, these projects can be understood as a network of formal (contractual) and informal (trust-based) relationships, or interfaces, among different project parties. Managing these commercial relationships between the owner organisation and the relevant supplier organisations is crucial to project success (Winch, 2010). If not dealt with properly, interface problems may easily occur such as: lack of communication, coordination and trust between project parties; improper packaging design; mismatch between contract type and project nature; insufficient or lack of alignment between work-breakdown structure and awarded contracts (Weshah *et al.*, 2013).

To be able to effectively manage such interfaces there is a need for a blend of contractual and organisational arrangements (Hartmann *et al.*, 2010). The more complex the projects, the more important such commercial skills and competences become (Caldwell and Howard, 2010). We, therefore, argue that public sector clients need to acquire commercial capabilities to maintain a healthy commercial relationship with their suppliers. These capabilities allow the project owner to manage the broad commercial relationship with the suppliers of the services that allow the project to be developed and delivered (Winch and Leiringer, 2016).

The above realisation is of course not new and a variety of relevant research has been conducted, albeit not always explicitly, on different aspects of commercial capabilities in the project context, such as contractual and relational capabilities (e.g. Poppo and Zenger, 2002, Hartmann *et al.*, 2010, Caldwell and Settle, 2011), as well as owners' decision of work packaging (Globerson, 1994). Activities that fall under in the commercial relationship between project owners and their suppliers include but are not limited to package scope, contracting strategy development and contract management, knowledge and information exchange, and trust building. Below we synthesise these activities into three sub-sets of owner commercial capabilities, namely packaging, contracting, and relational capabilities.

Packaging capabilities refer to the owner's ability to develop contracting strategies by packaging the project scope into market-friendly clusters of work and coordinate the interfaces between different work packages (Winch and Leiringer, 2016). For a large or complex project to be properly managed and delivered, there is a need to slice it into manageable work packages. The approach to break down a large project into proper segments are often called the work-breakdown structure (WBS), which defines various tasks and is the building block of project planning, execution, monitoring and control (Globerson, 1994). Packaging is a starting point for scope management in projects and it underpins the interfaces between different packages, which should be managed by the project owners. Inappropriate work packaging design would hamper the control and coordination of project work. It is, thus, important for project owners to define work packages and coordinate between different packages.

To ensure the delivery of the whole project, project owners need to coordinate the interfaces between different work packages or project suppliers. Work package is a collection of related tasks and different packages are related to each other to some extent. Normally a work package is the basis for the subsequent management of tasks. Different types of interdependence between work packages require different coordination mechanisms from the project owners, as reflected in the seminal work of Thompson (1967). Various WBS patterns also call for different organisational structures and management styles during the project implementation (Globerson, 1994). Therefore, project owners should probably pay attention to packaging capabilities on how to coordinate the relationship between different project suppliers.

Contracting capabilities refer to the owner's ability to identify potential suppliers, select and motivate project suppliers (Winch and Leiringer, 2016). Contracting capabilities underpin the project owners' ability to select appropriate contracting strategies and procurement methods. The contracting strategy is considered as a critical factor influencing project performance. Different project contexts with different contracting strategies require different contracting capabilities for project owners. This issue has been exacerbated by the increasing use of new and complex procurement forms (Morse, 2009), such as public-private partnerships. Different procurement forms may need various combinations of corresponding capabilities to manage the contractual interfaces.

An important sub-set of contracting capabilities is contractual capability, which refers to the ability to design, write, negotiate, monitor, and enforce contracts (Argyres and Mayer, 2007). The construction project is supported by performance incentive and contractual relationship networks (Pryke, 2004). The aim is to manage the contingencies within transaction relationships with other parties so as to deliver the projects effectively and efficiently (Hartmann *et al.*, 2010). The appropriate match

between contract design and transactional attributes contributes to higher performance (Poppo and Zenger, 2002). Research has shown that when contracting parties have competences and knowledge about the exchange services or products, they are more likely to benefit from the experience and prior interactions and learn insights about how to better specify technical clauses in contracts (Vanneste and Puranam, 2010). Those with contract design capabilities could learn to write better contracts (Argyres and Mayer, 2007). Public sector clients need to pay attention to such contractual capabilities to deal with transactional relationships using contracts.

Most contracts are incomplete due to human bounded rationality and it is impossible to foresee all kinds of situations and anticipate possible contingencies (Poppo and Zenger, 2002). Relational mechanisms, such as trust and relational norms, are needed to complement contractual governance mechanisms in order to mitigate exchange hazards associated with asset specificity and uncertainty (Schepker *et al.*, 2013). Hartmann *et al.*, (2010 p.2) defined relational capabilities as “application of socially complex routines, procedures, and policies in inter-organisational relationships”, comprising organisational solutions, procedures, and competences.

In this paper, we define relational capabilities as abilities needed by project owners to interact effectively with project suppliers in informal (trust-based) relations. Good owner-supplier relationships bring about a smooth project working atmosphere (Wethyavivorn *et al.*, 2009), which are important for project implementation and firm performance. With the increasing adaptation of alliances, frameworks, and public-private partnerships, there is a call for more attention into the relationships between project parties. Such relationships between different parties could generate advantages by creating relationship-specific assets, access to complementary capabilities, knowledge flow between different partners, and effective governance to reduce transaction costs (Kale *et al.*, 2002).

Recent research on procuring complex performance (Caldwell and Settle, 2011, Hartmann *et al.*, 2010) has also identified the importance of owners ‘relational capabilities’ on complex projects to complement the more commonly highlighted transactional focused capabilities. These capabilities enable project owners to interact effectively with their supply chain and to select and implement the appropriate mix of formal or contractual and trust-based relations on the project (Poppo and Zenger, 2002; Hartmann *et al.*, 2010). Relational capabilities are thus considered as an important aspect for public sector clients to facilitate the relationship with their project suppliers. These three sub-sets of owner commercial capabilities are systemic. Different capabilities should be developed by project owners in different contexts. Packaging is the very first step to contracting strategy and the selection of procurement methods depend on the nature of packages. Project owners need to use different coordination mechanisms to manage the interfaces between project suppliers in different situations. The contracting strategy, in turn, influences the decision of contract forms and terms. Different contracting strategies require project owners to develop different contracting capabilities. Meanwhile, contractual and relational mechanisms often interact with each other and there is a call for more research into the relationships between project parties. By illustrating the important roles of the three sub-sets – packaging, contracting, and relational capabilities, we further emphasize the importance of commercial capabilities in ensuring a healthy commercial relationship between the project owner and its suppliers.

## **DISCUSSION**

As a major actor in the construction process, the project owner could be argued to play the most important role in the process of project management and delivery. However, as we have argued above there is a growing awareness that public sector clients might well lack necessary capabilities to deliver the projects they promote. In no small way, this is caused by the increasing use of various forms of management contracting, the outsourcing technical expertise, as well as the inability to retain necessary in-house resources, skills, competences, and knowledge. Against this backdrop, there is a real need for public sector clients to realise the importance of building in-house capabilities rather than consulting and outsourcing; as well as deciding which capabilities should be maintained and which could be sourced from the suppliers.

Commercial capabilities, as an important dimension of owner project capabilities, are essential for project owners to manage the commercial relationship with project-based firms, which supply tangible and intangible resources to the projects. Few, if any, public sector clients (project owners) have the internal resources to undertake major projects in-house; instead they need to rely on project suppliers for these resources. The commercial interfaces between owners and suppliers are, therefore, crucial for achieving acceptable project performance. Meanwhile, we have here, based on the extant literature, put forward three sub-sets of commercial capabilities: packaging, contracting, and relational capabilities. All these capabilities could help project owners facilitate the commercial relationship with suppliers. Public sector clients thus need to develop in-house commercial skills and competences so as to ensure successfully infrastructure project delivery.

We claim no novelty to the included activities and tasks. These have all been dealt with at length in previous research. What is important here is the context. It would, however, be erroneous to suggest that public sector clients simply need to acquire all sets of owner project capabilities or these capabilities could simply be transferred across different contexts. Different contexts call for different combinations capabilities to ensure project management and delivery. To acquire all sets of commercial capabilities may not always be possible, or desirable. Instead, what is needed is a comprehensive understanding of what kinds of capabilities are needed to manage projects and deliver assets in different contexts. For instance, different scope packaging, various procurement types or contracting strategies, and different contract types demand project owners to acquire different corresponding capabilities to deal with the commercial relationship with project suppliers. These commercial capabilities need to be contextualized and match with the nature of projects and the attributes of the relationship between project owners and suppliers. In this scenario, a key area deserving of research, in order to further our understanding, is that of how different capability sets can be configured by project owners in different contexts for project management and delivery.

Further to the above comes the question of how project owners can develop and deploy these capabilities in practice. This is another key area which deserves further research. The questions are many. For example, is it better to develop the capabilities within the own organisation or depend on consultants? If the latter, how can the owner organisations learn and accumulate experiences and knowledge through repeated interactions? Is it feasible for them to invest in specific human and material resources? This line of inquiry could lead to a more comprehensive understanding of how to make use of owner project capabilities in practice. It could also add theoretical

contribution to the literature of dynamic capability view on how to develop and maintain dynamic capabilities.

Finally, the project management literature often focuses on the project itself in terms of achieving goals of time, cost, and quality and current project management practice concentrates on tools and techniques and an execution-oriented approach to managing projects (Morris, 2013). However, a project is part of the larger organisational context. It is within this context that the project is shaped, defined, delivered, and managed. So, instead of treating project management or management of projects as a best practice toolkit, focus should be directed on to the skills, competencies, and capabilities needed by project owners and project-based organisations. We therefore suggest the need for more attention towards the owner organisations and call for more research exploring into their critical role in managing and delivering projects.

## CONCLUDING REMARKS

To sum up, the role and capabilities of public sector clients have to some extent received inadequate attention. The aim of this paper is to contribute to a better understanding of owner project capabilities and calls for public sector clients in the construction sector to develop owner project capabilities in general, and commercial capabilities in particular, to deliver and manage infrastructure projects. The important role of commercial capability and its sub-sets is emphasized. With the concept of 'owner project capabilities' as our starting point, we have highlighted the commercial interfaces between owners and suppliers as an area worthy of further attention. We have attempted to provide a broader organisational perspective and more comprehensive understanding of project management research by focusing on the capabilities which need to be developed by project owners.

By addressing the above ideas, we hope to have taken a step ahead in illustrating the role of project owners in the project management domain, especially in the infrastructure project delivery area, and stimulating following research work. Though this paper has outlined why owner project capabilities, as well as commercial capabilities, are needed by infrastructure clients, no empirical data was collected to support such arguments. Recent research (Cha *et al.*, 2015, Davies *et al.*, 2016, Winch and Leiringer, 2016) does, however, provide a good starting point for following empirical studies to focus on the project capabilities needed from the owner perspective. Further work is needed before we can achieve a comprehensive understanding of owner project capabilities and how firms could obtain and, more importantly deploy, different sets of owner project capabilities in different contexts.

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# **CONTRACTS AND RISK**



# THE POTENTIAL OF BIAS IN MULTI-TIER CONSTRUCTION DISPUTE RESOLUTION PROCESSES

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Disputes have been identified as the inevitable happening in highly competitive construction contracting business. Amicable dispute resolution is welcomed by the construction industry. With major changes in Hong Kong construction dispute resolution landscape, wider use of alternative dispute resolution (ADR) methods has been advocated. As such, multi-tier dispute resolution (MTDR) processes incorporating ADR have become the design protocol for dispute resolution provision in contracts. Moreover, the use of multi-tier dispute resolution (MTDR) does not guarantee dispute can be resolved without the need to resort to formal proceedings. In some cases, multi-tier resolution processes may cause unintended obstacles against settlement. The possibility of biases creeping in may be one of those. The aim of the study is to examine the potential of bias on the part of the disputants as well as the neutral third party in MTDR processes. Among the types of bias reviewed for this study, anchoring appears to be the most likely bias that may creep in during MTDR processes. The concept of anchoring bias and its characteristics are therefore examined. The study points to further study on the means to alleviate the influence of anchoring bias in MTDR.

Keywords: bias, multi-tier construction dispute resolution, obstacles.

## INTRODUCTION

Promoting the use of alternative dispute resolution mechanism (ADR) is one of the strategies in enhancing the efficiency of the construction industry in Hong Kong (CIRC 2001). The use of ADR aims to reduce non-productive use of scarce resources in protracted and costly dispute settlement. It is well recognized that if negotiations or neutral-assisted resolutions are successful at project level, then the construction industry as a whole could reduce unproductive use of resources on dispute resolution. Furthermore, it is undisputed that dispute resolutions through arbitration and litigation take much longer time and are far more costly than using ADR. Therefore, dispute resolution clauses in construction contracts have typically incorporated ADR as an integral part of multi-tier dispute resolution (MTDR) process. As such, the success of using multi-tier dispute resolution (MTDR) process that embraces ADR should be welcomed by all stakeholders in construction contracting business. This study examines the potential of bias that may happen in MTDR processes.

Englich and Mussweiler (2001) found that even judicial decisions were influenced by bias. In the experiments of Englich *et al.*, (2006), participating legal experienced professionals anchored their decisions on a given sentencing demand and biased

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toward it even if this demand came from an irrelevant source. The randomization is so extreme that the anchors may even be determined by throwing a pair of dice by the participants. These findings suggested that the decisions of experienced experts are also subject to bias.

In essence, a dispute is likely to be evaluated several times in a MTDR process. The possibility of bias creeping in during the decision making process is real. This study posits to explore the conceptual bases of bias in MTDR processes. Bias on the part of the disputants as well as neutral third party are discussed.

## **MULTI-TIER DISPUTE DISSOLUTION (MTDR) FOR CONSTRUCTION DISPUTES**

### **Contractual use of MTDR**

MTDR for construction disputes can occur in the contractual regime and beyond. Dispute resolution procedures in construction contracts have undergone notable evolutions in the last few decades. Resolution mechanism stipulated in contracts has become more complex (Cheung 1999, 2010, 2014). The contractual alternative dispute resolution movements in Hong Kong construction industry have four milestones. First is the Private Sector Form of Conditions of Building Contract 1976 Edition, in which the 2-tier dispute resolution system includes architect's decision and arbitration. Second is the Hong Kong Government (HKG) General Conditions of Contract for Building Works 1999 Edition, which incorporated mediation to follow engineer's decision with arbitration being the final contractual resort. The third milestone is the 4-tier system used in dispute settlement system designed for the HKG General Conditions of Contract for Airport Core Programme (ACP) Civil Engineering Works, 1992 Edition.

The 4-tier includes in sequence engineer's decision, mediation, adjudication and arbitration. The fourth milestone is Dispute Resolution Procedure under Provisional Airport Authority (PAA) Conditions of Contract that also has a 4-tier dispute resolution process, namely i) project manager's decision, ii) project director's decision, iii) dispute review panel and iv) arbitration. It is notable that the development of dispute settlement clauses in Hong Kong is characterised by the wider use of ADR as intermediate step before arbitration. These multi-tier systems attempt to get the dispute resolved either by the help of neutral third party in mediation or earlier involvement of senior members of the employer organisations. The salient feature is that the dispute will be considered several times before reaching the final contractually designated device of arbitration. In order to achieve the desired outcome of a MTDR system, the contract clauses must be well drafted. The process should be explained clearly in terms of procedural requirements such as time for action. The consequences of non-compliance should also be unequivocally stated.

### **MTDR beyond the contractual regime**

In order to achieve the more effective and economic dispute resolutions, government greatly encouraged negotiations and mediations to be attempted before activating expensive and time-consuming arbitration and litigation. Moreover the contractual use of ADR under multi-tier dispute mechanism is voluntary and can be skipped by the parties to the contract (Cheung, 2010). In contrast, legal intervention has also been noted. Under the Civil Justice Reform in 2009, the Judiciary published Practice Direction 6.1 (PD 6.1). Section F of PD 6.1 states that parties in construction are encouraged to attempt mediation and in order to promote the use of mediation, the

Court may impose cost sanctions where a party unreasonably refuses to attempt mediation. Cost sanctions may also be ordered if either party doesn't meet the committed minimum amount participation in mediation.

The introduction of 'Med-Arb' provision under the 2011 Arbitration Ordinance (CAP 609) allows arbitrators to act as mediators prior to or following an arbitration with the consents of both parties. The Impending Security of Payment Legislation (SOPL) in Hong Kong will introduce adjudication as a statutory interim dispute resolution mechanism for time and payment related disputes. Similar arrangement first came into force when the Parliament of the United Kingdom passed the Housing Grants, Construction and Regeneration Act in 1996. The number of dispute referred to adjudication increased immediately after the introduction of SOPL (Adjudication Reporting Centre 2013). Similar legislations can be found in Australia, Singapore, Malaysia and Ireland. Nowadays, statutory adjudication with binding decision is employed to handle construction payment-related disputes in United Kingdom, New Zealand, Australia and Singapore. Moreover, United Kingdom and New Zealand also employ it to handle non-payment related construction disputes (Cheung, 2010). The above collectively demonstrate the trend in using multi-tier processes incorporating ADR mechanism beyond the contractual regime.

From the development of contractual dispute resolution mechanism and the legal intervention, it can be concluded that multi-tier dispute resolution (MTDR) incorporating alternative dispute resolutions (ADR) has developed substantially and is now the predominant approach in construction dispute management.

## **BIAS IN DECISION MAKING**

Decision making is built upon an intricate process of receiving, extracting, and communicating information in which people have to exercise judgments (Klayman, 1995). Scholars have been studying different types of bias that might occur in exercising judgment. Some of the common types of bias identified are anchoring, overconfidence, confirmation, hindsight and self-serving.

Anchoring bias greatly influences judgement because of the assimilation of previous impression (Sherif *et al*, 1965; Sherif and Hovland, 1961; Mussweiler *et al*, 2004). Decision makers tend to rely too much on the first set of information received (Tversky and Kahneman, 1974). Moreover the first set of information can simply be random and un-informing starting points (Chapman and Johnson, 1999). In some situations, the opening offer can just be a tactical ploy. Besides, the adjustment from the anchoring information to the final result is usually insufficient and prematurely done (Tversky and Kahneman, 1974). People tend to reach a final result because it is accessible (Epley and Gilovich, 2006), perhaps it is the easiest-reach among the large region of acceptable results (Quattrone *et al*, 1984; Wilson and Brekke, 1994). So as the vivid name speaks for itself, the final inaccurate judgments are outcomes of the anchors.

Being too confident over the accuracy of the judgment or the outcome of the decisions is another type of bias in decision making. Klayman, *et al.*, (1999) called this as overconfidence bias that is more noticeable in complex decisions. Moore and Healy (2008) identified three kinds of overconfidence behaviour: i) overestimation of one's actual performance; ii) overconfidence of one's performance compared to others'; and iii) overconfidence about the accuracy of one's judgment. As suggested by Pitz (1974), people are overconfident with general knowledge items of moderate or

extreme difficulty due to hyper precision effect. Interestingly, overconfidence is apparently correlated with anchoring bias. Block and Harper (1991) explained that people were inclined to overestimate the probability of conjunctive event. Since it provides a natural starting point, therefore creating an unwarranted confidence that the judgment is correct.

It is a basic trait that people will always look for evidence to prove their stance rather than opposing them. Confirmation bias is a form of bias where information is gathered and recalled selectively to support current thoughts or preconceived assumptions (Klayman, 1995). Klayman used a method called “Positive Test Strategy” to verify the existence of confirmation bias. In this method, the subjects were asked to identify a rule that applied to series of triple numbers, e.g. 2-4-6. Subjects may construct other sets of three numbers to test their assumptions about the rule the experimenter has in mind. The experimenter will then clarify whether those three numbers are satisfactory or not. Subjects were told to stop guessing once they were confident about their answer. From this experiment, it was found that most of the subjects were confident that the rule was it should be even number, with the addition of two. With the hypothesis generated themselves in mind, subjects automatically tried to confirm the hypothesis, but not attempted to challenge another set of odd number, 3-5-7, which was agreeable as well.

Individual’s overestimation of the happening of certain event, despite having been little or no basis for predicting it, is next type of bias to be studied (Hoffrage and Pohl, 2003; Roese and Vohs, 2012). Slovic and Fischhoff (1977) explained this type of hindsight bias happened when people “exaggerate the predictability of reported outcome”, therefore boosting the perceived probability of occurrence as much as fifteen percent. In 1988, Dawson and his colleagues conducted an experiment in regard to prove the existence of hindsight bias by presenting four medical cases to physicians and medical students. Some of the subjects were told the correct diagnosis while some others were not. Those who were not told the diagnosis were instructed to rank five possible diagnoses, whilst the others who have known the outcome were ordered to put themselves on the shoes of the decision makers and diagnose the case according to their own opinion. It was noted that 50% of the hindsight subjects gave the correct answer, as opposed to the other group in which only 30% managed to give the correct answer; thus confirming the presence of hindsight bias in human judgment.

This next type of bias is called self-serving bias. It is often the case that people take credits for their successes but blame others for failures simply because this trait acts as a motivation to sustain one’s self-worth. Beckman (1970) conducted a simple experiment where subjects were told to teach math to fourth grader students. Students were programmed in which one of them will fail and the other will succeed. Subjects then were asked to evaluate their performance with respect to their students’ test result and it was proven that the subjects whose student succeeded took all the credits for themselves while the subjects whose student failed either blamed student’s incapability of executing the problem properly or other external factors. This type of bias is often done unconsciously, due to the trend that people attribute positive outcomes as internally caused and negative outcomes as externally caused.

After studying the characteristics of the five types of bias, the study proposes that anchoring bias is likely the most probable type of bias that may creep in MTDR. In a MTDR process, the result of previous tier of resolution may act as the anchor affecting next tier of process. Decisions of disputants, third party neutral and judges

are susceptible to anchoring bias once they are involved in more than one tier of the MTDR.

## **ANCHORING BIAS IN MULTI-TIER DISPUTE RESOLUTION**

The existence of bias is an unjustified departure from the ground rule that “justice has to be seen”. The most potential type of bias existing in multi-tier dispute resolution processes is anchoring bias. This study conceptualizes anchoring bias in MTDR by analysing its characteristics and academic explanations. Biased behaviours in MTDR are examined.

Previous research studies found that it was quite natural that people made decisions with reference to previous relevant anchors. Researchers found more striking observation that anchors still have influence even when these seem to be irrelevant, un-informative and plausibly extreme or self-generated (Chapman and Johnson, 1994; Strack and Mussweiler, 1997; Chapman and Johnson, 1999; Mussweiler *et al.*, 2004). And it happens independent of people’s expertise, no matter experienced or not (Englich *et al.*, 2006; Northcraft and Neale, 1987; Mussweiler *et al.*, 2004; Wright and Anderson, 1989). Besides, anchoring bias occurs no matter what the motivation is. This cannot be avoided even with reminder of the bias potential (Wilson *et al.*, 1996). In MTDR processes, it has been found that accomplished trial judges with an average of more than 15 years of experience were influenced by authentic but normatively irrelevant sentencing demands, even if the demands were made by non-experts or determined randomly, even by random numbers extensively used in a prior task or during the trial (Englich and Mussweiler, 2001; Englich *et al.*, 2006; Wilson *et al.*, 1996).

Anchoring effect is proposed to be an appropriate theoretical explanation of biased behaviours in MTDR processes. The first explanation of anchoring bias is insufficient adjustment (Tversky and Kahneman, 1974). Anchoring effect involves two processes, firstly people make judgment from an initial value (anchor), then make adjustment from the starting point to a final estimation or decision. Moreover, the adjustments are usually insufficient and prematurely terminated. Many researchers tried to figure out the reason why the adjustment was insufficient. For example, Quattrone *et al.*, (1984) proposed that when making adjustment from the starting reference, people tended to stop as soon as they got into a region of acceptable answers. The adjustment process terminated once they found the first acceptable value (Mussweiler *et al.*, 2004; Wilson and Brekke, 1994). Chapman and Johnson (2002) further added that adjustment was not effortful and terminated too early because of the lack of cognitive resources. Accordingly, in MTDR processes, negotiations are significantly influenced by the first offer (anchor), the more a seller asks for, the higher the negotiation outcome; the less a buyer offers, the lower the negotiation outcome (Chertkoff and Conley, 1967; Galinsky and Mussweiler, 2001; Thompson, 2008; Schweinsberg *et al.*, 2012). Besides, people tend to suffer anchoring effect from irrelevant information during number estimation (Neale and Bazerman, 1992; Tversky and Kahneman, 1974; Huber and Neale; 1986; Northcraft and Neale, 1987). During negotiation, the neutral third party makes insufficient adjustment from the first offer, so the final estimation arrives around the initial values. Furthermore, the outcome of negotiation may act as an anchor, and the same third party in next tier of dispute resolution probably would make insufficient adjustment from the previous result, therefore dispute resolution at the next tier is biased towards anchor.

Conversational hint is another explanation of anchoring bias. In some experiments, subjects considered the information (anchor) provided by the experimenters as very plausible, informative, so they made estimation largely based on the anchors (Jacowitz and Kahneman, 1995; Grice, 1975). In this connection, decisions and judgment were made on the belief of subjects that the values of target were of great vicinity and relevancy with the anchor (Northcraft and Neale, 1987; Mussweiler *et al.*, 2004). In MTDR processes, Med-Arb arrangement or mediation before trial, the neutral third party could take the information they get during mediation into account. And their judgment in the present resolution phase could greatly rely on their belief in the information collected before.

Selective accessibility model is another explanation of anchoring effect (Mussweiler, 1997; Mussweiler and Strack, 1999; Strack and Mussweiler, 1997). The mechanism works on the basis of the proposition of a two-step judgment-making process. First, human make comparison between the estimation target and anchor, then followed by final estimation. During the comparison process, the approach of “hypothesis-consistent testing” is applied. This means human compare the target and anchor by testing the hypothesis that the target is same as the anchor (Mussweiler, *et al.*, 2004). The result of the comparison is that it increases the accessibility of anchor-consistent knowledge of the target, which helps the final estimation arrives at the vicinity of the anchor (Mussweiler, *et al.*, 2004). Chapman and Johnson (1999 and 2002) proposed “anchoring as activation” in a decision making process. It is proposed that anchors influence judgment by changing the availability, construction or retrieval of features of the target. It has been found that judges have been affected by anchors that creep in and legal decisions were resulted (Chapman and Bornstein, 1996; Hastie *et al.*, 1999; English *et al.*, 2006). It has also been shown that even trial judges were influenced by authentic information used or collected in a prior task or during the trial (English and Mussweiler, 2001). Information and results of prior alternative dispute resolution (ADR) may activate the features that the current judgment and previous results had in common, leading to a biased estimation.

## **WAYS TO AVOID BIAS IN MTDR**

From the review of studies on anchoring bias, it can be observed that even when the subjects have been reminded that their judgment may be influenced by the anchoring information (Wilson *et al.*, 1996), the influence persists. How to eliminate the effect of bias? Analysing the results of the experiments of Chapman and Johnson (1999), researchers found that trying to find the differences between the anchor and the target deliberately, or consider the reasons and features inconsistent with the anchor can reduce the effect of anchor. Lord, *et al.*, (1984) called the manipulation to consider the inconsistent reasons, features and alternatives as “considering the opposite”. Therefore, trying to find the differences between the result of the previous tier of resolution and the present judgment deliberately, or consider the reasons and features inconsistent with previous collected information can reduce the effect of anchoring bias. Similarly, Diamond (2015) proposed that the presiding arbitrator should ask each party to provide a best case for the other side, which would encourage each party to look into opposite facts and to counter bias. Besides, in the same study, Diamond (2015) also stated that it would be better to have an arbitrator panel instead of a single arbitrator. Because debates and opinion exchange can provide the opportunity for arbitrators to consider the judgment carefully.

## CONCLUSIONS

Dispute resolution is a fact of life in construction contracting. The use of multi-tier dispute resolution processes (MTDR) incorporating ADR has become the norm for resolving construction dispute. As such, a dispute is likely to be evaluated several times in a MTDR process. Bias may creep in when a dispute is evaluated at different tiers of a MTDR process and affect those who are involved in more than one tier. Among the possible types of bias, anchoring bias is proposed to have the potential to creep in MTDR. The study examined concepts and characteristics of anchoring bias. The study suggests some methods and mechanisms to reduce bias effect in MTDR processes. Further studies in this regard would be of both academic and practical value.

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# EVERYTHING'S COMING UP (SILK) ROSES\*

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The enactment of the Housing Grants Construction and Regeneration Act 1996 transformed the dispute resolution landscape within the UK construction industry. The ability of one party to a construction contract to take any dispute to adjudication at any time quickly superseded arbitration as the traditional dispute resolution process within the industry. The Adjudication Reporting Centre (ARC) at Glasgow Caledonian University was established in 1999 and subsequently published twelve annual reports. Data was collected each year from Adjudicator Nominating Bodies and a sample of practising Adjudicators. This paper collates the data gathered over the full twelve-year life of ARC to date and analyses longitudinal trends such as the number of adjudications reported, seasonal variations, matters and values in dispute, proportion of winners and losers, fees charged by adjudicators, etc. Conclusions are drawn about the changing nature of adjudication since its inception.

Keywords: adjudication, contract law, dispute resolution.

## INTRODUCTION

Following an extensive review of procurement and contractual arrangements in the UK construction industry, Sir Michael Latham (1994, 91) recommended that: a system of adjudication should be introduced within all the Standard Forms of Contract; that there should be no restrictions on the issues capable of being referred to the adjudicator; that the award should be implemented immediately; and that any appeals to arbitration or the courts should be after practical completion.

Pickavance (2016, p.3) defined Construction Adjudication as an interim dispute resolution procedure by which the parties submit their dispute to an independent third party for a decision. Henderson, Turnbull and Frame (2015, p. 338) stated that [The 1996 Act] was, arguably, the most significant piece of legislation to affect the construction industry for decades. [T]he aim of the 1996 Act was to offer a quick means of resolving disputes. Simmonds (2003, pp. 3-4) opined, however, that adjudication in one form or another had been around for some time. For example, in 1997 it was introduced into various forms of building subcontracts such as DOM/1 and NSC4 (now NSC/C). Only a handful of set-off disputes were referred to adjudication. According to Coulson (2007, p. 9), what was radical about the recommendations of the Latham Report was that adjudication would now be the compulsory first step in any dispute arising under most construction and engineering contracts. In *Macob Civil Engineering Ltd. v Morrison Construction Ltd.* (1999) Dyson J stated at [14] that, 'The intention of Parliament in enacting the Act was plain. It was to introduce a speedy mechanism for settling disputes in construction contracts

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on a provisional interim basis, and requiring the decisions of adjudicators to be enforced pending the final determination of disputes by arbitration, litigation or agreement. In *Nikko Hotels (UK) Ltd. v MEPC Plc* (1991) Knox J stated at [108B]. 'If [the adjudicator] has answered the right question in the wrong way his decision will be binding. If he has answered the wrong question, his decision will be a nullity.' In *Carillion Construction Ltd. v Devonport Royal Dockyard Ltd.* (2005) Chadwick L J stated at [86] that the need to have the 'right' answer has been subordinated to the need to have an answer quickly. The essence of UK construction adjudication is, therefore, the statutory right to refer any dispute to adjudication at any time, to get a quick decision which must be implemented immediately on a temporary binding basis to be finally settled by arbitration, litigation or agreement.

## FINDINGS

Following the introduction of the Housing Grants Construction and Regeneration Act in 1996, Glasgow Caledonian University set up a UK-wide Adjudication Reporting Centre to gather data on the progress of adjudication and disseminate this back to the construction and property industries. This research was supported by the Adjudication Nominating Bodies (ANBs) which were asked periodically to complete a detailed questionnaire and return it to the Centre. The first phase of the research was to consider who was carrying out the adjudications, how many there were and how the adjudication process was developing. Sixteen Adjudicator Nominating Bodies provided a service throughout the UK and five were based in Scotland. All were approached and sent Questionnaires for completion. Fifteen ANBs responded to the questionnaires initially and this number had grown to 21 by 2012. The second phase sought to provide more information about the adjudications themselves by collecting data from the adjudicators who were invited to respond confidentially to the Centre. Approximately 60 responses were received annually.

*Table 1: Adjudications by all reporting ANBs*

Time Periods	Referrals	Growth
May 1998 - April 1999	187	
May 1999 - April 2000	1309	600%
May 2000 - April 2001	1999	50%
May 2001 - April 2002	2027	1%
May 2002 - April 2003	2008	-1%
May 2003 - April 2004	1861	-7%
May 2004 - April 2005	1685	-9%
May 2005 - April 2006	1439	-15%
May 2006 - April 2007	1506	5%
May 2007 - April 2008	1432	-5%
May 2008 - April 2009	1730	21%
May 2009 - April 2010	1538	-11%
May 2010 - April 2011	1064	-31%
May 2011 - April 2012	1093	3%

Table 1 highlights the sharp rise in the number of adjudication appointments from 1999 to 2001. Then a steady decline in referrals can be seen from 2004 to 2006, an increase in referrals in 2007 and then the return to the decline in referrals again in

2008. A sharp increase in referrals of 21% in 2009 was followed by a reversal the next year and a further substantial decline of 31% in 2011. This was the second lowest number of annual referrals reported since the first year when 187 were reported following implementation of the HGCR Act in 1998. There was a small increase of 3% in 2012 and although the continuous decline from 2009 has halted, the upturn was only marginal.

Intuitively, it may be thought that the number of referrals would fall when the construction industry was booming and, conversely, a recession would generate a higher number of referrals as contractors and sub-contractors strove to secure payments. The numbers of Referrals adjusted to an annual January to December basis show a slightly different profile to the original May to April series and this was compared with Annual Construction Output. It was clear that there was an inverse correlation between construction output and adjudication referrals. This was not unexpected.

It appeared that referrals varied in number throughout the year. In order to smooth the series, the monthly referrals were calculated as a percentage of the annual total and averaged over the period. It was clear that there was a primary peak in November, a secondary peak in March and a tertiary peak in June/July. Why these peaks should occur at these times is difficult to explain. It may be that referrals are launched in November to spoil the Responding Party's prelude to Christmas, and in March to affect the Easter Break. That would subscribe to an 'ambush' theory of Referrals which may or may not be true. It is clear, however, that November was the most popular time to submit a Referral to adjudication and December the least popular.

Table 2: Number of Adjudicators

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2010	2011	2012	Av.
Total	843	1012	1170	1203	998	1135	1128	1036	967	966	873	825	915	1005

The reporting year was the end of April. The total number of adjudicators registered with the listed Adjudicator Nominator Bodies (ANBs) shown in Table 2 ranged from 843 in 1999 to 1203 in 2002 with an average of 1005. The major nominating bodies were: Chartered Institute of Arbitrators (CI Arb) with an average of 147 Adjudicators; Technical and Construction Solicitors with 127; Association of Independent Construction Adjudicators with 115; Construction Industry Council (CIC) with 117; Royal Institution of Chartered Surveyors (RICS) with 108; Technology and Construction Bar Association (TechBar) with 82; Institution of Civil Engineers (ICE) with 79; Royal Institute of British Architects (RIBA) with 66.

All Adjudication Nominating Bodies indicate a reduction in the number of appointments between 2002 and 2012, with a few exceptional years. By far the biggest appointer was The Royal Institution of Chartered Surveyors (RICS), with an average of 925 appointments per annum, but even it suffered a reduction in appointments from 1077 in 2004 to 626 in 2012, a reduction of 41.9%.

The reporting year was the end of April. The average proportion of the total for the period was: Quantity Surveyors 37.2%; Lawyers 22.1%; Civil Engineers 14.9%; Architects 9.4%; Construction Consultants 4%; CIOB Builders 3.1%; Building Surveyors 1.5%. The proportion of Quantity Surveyors fell from 44.5% in 2000 to 34.8% in 2012, whilst that for Lawyers rose from 10.2% in 1999 to 34.5% in 2012. Lawyers and Quantity Surveyors each had a third of the total in 2012. The proportion of Architects fell 72.9% from 16.6% in 1999 to only 6.5% in 2012. The proportion of

Building Surveyors, in contrast, increased from a mere 0.9% in 1999 to 2.2% in 2012.

Table 3: Primary Disciplines (Percentage)

DISCIPLINE	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2010	2011	2012
Quantity Surveyors	38.5	44.5	41.1	28.9	43.8	41.6	38.8	35.7	34.5	31.4	33.5	37.0	34.8
Lawyers	10.2	22.0	20.0	22.1	22.1	21.6	6.3	25.6	26.6	28.4	15.6	27.4	34.5
Civil Engineers	24.0	15.0	20.1	14.6	13.2	11.1	11.0	15.8	15.0	14.5	14.1	14.2	11.3
Architects	16.6	12.1	11.3	7.8	10.2	9.3	9.6	9.0	8.7	9.6	8.1	6.8	6.5
Constr Consuls	4.2	0.6	0.5	2.5	0.9	4.1	4.7	4.6	5.6	7.5	4.7	6.1	4.3
CIOB/Builders	3.1	3.7	3.8	3.4	2.6	5.2	4.9	4.7	4.9	2.5	0.2	1.2	1.8
Building Surveyors	0.9	0.9	1.6	2.1	1.4	1.0	1.4	1.2	1.3	1.9	0.5	2.0	2.2

Table 4: Complaints (Percentage)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Av
Made	0.45	1.97	0.90	1.07	1.48	1.46	1.20	1.19	0.23	0.26	2.44	1.15
Upheld	0.05	0.35	0.00	0.21	0.00	0.00	0.07	0.00	0.06	0.00	0.00	0.07

The number of complaints made against Adjudicators averaged only 1.15% over the period, ranging in value from a peak of 1.97% in 2003 to 0.26% in 2011, before surging to an unprecedented 2.44% in 2012. The complaints upheld continued at the very low level of average 0.07% over the period.

Table 5: Appointments

	2002	2004	2005	2007	2008	2011	2012	Av
Through an ANB	89.6%	83.1%	83.2%	85.0%	87.3%	90.7%	90.7%	87.4%
By agreement of the parties	9.9%	16.6%	16.8%	12.0%	12.0%	8.1%	7.8%	11.3%
Named in the contract	0.6%	0.3%	0.0%	3.0%	0.7%	1.2%	1.6%	1.3%

Appointments made through Adjudication Appointing Bodies averaged 87.4% of the total during the period, increasing from 83.1% in 2004 to 90.7% in 2012. Parties agreed on the Adjudicator in only 11.3% of disputes, decreasing from 16.8% in 2005 to 7.8% in 2012. Adjudicators named in the contract averaged only 1.3% of the total, but increased from 0.3% in 2004 to 1.6% in 2012.

On average, the Referring Party won two-thirds of the disputes, ranging from 65% in 2004 to 68% in 2012 with an average of 68%. The Responding Party won on average 21% of the disputes, increasing from 14% in 2000 to 23% in 2012. There was, therefore, a slight convergence over the period, except in 2011. On average, only 11% were split decisions.

Table 6: Successful Parties

	2000	2001	2002	2004	2005	2007	2008	2011	2012	Av
Referring Party	66%	74%	69%	65%	72%	68%	60%	71%	68%	68%
Responding Party	14%	17%	22%	25%	21%	20%	29%	17%	23%	21%
Split Decision	20%	9%	9%	10%	7%	13%	12%	12%	9%	11%

The four principal subjects in dispute were: Payment Provisions, 21%; Final Accounts, 20%; Variations, 19%; Interim Payments, 15%. Disputes regarding Final Accounts fell from 29% in 2011 to 17% in 2012 whilst those concerning Payment

Provisions fell consistently between 2000 and 2007 before increasing to 2012. Disputes concerning Variations fell from 36% in 2002 to 9% in 2012 whilst those concerning Interim Payments increased from 13% in 2005 to 26% in 2012. All other causes accounted for less than 8% of the total. The nature of disputes being referred to adjudication appears to be shifting with Interim Payments beginning to dominate in 2012.

Table 7: Primary Subjects in Dispute

	2000	2001	2002	2003	2004	2005	2007	2008	2011	2012
Final Account	18%	17%	27%	27%	12%	14%	22%	22%	29%	17%
Payment Provisions	38%	26%	24%	24%	19%	14%	8%	19%	17%	18%
Interim Payments		4%			15%	13%	15%	16%	19%	26%
Withholding		2%			10%	11%	10%	10%	3%	2%
Extension of Time	5%	10%	3%	4%	8%	8%	8%	9%	5%	7%
Loss and Expense	8%	10%	8%	7%	9%	10%	2%	7%		
Variations	21%	23%	36%	36%	15%	17%	11%	6%	17%	9%
Defective Work	7%	4%	2%	2%	4%	5%	7%	5%	8%	7%
Determination	3%	3%			2%	3%	4%	4%	2%	
Non-payment Fees		1%			2%	1%	7%	2%		3%

Table 8: Procedures Adopted

	2001	2002	2004	2005	2007	2008	2011	2012	Av
Documents only	56.0%	52.0%	56.9%	46.8%	57.6%	77.9%	62.1%	69.0%	59.8%
1 party meeting	3.0%	0.3%	0.8%						1.4%
2 parties meeting	35.0%	21.0%	24.6%	30.3%	15.2%	10.6%	28.8%	14.5%	22.5%
Full hearing	6.0%	6.0%	8.1%	15.6%	14.1%	7.7%	3.1%	11.5%	9.0%
Conference call			5.8%	6.4%	10.9%	3.9%	3.0%	5.0%	5.8%
Site Visit		11.0%	1.9%	0.9%	1.1%		3.0%		3.6%
Legal debates			1.5%		1.1%				1.3%

A Documents-only procedure was used on average 59.8% of the time, increasing to an overwhelming 69% in 2012. An Interview involving both parties averaged 22.5% and decreased over the period. A Full Hearing took place on average only 9% of the time.

Table 9: Timescale for Adjudications

	2001	2004	2005	2007	2008	2011	2012	Av
Within 28 days	69%	60%	58%	58%	56%	49%	44%	56%
28 to 42 days	27%	30%	32%	32%	36%	40%	37%	33%
More than 42 days	4%	10%	10%	10%	8%	11%	19%	10%

Decisions issued within 28 Days averaged only 56% and decreased from 69% in 2001 to 44% in 2012. Those issued between 28 to 42 days averaged 33% and increased from 27% in 2001 to 37% in 2012. Decisions issued after 42 days and, therefore, requiring both parties' agreement, averaged 10%, but increased from 4% in 2001 to 19% in 2012. Decisions appear to be taking longer.

Adjudications completing to a decision occurred on average 64% of the time, increasing from 56% in 2008 to 69% in 2012. Settlement by the parties averaged 19% and remained steady during the period. Adjudications abandoned during the process

averaged 13% and decreased from 20% in 2011 to 10% in 2012. Adjudications still continuing averaged only 5%.

Adjudication appointments were challenged on average 34% of the time, but decreased from 38% in 2007 to 28% in 2012. The dominant challenge was 'No dispute/dispute not crystallised'.

Table 10: Decisions

	2004	2005	2007	2008	2011	2012	Av
Decisions issued	67%	66%	67%	56%	60%	69%	64%
Settled by the Parties	21%	20%	15%	23%	14%	19%	19%
Abandoned	9%	12%	14%	11%	20%	10%	13%
Still continuing	3%	2%	4%	10%	6%	2%	5%

Table 11: Challenges

	2005	2007	2008	2009	2011	2012	Av
Appointments challenged	36%	38%	34%	34%	33%	28%	34%

Table 12: Initiation

	2001	2007	2008	2011	Av
Before Practical Completion	33%	16%	17%	10%	19%
After Practical Completion	67%	84%	83%	90%	81%

On average, only 19% of adjudications were initiated before Practical Completion and decreased from 33% in 2001 to 10% in 2011. Those initiated after Practical Completion accounted for 81% of the total and increased from 67% in 2001 to 90% in 2011. The Statutory entitlement to take any dispute to adjudication at any time does not appear to be practiced and those initiated After Practical Completion dominate.

Table 13: Fees per Hour

	2000	2001	2002	2004	2005	2007	2008	2011	2012	Av
Less than £75	10.4%	11.5%	8.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.3%
£75 - £100	57.3%	53.1%	40.0%	35.7%	14.3%	0.0%	0.0%	0.0%	0.0%	22.3%
£101 - £125	22.9%	20.8%	31.0%	17.9%	28.6%	14.3%	25.0%	12.8%	0.0%	19.3%
£126 - £150	0.0%	4.2%	8.0%	35.7%	21.4%	28.6%	25.0%	15.4%	5.6%	16.0%
£151 - £175	7.3%	4.2%	4.0%	3.6%	17.9%	10.7%	28.6%	28.2%	22.2%	14.1%
£176 - £200	0.0%	4.2%	6.0%	0.0%	0.0%	3.6%	7.1%	30.8%	38.9%	10.1%
>£200	4.2%	2.1%	3.0%	7.1%	3.6%	3.6%	3.6%	12.8%	33.3%	8.1%

Fees charged by Adjudicators increased significantly over the period. In 2000, 57% were in the range £75-100 and only 23% at £101-125. By 2012 this had increased to 39% at £176-200 and 33% over £200. Some 91% of fees did not exceed £125 in 2000, whereas by 2012 some 94% exceeded £151. In comparison, the Retail Price Index increased by 42.5% from 170.3 in 2000 to 242.7 in 2012. Current levels of Fees may reflect Adjudicators' awareness of how much legal representatives charge and/or

a concentration of appointments into only a few ‘safe pairs of hands’ who know their economic worth.

Table 14: Values in Dispute

	2001	2002	2004	2005	2007	2008	2011	2012	Av
< £10k	18%	17%	14%	9%	5%	6%	5%	10%	10%
£10k - £50k	31%	27%	26%	29%	24%	37%	39%	31%	31%
£50k - £100k	22%	20%	25%	20%	28%	15%	8%	18%	19%
£100k - £250k	16%	18%	17%	18%	22%	21%	19%	22%	19%
£250k - £500k	8%	8%	12%	12%	11%	12%	14%	10%	11%
£500k - £1m	4%	5%	3%	6%	7%	5%	5%	4%	5%
£1m - £5m	1%	3%	3%	5%	3%	3%	10%	4%	4%
£5m - £10m	0	0	0%	0%	0%	1%	0%	1%	0%

The median value in dispute was £10,000-£50,000 at 31% of the total. Some 50% were in the range £50,000-£500,000 in value and only 9% exceeded £500,000.

Table 15: Parties in Dispute

	2000	2001	2005	2007	2008	2011	Av
Consultant/client		3%	2%	5%	3%	6%	4%
Contractor/client	25%	31%	33%	28%	35%	33%	32%
Nom. Sub/client	0%	7%	0%	2%	0%	0%	2%
Dom. Sub/MC	65%	48%	51%	52%	48%	61%	52%
Nom. Sub/MC	1%	2%	0%	3%	0%	0%	1%
Sub-sub-contractor/sub	4%	6%	4%	9%	8%	0%	5%
Contractor/consultant	1%		1%	3%	1%	0%	1%
Trade contr./employer	0%		3%	2%	4%	0%	2%
Package contr./man con.	1%	1%	2%	3%	4%	0%	2%
Sub-consult/consultant	0%		0%	0%	1%	0%	0%

Disputes between Domestic Sub-contractors and Main Contractors averaged 52% of the total over the period and increased from 48% in 2001 to 61% in 2011. Those between Contractors and Clients averaged 32% and remained steady over the period. All other combinations of disputants were of low percentages.

## CONCLUSIONS

Adjudication continues to be the dispute resolution process of choice within the construction industry. The annual number of Referrals almost halved, however, from a peak of 2027 in 2002 to 1093 in 2012, although that number increased slightly from the previous year. There appeared to be an inverse correlation between the numbers of Referrals with the value of Construction Output in each year, i.e. as Output increased the number of Referrals decreased, and vice-versa. The Seasonal Trend of Referrals showed a major peak in November and a minor peak in March, although the reasons for that remain unclear.

The total number of registered Adjudicators fell by a quarter from a peak in 2002 to 2012. The Royal Institution of Chartered Surveyors continued to be the largest appointer of Adjudicators, but even its number of appointments fell by 42% from a peak in 2004 to 2012. Only 11% of Adjudicator Appointments were by the Parties themselves, whilst 87% were through Adjudicator Nominating Bodies. About a third of appointments were challenged over the period, but that proportion fell in recent years. The primary profession of Adjudicators changed from the dominance of Quantity Surveyors to an equality of 35% each of Quantity Surveyors and Lawyers over the period. This suggests that legal issues are being adjudicated as well as technical matters. Complaints about Adjudicators remained consistently low throughout the period and those upheld were a tiny fraction of the total.

The Referring Party continued to be the more successful disputant in more than two-thirds of adjudications, although the success of Responding Parties increased latterly. The primary matters in dispute were now Interim Payments, Payment Provisions and Final Accounts in descending order. The principal disputants continued to be primarily Sub-Contractors v Main Contractors and secondarily Main Contractors v Employers. A documents-only procedure continued to be favoured in the vast majority of cases and accounted for 69% of the total in 2012. Adjudications were taking longer during the period. Fewer than half were completed within 28 days in 2012 and 19% now took more than 42 days. Decisions were issued in 69% of adjudications which remained steady during the period. An astonishing 90% of adjudications were initiated after Practical Completion in 2012, up from 67% in 2001.

Fees charged by Adjudicators rose substantially over the period. Whereas 57% were in the range £75-100 per hour in 2000, 33% were over £200 per hour in 2012. Adjudicators now appear to know their economic worth.

The median value in dispute remained constant at £75-100k over the period, but the proportion in the ranges £100-250k and £250-500k increased. High value disputes over £500k were seldom taken to adjudication.

Adjudication has certainly changed over the 12 year period of the Adjudication Reporting Centre. There are fewer adjudications, they ebb and flow contrary to construction output, they take longer, they are more expensive, the values in dispute are slightly higher, they are increasingly processed by documents-only, they are more concerned with Interim Payments, and lawyers now rank alongside quantity surveyors in the largest proportion of adjudicators.

Some aspects, however, remain fairly constant. The RICS continues to make most appointments, complaints against Adjudicators remain low, most appointments are through ANBs, challenges to appointments remains steady at one-third, decisions issued remain steady, adjudications are initiated predominately after Practical Completion, and most Referring Parties win.

Adjudication in the UK Construction Industry is undoubtedly popular as evidenced above. It is, however, not without its problems. It has, arguably, become over-legalistic and has spawned over 600 reported court cases to date according to Pickavance (2016, 5). Its stated aim to enable parties to take any dispute to adjudication at any time has not translated into practice as the vast majority of disputes are initiated post-Practical Completion. It has become an expensive process.

Perhaps everything's not coming up rosy, silk or otherwise, after all.

## NOTES

\* A Twelfth Wedding Anniversary is denoted by Silk & Linen.

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# WHY CLAIMS FAIL: AN AUTOETHNOGRAPHIC INVESTIGATION OF CLAIMS MANAGEMENT UNDER GCC CONSTRUCTION CONTRACTS

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This paper explores some of the central issues faced by claims management practitioners within contracting organisations in the GCC, from an insider perspective. Through an auto ethnographic study of the author's practice as a claims consultant in the GCC, the paper illustrates how the meanings practitioners attach to claims can lead to recurring patterns of behaviour that are constantly adapted to the changing circumstances of construction projects. It also suggests how these meanings might affect the ways in which claims are acted upon, and the consequences these actions might have on claim management practice. The empirical perspective of this paper therefore has value in an academic setting, by offering a possible explanation for poor claims management practice.

Keywords: construction management, claims management, GCC, autoethnography

## INTRODUCTION

The construction industry is a major contributor to the GCC's economy. Projects totalling over \$140bn are likely to be awarded in 2016 alone (MEED, 2015), whilst construction accounts for over 8% of gross domestic production in rapidly developing states like Dubai, UAE (Emirates NBD, 2015). Yet globally, the construction industry is characterized by low efficiency, cost and time overruns, disintegration, and conflict (Aloini, Dulmin, Mininno, & Ponticelli, 2012; Yeo & Ning, 2006). These circumstances result in major inefficiencies and non-productive cost (Latham, 1993, 1994). The Middle East's volatile political and economic landscape and the highly internationalised GCC construction market compound these issues, making the GCC a hot bed for claims and disputes.

Despite the importance of claims within the construction industry, claims management literature has stagnated to consist of broadly two streams. The first examines the causes of claims (Diekmann & Nelson, 1985; O'Connor, Chmaytelli, & Hugo, 1993) or the approaches taken by practitioners in evaluating them (e.g. Arditi & Pattanakitchamroon, 2006; Braimah, 2013; Ndekugri, Braimah, & Gameson, 2008). Literature in this stream typically adopts quantitative methods void of specific context. The second stream proposes normative models to explain how claims administration, management and evaluation might be best achieved on future projects (e.g. Abdul-Malak, El-Saadi, & Abou-Zeid, 2002; Motawa, 2012), but offers little evidence that any of the proposed systems could work in practice. Aside from some limited

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examples (e.g. Rooke, Seymour, & Fellows, 2003, 2004), there has been little focus on the “real” practice of claims management.

In order to address this gap, this paper sets out some initial findings of a doctoral research project in which I utilise Autoethnography to draw on my work life in the GCC as a claims management specialist. In the sections that follow I firstly provide a background to claims management in the construction industry, and I explain the research methods on which this paper is based. I then provide a short auto ethnographic account of three stages of a construction project, in which I attempt to explain how the changing social context of these stages might influence the ways in which contractors approach claims. I conclude the paper with a summary of the principal findings of the study, and the further potential the research in this paper might have.

## **BACKGROUND**

From a construction industry perspective, a claim is simply the “assertion of a right” to additional time or payment sought by the contractor under the terms of a contract (Chappell, Powell-Smith, Marshall, & Cavender, 2008, 70). For example, the FIDIC 1999 suite (FIDIC, 1999) - perhaps the most widely used contract forms in the GCC (Bueno, 2011) - require the contractor to issue an initial notice to the Engineer within 28 days of a claim event, to keep contemporary records as evidence of time and cost incurred, and to present a detailed and reasoned assessment of the entitlement to which it considers itself due for the Engineer’s determination. Often employers amend standard forms to make these requirements even more onerous. This means that for a contractor to present a claim of any complexity timeously and in a format that satisfies the contract, the formation of a claims management team and the development of a methodical approach to dealing with claims is vital (Jaeger & Hök, 2009, 366-367).

The process of making claims, or “claims management”, is the development of a claim from identification of a claim event, to notification, evaluation of its effect and negotiation of any compensation due. Ren, Anumba, and Ugwu (2001, 186) describe this as “the process of employing and co-ordinating resources to progress a claim from identification and analysis through preparation, and presentation, to negotiation and settlement”, including the production of documentary evidence, analysis of effects, and preparing a persuasive written submission setting out the entitlement the contractor seeks.

However, there is also a social perspective to claims management which influences the ways in which practitioner’s act towards claims. For example, Klee (2014) takes the view that claims management is a “business strategy” that is tailored to the particular relationship with the client under the contract. This suggests that contractors may adapt the ways in which claims are managed to the particular social context of a project. In either case, claims management is a specialist function that requires dedicated expertise (Jaeger & Hök, 2009; Ndekugri *et al.*, 2008). Potts and Ankrah (2014) suggest that this expertise includes construction technology, construction law, conditions of contract, contract administration, planning systems and negotiation strategy.

It is therefore unsurprising that several studies confirm that a failure by contractors to properly manage claims diminishes prospects of recovery, reducing project profitability (Ren *et al.*, 2001). For example, British construction consultants

surveyed by Vidogah and Ndekugri (1998) confirm that contractors' failures to establish contractual entitlement, provide adequate information, and properly quantify claims, are common causes of claim failure. Research by Enshassi, Mohamed, and El-Ghandour (2009), Bakhary, Adnan, and Ibrahim (2014), Braimah (2013) and Ndekugri *et al.*, (2008) demonstrate that issues such as poor record keeping, late or absent claim notices and deficiencies in analysis claim events all lead to under recovery, increasing the likelihood of disputes. Whilst studies with a GCC focus are rare, Zanelidin (2006) finds that UAE based contractors can typically expect to receive just 10-15% of the submitted claim value due to poor claims management.

However, whilst demonstrating the importance of claims management, these studies fail to answer two important questions. The first is, how do contractors manage claims in the real world? Without such contextual understanding of claims management, it is difficult to appreciate the various challenges contractors face in practice. The second and related question is; why do contractors fail to consistently adopt robust claims management strategies? An understanding of the circumstances that lead to such failures could provide a basis from which to develop methods to improve practice. In an attempt to address these questions, the remainder of this paper presents an Autoethnography based on my work life experiences as a claims specialist in the GCC.

## METHODS

In classic ethnographic investigation, the ethnographer "goes somewhere, observes, returns and reports" (Dourish, 2006, 3). The ethnographer, typically an outsider to the cultural group being studied, collects "data" derived from field notes, observations and participation (Wolfinger, 2002), and reconstructs and analyses that data in terms of social theory (Button, 2000). The auto ethnographic methods utilised in this paper share many of the characteristics of classic ethnography, but with one principal difference. The difference is that I am not an outsider to the society that I have chosen to research. I am an opportunistic researcher reporting from within.

Like all qualitative research strategies, Autoethnography is associated with particular advantages and disadvantages. The obvious advantage is that an insider position brings *a priori* understanding of the culture being studied. As Greenfield (2000, 233) puts it: "When one studies behaviour in one's own culture... one has de facto an insider's cultural perspective..., the insider understands the meanings and motives behind in-group behaviours". However, because insider-researchers are attached to the same messy reality which they are attempting to explain, they might be less able to reconcile the contradictory mixture of observations necessary to explain an essential underlying phenomena (Fay, 1996). This is a problem that Van Ginkel (1998, 257) illustrates as not being unlike "trying to push a car while being inside it, observing a parade whilst marching along, or being a fish and attempting to see the water". Thus the auto ethnographer's challenge is "'breaking out' from the taken for grantedness of a particular framework and of creating knowledge" by interpreting the behaviour used by oneself and others from a certain distance (Alvesson, 2003, 176).

This challenge also leads to the common perception that auto ethnographic approaches are synonymous with self-focused "evocative" and post-modern styles of research that largely ignore theoretical analysis and explanation (Ellis & Bochner, 2000). However, in order to minimise the methodological disadvantages my insider status brings with, I adopt an "analytical" style of Autoethnography in this paper. The "analytic" auto ethnographic approach is rooted in a soft-realist (rather than a hard-interpretive)

theoretical tradition. It was first described by Anderson (2006) as research where the researcher is (1) a full member in the research group or setting, (2) visible as a member in reporting, and (3) committed to explanation social phenomena through social theory.

The findings presented in this paper have emerged from analysis of auto ethnographic data derived from three primary sources: from a chronicling of and reflection on my own prominent experiences as a claims manager in the GCC (Chang, 2008), from field notes recording participative-observation of my own practice over a four month period, and from unstructured interviews with four GCC contractor's claims managers to refine the initial data collected. In order to identify salient themes and form a basis for explanation, data was textualised and analysed thematically to identify recurring patterns of behaviour, three of which form the basis of this paper. Finally, symbolic-interactionism - a perspective that assumes individuals act and adapt their behaviour according to the subjective meaning they attach to people, events and social contexts (Blumer, 1986) - was adopted to explain recurring behaviours recorded in the data.

## **AUTO ETHNOGRAPHIC FINDINGS**

### **The social context of claims**

A negative portrayal of “claims culture” has been prevalent in the construction management literature for decades. This is a culture in which contractors are said to emphasise the planning and management of claims as a method of making money (Rooke *et al.*, 2003, 167). Industry commentators lament at the so called “claims conscious” contractor, where the primary motivation for claims is to profit at the expense of employers’ misfortunes (Chappell *et al.*, 2008). However as will be illustrated below, the findings of this paper paint a much more complex picture of the social context surrounding claims, at least from a GCC perspective.

Claims management in the GCC is epitomised by obstinate parties, powerful clients, partial client representatives and contractors who are often unacquainted with the specialist skills and lack the resources needed to settle claims effectively.

It is not abnormal for employers (via their certifiers) to reject claims as a policy irrespective of entitlement, and then to withhold substantial payments pending final settlement of accounts. It is also common for parties to continue negotiating the final account of a complex contract several years after completion of works at site, for contractors to ignore contractual rights to invoke a neutral determination through arbitration, to accept the lack of momentum towards settlement as the status-quo, and rely instead on local agents to reach a settlement outside the framework of the contract.

Above all, the balance of power in the GCC is shifted firmly in the client’s favour, directly contradicting the populist perception of “claims culture” advanced by some commentators. To illustrate how this context relates to practice, I explain in the following sections some of the factors that influence claims managers’ behaviour during three stages of a construction project.

### **Claims Management at the Outset of the Project**

Following award of contract, project teams representing the interests of both employer and the contractor are under pressure to build relationships strong enough to endure for several months or years. Claim managers must face day-to-day social interactions with the employer’s team, including the employer’s representative, a situation which

leads to tension between the need to fulfil mandatory contractual requirements relating to claims, and the desire to build long relationships.

Reluctance to disturb an otherwise harmonious relationship is unsurprising in an industry where clients identify contractor claims as source of mistrust (Kadefors, 2004), and project team integration is recognised by executives as a key performance driver (Baiden, Price, & Dainty, 2006). In consequence, the negative perception of claims during the “honeymoon” period of a project has direct influence on the ways in which claims are approached:

Memory: Renjith [the project manager] and I discussed whether we would raise a claim notice for the delay associated with the utility diversion [on a major retail development]. For my part, the diversion was caused by quite a clear change in conditions and was a claim that would be easy enough to prove. But Renjith was staunchly against raising any “formal” correspondence at these early stages in the project. I suppose he was reluctant to “upset” the engineer by appearing overly aggressive.

The above illustrates how the desire to avoid conflict can control claim managers’ behaviour, despite that this behaviour is neither in the direct interests of the contractor nor in accordance with the contract.

From the claim manager’s perspective, the prospect of formalising a claim by raising notices becomes associated with a deterioration in relationships between contractor and engineer owing to negative experiences of settling claims on previous projects. There is often a belief that an employer’s representative, invested in the knowledge that certain claims could have been raised by the contractor but were not, should extend favours when the contractor is in need later on in the project. As I will illustrate below, owing to subsequent events, this expectation rarely plays out.

### **Claims Management during the Project**

The GCC construction industry places a range of pressures on individuals during the management of projects. These pressures both positively and negatively influence the motivation of contractors to pursue claims against the employer. The first pressure is placed on contractors by the chaotic demands of complex projects and burdensome reporting requirements. Lower paid technical staff in particular face long working hours (Zachariah, Prakash, & Rajan, 2002) where much of the available time is consumed by day to day project requirements:

Journal entry: I visited site... to establish whether there were any further delays in access availability that would require action. It transpired that several areas of the site had were about to stall due to lack of access. But when I asked [the contractor’s de facto claim manager] whether records had been kept documenting the extent of this situation, he responded (belligerently): “how can I keep these all these [tables of access dates] up to date when I have to finish the [payment application] and process all these...variations?”.

In the above example, the contractor’s claim manager faced a conflict between his primary role as quantity surveyor for the project and his secondary role as claims administrator. At the time, he attached relatively more value to his primary role because the ongoing delaying events had yet to significantly impact progress at the site, and acted accordingly.

However, as projects progress, events occur which result in unrecoverable delays and which put profitability at risk. It is in these circumstances that the importance of claims is raised to a level where they are more actively pursued. However, as many of these events are perceived to be caused by the employer’s representative, they tend

also to erode any perceived trust between contractor and employer representative, thus influencing the ways in which claim managers act towards claims:

Journal entry: ...however [the contractor] had quite clear issues surrounding their own contribution to the delay, which I thought [would have been] found by anyone with time to review the records properly. After suggesting we concede and expressly identify these delays in the claim (if only to demonstrate that we were transparent and trustworthy), Mohamed [the contractor's claims manager] responded: "why would we reduce our own claim - surely the engineer [i.e. the employer's representative] should be doing that for us? He does it to everything else!"

In the above example, a build-up of issues including reluctance by the engineer to correct design errors and delays in providing information had not only resulted in a need to raise claims, but also a significant deterioration in relationship between contractor and employer. The contractor's claim manager perceived the engineer's failures as a betrayal of trust, a perception that manifested itself in the way the contractor intended to approach the claim submission.

### **Claims management at the end of the project**

As unresolved claims accumulate towards the end of the project, the initial desire to cooperate with the employer's representative is almost entirely abandoned, and it is at this stage that the contractor's claims manager becomes most willing to submit and pursue spurious claims. The following field note illustrates what is fairly typical behaviour by the contractor's claim manager at the end of a difficult project:

Field note: When Shaik [the contractor's claim manager] and I met today about the final account presentation for [a residential development] ... he proposed that we should concentrate on raising claim notices for "each and every little issue than comes in from now..." He explained further that "...we need to be on the strong side of the table when we do a deal".

As illustrated above, I have found that claim managers adjust their behaviour towards claims in reaction to the (perceived) negative acts of the employer representative's.

However, the above example reveals a further factor that influences behaviour at these later stages of the project. That factor is the belief, based on experiences with previous projects, that "senior management" will eventually do a "deal" (i.e. come to an amicable settlement of all claims through negotiation). Claims are resolved through negotiation because there is a tendency in the GCC for project representatives to avoid making reasoned claim determinations, often due to influence from the employer. Whilst the employer might instruct specialists for advice on the merits of the claim, this information is rarely provided to the contractor.

In consequence, claim managers are denied opportunities to experience rigorous testing of the claims that they prepare. The perceived importance of timely notices, sufficient evidence and detailed analysis reduces, feeding back into the cycle of poor administration and practice on future projects.

## **DISCUSSION/CONCLUSION**

This paper has tentatively illuminated an area of practice that is often met with suspicion and misunderstood. Whilst much existing literature takes an academic view to issues surrounding claims, I have attempted to provide a more "truthful" account of claims management from the viewpoint of a practitioner working in the field.

The nature of issues surrounding claims as reported in existing literature may lead to a presumption that deficiencies in management and project systems might be the

primary cause of poor claims practice. For example, it has been suggested that issues surrounding contractual administration, document control and claims analysis might be best addressed through the implementation of normative process models or project controls (e.g. Abdul-Malak *et al.*, 2002; Motawa, 2012). However, whilst proposals to improve practice through these means might have merit, this paper has suggested that the social context in which claims are made may also contribute to poor practice.

The GCC is characterised by highly complex megaprojects, multi-cultural teams, partial certifiers and onerous contract terms which make for a tense social context, where claims become viewed as symbols of conflict. From this context I have illustrated how claim managers attach meanings to claims, how these meanings affect the ways in which claims are acted upon, and the consequences these actions might have on claim management practice.

I have demonstrated that these meanings can also lead to recurring patterns of behaviour that are constantly adapted to the changing circumstances of the project. However, these patterns of behaviour do not emerge solely from within individuals, rather they are linked to socially constructed norms of acceptable and unacceptable conduct which are themselves subject to change based on how claims managers perceive the acts of others.

The recognition of “people issues” as a barrier to claims management has been raised in previous work (Ren *et al.*, 2001; Vidogah & Ndekugri, 1998), yet specific research in this area remains critically undeveloped, particularly from a GCC perspective. The autoethnography utilised in this paper revealed some initial possible inhibiting factors to claims management practice in the GCC, but there are many more implications that are yet to be explored. Consequently, this paper points towards a new research direction that if perused, could have real implications to practice.

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# PERCEPTIONS OF REGULATORY BUILDING INSPECTORS AND DESIGNERS ON THE PROPOSED RISK-BASED INSPECTION REGIME IN NEW ZEALAND

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The New Zealand government proposed a new control regime to streamline the process of building approval by introducing risk-based inspections for certain types of building works. The risk-based inspection is generally perceived as having the capacity to accelerate the process of building approvals therefore allowing contractors to project manage their time and workers without the bottleneck of regulatory inspections. The paper evaluates this newly proposed risk-based building inspection scheme. The perception of construction stakeholders on this new scheme was sought. Data was collected through a questionnaire survey and in-depth interviews with construction stakeholders. Regulatory building inspectors expressed concerns about the shift in liability from councils to licenced building practitioners and the need for regulatory bodies to introduce compulsory surety and warranties for building practitioners. Respondents also expressed that building licenced practitioners were unskilled and not mature enough in terms of experience and qualifications to undertake self-certification.

Keywords: building regulations, liability, licenced building practitioners, risk

## INTRODUCTION

In August 2009 the New Zealand Government announced a review of the Building Act 2004 to identify areas the Act could be improved to minimize the cost of compliance without compromising quality of building and construction works (Williamson, 2010). The Government focus is on achieving quality homes, through building activities that is business-enabling and within efficient regulatory framework. In other words, construction that is produced cost-effectively by a productive sector that is competent, and with a regulatory system that is administered efficiently and cost-effectively. Government also has a target on restoring consumers' confidence following historical building quality failures, so that they are able to make informed decisions when carrying out transactions in the building and housing market (DBH, 2009).

A report initiated by the Building and Construction Sector Productivity Taskforce (2009) had suggested that productivity within the construction industry is relatively lower than those in other sectors of the New Zealand economy. The report went further to recommend the development of quicker regulatory and consenting processes

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to reduce the barriers and roadblocks faced by urban development projects. This realisation is the starting point for this research study and effectively its desired conclusion. Currently there is insufficient data on the effects of building regulatory initiatives in New Zealand, and on productivity enhancement without compromising quality. Also very little is known about the implementation of the risk-based inspection by those stakeholders involved. Therefore the current study provides some empirical data that could contribute to construction stakeholders' knowledge of the risk-based inspection regime as a regulatory tool.

## **LITERATURE REVIEW**

### *Productivity within the construction industry*

The construction industry gives an indication of the state of the national economy. When the construction sector is booming so too is the economy and when the economy takes a dip the construction sector usually follows suit. It can be said that construction is important to a country financially and in providing gainful employment to a variety of actors and participants. Lewis (2009) notes that the construction industry is normally narrowly defined to involve only those trades that are directly involved with the construction of building structures but the industry should be seen to be part of a wider construction sector that includes other aspects of the business from obtaining raw materials through to the removal and demolition of the facility at the end of its lifecycle. The New Zealand construction industry sector is the fifth largest, employing over 157,000 fulltime equivalents (FTEs) which equates to 8% of the total economy. The wider construction related services employ a further 42,000 FTEs. A Price Waterhouse Coopers (2011) report indicates that, a decade post the millennium, 14% of all new employment have been in the construction industry in New Zealand and the sector contributes averagely 4.4% of Gross Domestic Product.

The New Zealand construction industry is a volatile market and certain events have contributed to this ongoing trend. The shortage of building stock experienced in Auckland (Auckland Council, 2013) and Christchurch (exacerbated by the 2011 and 2012 earthquakes) have major implications on Building Control Authorities as there is evidence that inspection services already contribute bottlenecks. (Department of Building and Housing [DBH], 2012). Auckland's housing demand pressures are evident with a lack of supply causing soaring housing prices throughout the region which has also pushed up demand in the major cities. Aucklanders are unable to afford within the city limits, so are looking to purchase properties outside its boundaries which is also pushing regional house prices up. The situation in Auckland and Christchurch is consequently impacting the rest of the nation. The government is under pressure to deal with this crisis as Auckland homes alone have hit an all-time high as average house prices of \$828,502 in 2015 have risen to \$955,753 in 2016 which equates to a 15.4% increase, (Quotable Value New Zealand [QV], 2016).

### *Building regulations*

One may ask, why there is so much emphasis on building regulations. At the lower level of the spectrum building controls set out to provide a minimum standard of building requirements to ensure the safety of occupants. Some other requirements are to ensure occupants remain safe and healthy in which performance based criteria's and plumbing provisions are provided. Apart from the health and safety aspect, minimum standards for building should also ensure that public expectations of buildings they purchase, particularly the family home are fit for purpose and have a certain minimum level of quality.

However building controls are very often become a source of frustration and too bureaucratic for many involved in the construction industry. Owners seeking to develop new housing or rehabilitate existing housing are in disarray of the regulatory gauntlet involved in consents and approvals. Constructors very often find the consent and approval process bureaucratic and costly. Thus there is pressure internationally on governments and regulators to develop modern forms of regulation that deliver more for less, and in more sophisticated ways.

The role of the building inspector and licenced building practitioners (which in this study are licenced builders and building designers) are highly dependent on each other's professionalism and competency for a project to be completed in a compliant and fit for purpose manner for its future users. Figure 1.0 shows the current building consent process in New Zealand and displays the regulatory intervention of authorities at each phase which could add up to weeks and months. The present model under the building Act 2004 sets a 20 day consenting processing time frame for building projects in which the clock can be stop during this time for request for further information prolonging the issuing of the consent. Once the building consent is granted the owner or its agent (usually the head builder) is required to notify the building consent authority on predetermined inspections which on new simple residential building could range up to 20. This whole process is becoming cumbersome for builders to down tools until notifiable inspection signoff. Also building inspectors are under pressure due to resourcing as a result of the high demand of buildings in the main regions.

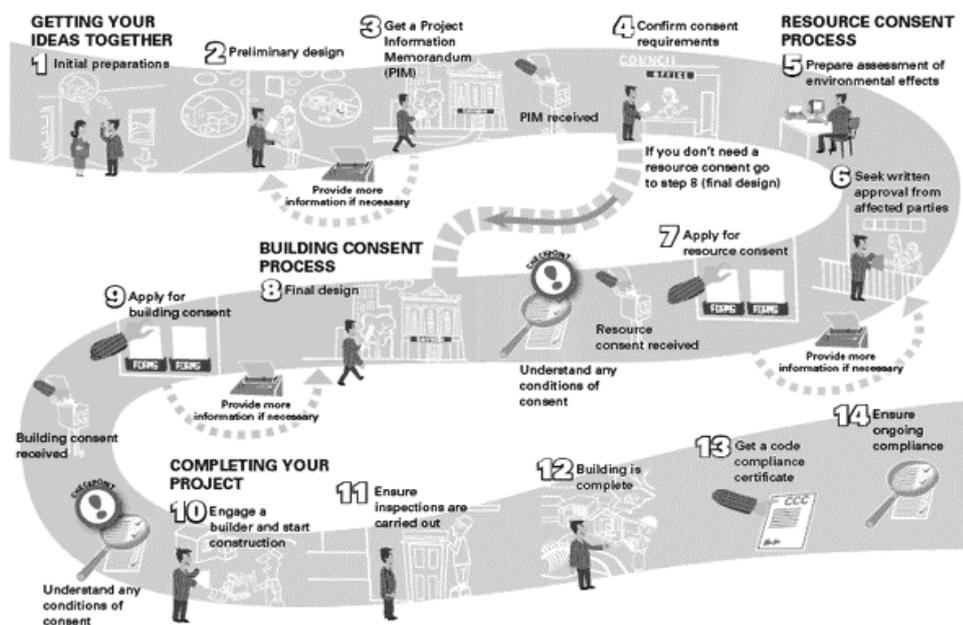


Figure 1 New Zealand building consent process (DBH, 2010).

May (2005) identified two barriers which have regulatory implications on affordable housing. First, are the cumbersome regulatory decision making processes that contribute to delays in construction and rehabilitation of housing. The second discourages housing development or rehabilitation in the first place which lessens the availability of housing in those areas due to developers moving to more favourable locations, consequently reducing overall housing supply. May and Burby (1998) discuss stylized enforcement strategies and what actually occurs out on the field categorizing enforcement into strict, creative and the most frequently used

accommodative enforcement, which in turn provides inconsistency in inspectors' decisions in whichever style they adapt.

Betts and Farrel (2009) indicate that global construction in the years towards 2020 forecast that an increase in construction activity over the next decade will put pressure on world materials and human resources to cater with development. May (2004) had explained constraints on homebuilders compliance with building code provisions due to the complexity of codes in which some codes number hundreds of pages and are often specified in technical terms that are not easily understood. This is evident of the New Zealand regulation system where there are thirty seven code clauses (35 technical) in which certain codes clause pages, number into the hundreds with specific verification methods for compliance. The logistic for homebuilders has dramatically changed in the last decade with modern homebuilding becoming more of a collaborative effort in which general contractors employ a range of subcontractors specializing in different phases of the construction process. In a typical 3 bedroom, brick and tile single level dwelling, it is not unusual to have six or more subcontractors providing services to complete its construction in New Zealand. May and Wood (2003) also mention that other constraints that frustrate homebuilders, are inconsistencies in what building inspectors require and their different interpretation of building code regulations.

#### *Risk-based regulations*

Rothstein (2006) describes risk-based regulation as the allocation of resources in proportion to risks to society, considering both the impacts themselves and the likelihood that they happen, in order to establish appropriate levels of control. The Department of Building and Housing in New Zealand envisages providing a better balance between regulation and risk, so that building consent authority's oversight and control of building work is proportional to the risks and consequences of failure and the skills and capability of the people involved (DBH, 2010).

The proposed risk-based (or "stepped" or "streamlined") building consenting process which forms part of the Building Amendment Act 2012 in contrast to other legislation in this Act has not been implemented as the government has emphasised that it will not come into effect until the construction industry is ready. The Licensed Building Practitioner scheme is in its ninth year and indications are the risk-based building consenting is on the horizon.

The legislation will create four types of building consents in which applicants will be able to align their project with, according to the criteria and parameters of building work involved. The four types of building consents are low-risk residential, simple residential, standard and commercial. Applicants will also be required to provide the BCA, risk profiles and quality assurance systems for projects which government have yet specified the criteria. The implementation of this scheme will relax the number of notifiable inspection by the BCA and provides for review and inspection by third parties. At the time of the current study, definitions and regulation of this scheme have not yet been released.

It appears from these different types of consent that the scope of the BCA's duty of care will become "user-pays". For lower risk building jobs, a person could make use of the cheaper low risk application process but would not be able to hold the BCA liable if the building project goes awry due to an unperceived fault in the plans.

This scheme has a major impact on the roles of construction stakeholders in New Zealand. The different types of consents provide applicants the options to take the

risk of paying a lower fee for no regulatory input and taking on more liability or standing than with the status quo. If issues arise in the future the "duty of care" (Invercargill City Council v Hamlin, 1994) placed on councils would come in to play during the disbursement of cost for repairs if negligent inspection was part of the cause.

In New Zealand, the transition of building consent authorities adapting to risk-based inspection is sporadic with two of its largest cities Auckland and Christchurch utilising this tool to cope with demand on the consenting regime. In 2013 the Christchurch City council had implemented a pilot scheme of risk-based (or "stepped" or "streamlined") building consenting process in lieu of the Building Amendment Act 2012 and despite other parts of the Act coming into force, risk-based still remained inactive. The Council would determine what buildings would qualify and set prescriptive parameters for applications. Applications that do not meet the standard were reverted back to the status quo of the 20 day consenting process duration from the Building Act 2004. Those that were successful were able to fast track their building projects and where a request for further information was required and the issue was minor, a phone call was made instead of a formal letter for further information.

A review of the process showed that the average processing applications for low-risk building consents was four hours and that all consents were processed within 24 hours of lodgement. The Auckland Council has a similar process which they also introduced to their customers. Under a memorandum of understanding (MOU) the criteria and expectations that both parties would be privileged to agree upon. The objective is to achieve partnership in providing a fit for purpose product, on time without compromising quality. Organisations were pre-approved by the Council and were able to participate but were monitored on their performance to remain on the scheme. The building consents were either granted or refused within a timeframe of usually 2 - 5 working days.

Current regulations are increasingly regarded as barriers to market liberalization and as a result there is an international trend towards reducing government responsibility for building quality (Burby et al., 2000). Many countries are attempting to simplify their building control regimes, often through a combination of deregulation and the shifting of responsibility (and in some cases balance) to the private sector (Yau, 2009). At its simplest, Rothstein et al. (2006) conceives risk-based regulation as allocating resources in proportion to risks to society (such as health, safety or environmental risks), considering both the impacts themselves and the likelihood that they happen, in order to establish appropriate levels of control.

A report by Berman (2012) with experience from overseas building control bodies with experiments with risk-based inspection and Contractor Quality Assurance programmes that focus inspectorate efforts where needed, and not where not, suggests that gains of construction time are possible without diminishing built quality. Risk-based inspections is an established practice in a number of areas in the UK sector. These are evident in the health sector with the enforcement of food safety, Hobbs (2002) and areas of fire safety, Ramachandran (1999). Bennett (2002) provides a risk-based component in satisfying inspection regulations in occupational health and safety sector. In each case the frequency of inspection and associated enforcement actions are based on a combination of the risk posed by the activity and the standard of management.

## **THE RESEARCH**

### **The research questions**

The literature review provides in-depth understanding of the New Zealand building controls dilemma: productivity vis-à-vis quality. Construction productivity is low in comparison to other commonwealth partners. There are pressures from two of its largest cities Auckland (Auckland Council, 2013) and Christchurch (Ministry of Business, Innovation & Housing, 2013) for supply and demand for residential housing. The study explores process review of the risk based system as an alternative to resourcing building officials. This provides the so called benefit of minimizing time and cost without undermining quality but also relies on licensed stakeholders doing the work to stand by their product and be more accountable, if issues arise in the future pertaining to any of their projects. Critical evaluation of literature from Black and Baldwin (2010), Department of Communities and local government (2012a) and Department of Communities and local government (2012b) indicate that there is a current need to examine risk based inspection as a regulatory tool in New Zealand. Thus the following research objectives are formulated to provide an exploratory evaluation that could help institute the risk based inspection scheme in New Zealand.

2. To understand the impact of reduced regulatory intervention in residential building construction in New Zealand.
3. To ascertain problems with ensuring responsibility sits in the right place

### **Research methods**

This research is undertaken to gain insights into the general nature of the risk based scheme as a regulatory tool. It is not geared toward developing precise statistical projections or descriptions but to evaluate the risk based scheme through regulatory building practitioners and identifying any relevant issues.

The sampling units for this study consisted of regulatory building inspectors and building designers in New Zealand as the main sample frame. These construction stakeholders have been selected because they are at the fore front of risk-based inspection being regulated into legislation as a Building Control tool. Building inspectors were randomly selected from data obtained from council's staff list and designers were selected through the Institute of Architects (NZIA) database in which designer's pre-requisite was residential construction. Table 1 shows building inspectors and building designers responses throughout New Zealand.

Deliberate and area sampling of large Building Consent Authorities throughout New Zealand (Auckland, Hamilton, Wellington, Christchurch and Dunedin) is undertaken. This not only covers the majority of the population but also covers the geographic makeup of the country. Interviewee variety is essential to the quality of data sourced in qualitative research, therefore all participants that are engaged for the research, have practical understanding of regulatory building inspections and residential construction practice. Adopting a semi-structured questionnaire with quantitative and qualitative approaches complement finding data. Data analysis for the quantitative results were undertaken through the use of SPSS software version 22, and qualitative results through NVivo 10.

The research findings will be validated in a future exercise through interviews with key industry players (i.e. subject matter experts or SMEs). All interviews are recorded and transcribed verbatim, then analysed using NVivo qualitative analysis software package.

Table 1: Geographic location of Building inspector and Designers surveyed

	Response Percent	Response Count	Response Percent	Response Count
Auckland (Auckland and Northland)	68.3%	43	38.3%	46
Canterbury (Canterbury, Ashburton and South Canterbury)	25.4%	16	16.7%	20
Central North Island ( Taranaki, Wanganui, Hawkes Bay, Manawatu, Gisborne)	0.0%	0	8.3%	10
Southern (Otago, Gore, Southland)	4.8%	3	5.0%	6
Midlands (Waikato, Tauranga, Whakatane, Rotorua, Taupo)	1.6%	1	5.0%	6
Cook Strait (Wellington, Wairarapa, Nelson, Marlborough, West Coast)	3.2%	2	21.7%	26
Others	3.2%	2	5.0%	6
Total Inspectors		63		
Total Designers				120
Total Participants				183

## RESEARCH FINDINGS

The first set of questions required participants to indicate if there was a need to review the current regulatory inspection regime and to comment on the appropriateness to risk of the number of inspections required on residential buildings. It is noted that both building inspectors and designers have responded overwhelmingly with over 70% agreeing that a review was needed on the number of regulatory inspections during residential construction.

Table 2: Building inspectors and designers views on the review of current regulatory inspections including the number of current inspections.

	Need to review current regulatory inspections?		Appropriateness of the number of building inspections	
	Response Percent	Response Count	Response Percent	Response Count
Yes	71.7%	33	68.8%	55
No	23.9%	11	13.8%	11
Not sure	4.3%	2	17.5%	14
Total Inspectors		46		
Total Designers				80
Total Participants				126

The second question reviewed the United Kingdom model in which the following paragraph was provided to participants to get a background understanding of currently implemented scheme in New Zealand. “United Kingdom risk-based inspection systems include a minimum number of phased inspections for all buildings and they typically give priority to buildings with high risk, such as environmental ones and optimize the process. For example, defined key stages of inspections for all buildings, plus additional inspections based on the building’s risk level. Hence risk-based inspections focus on what to inspect and when. Risk-based inspections are conducted to ensure a building’s structural safety, fire safety, worker safety and public safety but in a more efficient manner. Riskier buildings face more inspections. Having fewer

inspections for less risky buildings lowers costs without compromising safety, increasing flexibility and enabling inspectors to move away from random and phased inspections”.

The results presented in Table 3 show that there was a positive outlook for adopting a UK risk assessment approach in New Zealand. There was an average of 70% participants that agree to similar changes as the UK. The third set of questions required participants to indicate if the New Zealand construction industry was ready for change in the relaxation of regulatory inspection in favour of a risk-based approach.

Table 3: Building inspectors and Designer views on adopting a United Kingdom risk assessment risk-based assessment approach.

	Building Inspectors		Designers	
	Response Percent	Response Count	Response Percent	Response Count
Yes	76.1%	35	67.5%	54
No	23.9%	11	17.5%	14
Not sure	0.0%	0	15.0%	12
Total Inspectors		46		
Total Designers				80
Total Participants				126

Table 4 present the responses received from the key stakeholders. The result shows that both building inspectors and designers have concerns with this change in regulation with 65% of inspectors not confident that New Zealand is ready for such change. Just over half of designers surveyed also express similar concerns.

Table 4: Building inspectors and Designer views on the New Zealand construction industry mature enough to implement the deregulation of current inspections

	Building Inspectors		Designers	
	Response Percent	Response Count	Response Percent	Response Count
Yes	15.2%	7	33.8%	27
No	65.2%	30	52.5%	42
Not sure				11
Total Inspectors		9		
Total Designers	19.6%	46	13.8%	80
Total Participants				126

To understand more about these results, participants were provided an opportunity to comment on their responses. Some key comments are transcribed in Table 5.

In response to deregulation of current building inspections a building inspector (BI003) states that builders and other contractors put profits before quality and inspection deregulation will only speed up this process in their favour. Similarly building inspector (BI023) explains that the building industry has a long way to go before regulation could be relaxed and that more education is required at all facets of the construction process. He often feels that he is expected by builders to carry out a "clerk of works" role rather than that of a building compliance regulator. Designer (D59) explains that until licensing of builders is graded as other established trades, self-assessment at this current stage was inappropriate.

## CONCLUSIONS

Conclusively the study finds that stakeholders are apprehensive about risk-based regulation being rolled out, but there was optimism from the industry that risk-based regulation did have a place in the building consent framework. There are indications that once LBPs upskilled themselves in particular in building code compliance it

would eventually accelerate the building process without compromising cost and quality. It is evident from the findings that the current licencing scheme for practitioners is not robust enough for confidence of relaxed building relegation to be implemented. Stakeholders are requesting that better training is required and a call for regulatory bodies to introduce a compulsory surety and warranties scheme for all licenced building practitioners to be a part of.

Table 5: Stakeholders transcripts on New Zealand construction industry readiness for current regulatory inspections to be relaxed in favour of risk-based assessment approach.

Participant's coding	Commentary provided by participant's
D59	Until licensing of builders is graded and has meaning self-assessment as done by electricians and gas fitters is inappropriate.
B38	Building practitioners and the need for regulatory bodies to introduce compulsory surety and warranties for building practitioners.
D61	Even LBPs don't seem to get it right. And many tradespeople seem unaware of requirements for other trades work, so cause problems for other trades.
D89	Better training required for builders
BI003	Not all builders - Franchise holders and developers sometimes come from outside the building industry and view the building in the short term as speed and profit ( Contract law is the best way to deal with this )
BI016	The quality of workmanship is very poor across all Trades, including designers.
BI023	In particular reference to the residential building sector I feel the Building Industry has a long way to go before regulation is relaxed, More education, especially Building Act / Code Clauses / Standards, not only at the coal face but at all stages of the building process, I feel Designers are not providing well considered and fully evaluated plans and specifications, this combined with a lack of knowledge and supervision on site is very unnerving from a Building control perspective, I often feel that I am carrying out the ""Clerk of Works"" role and more than 50% of inspections carried out this is the expectation of the builder/contractor
BI049	The LBP scheme has not been a panacea for skilled work

The fact that the scheme is risk-based may mean that current inspections could be de-regulated in low risk areas providing opportunities for LBPs to cut corners during construction. The leaky building saga is a harsh reminder that initial intention of a new scheme being implemented for the sake of innovation to a performance based system also carries its dis-advantages, notably the shift of balance of regulatory oversight. In situations where regulatory resources are stretched and the pool of competent talent is lacking, the new scheme also provides regulatory teams a tool that can be utilized. The fast tracking of building inspections will positively enhance the rebuilding of Christchurch and address the supply demand in Auckland for example.

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# OPENING UP RISK MANAGEMENT THROUGH GOFFMAN'S DRAMATURGICAL APPROACH

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Although a great deal has been written on risk management in construction field, less attention has been given to risk management as a qualitatively dynamic process of what people do in everyday organizational practices. In this paper, we address this lack by drawing on Erving Goffman's (1959) metaphor of life as a stage to view risk management as a social interaction. Specifically, we adopt Goffman's dramaturgical analysis to raise questions on how we can study risk management in construction beyond prevailing techno-rational approaches. Viewing risk through Goffman-inspired dramaturgical lens, the management of risk is not simply a technical process, but also a dynamic social interaction where the thinking and doing of risk and risk management are staged. Thus, there is a need for deeper engagement with actual performances of risk management embedded in everyday organisational practices.

Keywords: dramaturgical analysis, Goffman, risk management

## INTRODUCTION

Risk management is a longstanding matter of concern in the field construction management research, and regarded as an integral part of project management. There appears to be two key strands in current research on risk management construction. On the one hand, scholars have treated risk as an object (Zhang, 2011) to be (often quantitatively) assessed, modelled and managed (Fung *et al.*, 2010; KarimiAzari *et al.*, 2014, and; Leslie and Lix, 2014). There is an overwhelming body of literature that supports the development of formal risk management based on objective, rational decision making (Zhang, 2011). On the other hand, some have suggested that risk is a subjective and socially constructed phenomena, where experience and intuition play a crucial part in our perceptions of and responses to risk (Tah *et al.*, 1994; Akintoye and MacLeod, 1997, and; Shen, 1997). Lyons and Skitmore (2004) for example surveyed 200 construction contractors in Queensland in Australia to find that intuition, judgement and experience, rather than formal risk management techniques, are most frequently relied on.

There is a growing movement that argues for a need to move beyond the development of new techniques to consider more carefully the practices of risk management. Laryea and Hughes (2008), for instance, stressed that introducing new models or methods may not necessarily be useful because practitioners prefer to conduct risk analysis in a simple and personalised manner rather than to depend on sophisticated methods that require detailed input information, which is not always available in every

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case. Indeed, despite the variety of available techniques and methods, formal risk management has been criticised for its inadequacy in bringing more certainty to a project by minimising threats and maximising opportunities (Tang *et al.*, 2007, and; Osipova and Eriksson, 2013). Stalker (2003) argued that the scientific and technical approaches to risk separates the thinking about risk away from the actual practical context in which risk behaviours and actions of risk management are played out. Thus, there is increasing recognition for the need to examine the realities of risk management practices more qualitatively.

In this paper, we adhere to this line of thinking by drawing on Goffman's (1959) dramaturgical metaphor to raise questions on how risk management practices in construction can be studied more qualitatively beyond prevailing techno-rational approaches. For Goffman (1959), metaphors connect realms of human experience and imagination, which direct the human perceptions and interpretations of reality, which in turn can help facilitate better representations and understanding of the world. In *The Presentation of Self in Everyday Life*, Goffman (1959) considered social life as analogous to theatre, where individuals behave like stage performers in their everyday interactions with others. Such a perspective has seen renewed interest in recent organisational scholarship that analyse inter alia issues of workplace dynamics, leadership, and the market (Gardner and Avolio, 1998; Sharma and Grant, 2011, and; Darr and Pinch, 2013; Urick, 2014; Rosengren, forthcoming).

In this paper, we use Goffman's dramaturgical analysis is to review and examine risk management in construction, with a view to open up the 'black box' of risk management in construction and identify possible research questions that can aid in the qualitative assessment of construction risk management. To give this shape, we first present a brief overview of key concepts according to Goffman's dramaturgical approach, which illustrates the notion of regions, actors, audience, performance, and impression management. Following this salient review, we apply these concepts to raise questions around how risk and risk management are conceptualised in construction management (i.e. what), who the key actors/players of risk and risk management are, where and when are risk management staged and to what consequences, and what possibilities a Goffman-inspired approach would create for understanding how and why risk management is done in practice. In so doing, the paper concludes with recommendations for future research on risk management in construction.

## **THEORETICAL ORIENTATION: RISK MANAGEMENT AS A SOCIAL INTERACTION**

In emphasising the formal processes of risk management, the central tenet in much scholarship on construction risks takes the view that risk is an object to be tamed that is free of people's minds and values. A corollary of such an approach is that the scholars have predominately focussed on the technical aspects of risk, and efforts on promoting and accelerating the standardization of risk analysis and management (Zhang, 2011). Zhang (2011) noted that the standard approach often starts with characterising the risk phenomena in objective terms, using , and the use of scientific methods (such as data collection and quantification) are considered to be beneficial to the identification, explanation, forecast, and control of risks.

Prevailing research on risks have tended to focus on quantifying probabilities of risk occurrences and risk consequences (Starr and Whipple, 1980). In quantifying risk probabilities, scholarship on risk take a reductionist view to focus on analysing risk as

an objective entity (Bradbury, 1989). Such approaches tend to assume a value-neutral position where the emphasis (and faith) is placed on the development of mathematical tools and techniques (Shrader-Frechette, 1991). However, Stalker (2003) argues that taking a technical approach to risk ignores the social signs and isolates a particular risk or risk behaviour from the context in which those associated risks and risk behaviors are situated. Therefore, it is of crucial importance to shift the attention away from the formal techniques to consider risk management practices situated in context.

By repositioning the focus towards the situated context of risk and risk management practices, there is a need to consider risk from a subjective, less formal viewpoint. This has a number of implications. First, different people will potentially have different perspectives of identifying what constitutes risk for them, as well as different approaches for making sense of, and thus managing, risk. Second, by emphasising subjective aspects of risk, we also take the view that, far from reducible into an objective entity, risk is constituted by the process of social construction and interaction. Thus, by freeing ourselves from the shackles of formal risk management techniques to consider the subjective character (and inter-subjectivities) of risk, we can get closer to understanding how people make sense of risk and their concerns about the future. In so doing, the emphasis is turned on to examining risk not in technical terms, but as a consequence and condition of political, moral and ethical, as well as emotion responses to their everyday experiences, encounters and circumstances (Douglas and Wildavsky, 1983). To put simply, the interaction and interplay of people and events, along with their emotive reactions contributes to the how risks are conceptualised and how risk management is enacted.

Thus, social processes are key to unlock an understanding of how perceptions of risk are mediated by the experiences and values of people in organisations (Douglas and Wildavsky, 1983). In taking into account the subjectivity of risk, one potentially expands the scope of the management of risk, where risk consequences are not limited to physical losses but also involve secondary or derivative impacts, such as belief and blame (Douglas, 2013), reputation (Power, 2004), shame (Wolff, 2006), justice and fairness (Slovic, 2000), and so on. The purpose of risk assessment is then not limited to a quantitative measure designed to provide early-warning, calculative support for the sharing eventualities but are instead broadened to consider how perceptions of risk are acculturated (Renn 1992). In so doing, one can shift the emphasis to contextualise decisions made around the management of risks (Zhang, 2011).

It is to these situated contexts – the relationships between formal and informal approaches to risk management – that we reflect on in this paper. To facilitate this reflection, we draw upon a selection of concepts from Erving Goffman's dramaturgical analysis. According to Goffman (1959), a dramaturgical approach examines social reality in the presentation of self in everyday life. This can be used to understand human behaviour as theatrically-staged performance (Sinha *et al.*, 2012). The term "dramaturgy" invokes the metaphor of life as theatre. Goffman (1959) introduced the dramaturgy metaphor to describe an individual in an organisation as an actor in a play putting on a show (front) for others in interaction. As Goffman (1959: 78) noted,

"All the world is not, of course, a stage, but the crucial ways in which it isn't are not easy to specify."

Goffman (1959) explained that people act on the stage while they are required to manage their settings, clothing, words, and verbal actions to express a particular impression to others (Goffman 1959). Thus, Goffman (1959) provided a few key concepts to help us understand what he termed as 'impression management', which connects the actor and the audience; these concepts include the regions of the front-stage and the back-stage, actor, performance, character, audience, and team performance. Goffman (1959) defines performance as "all the activity of an individual which occurs during a period marked by its continuous presence before a particular set of observers and which has some influence on its observers" (Goffman, 1959, p.22). He distinguished between two key regions of any performance, namely the front-stage and the back -stage. As Goffman (1959: 109) noted,

It is clear that accentuated facts make their appearance in what I have called a front region; it should be just as clear that there may be another region – a 'back region' or 'backstage' – where the suppressed facts make an appearance. A back region or backstage may be defined as a place, relative to a given performance, where the impression fostered by the performance is knowingly contradicted as a matter of course... It is here that the capacity if a performance to express something beyond itself may be painstakingly fabricated; it is here that illusions and impressions are openly constructed. (114-115)

According to Manning (2008), understanding these performance regions can help open up the 'black box' of organisation; rather than to treat organisation as a done deal, a Goffman-inspired analysis of organisation would delve deeper into "the ways in which 'organization' becomes meaningful to individuals", and how "it can at times be liberating, enlivening or oppressive" (Manning, 2008: 683). ). Applying this line of thinking to the examination of risk, one could unpack more meaningfully where risk matters in the various performance regions of organisational life (e.g. board meetings, external-facing media and press representations, internal communications). Although there are different authenticities found between the front and back stages of any performance, Sharma and Grant (2011) stressed the importance of "stage management", where an absence of stage management can be seen in clear segregation between back and front that serves to produces incursions, disruptions and faux pas, which in turn serves to weaken the leader's performance.

A second concept relates to the importance of Goffman's impression management in which Goffman (1959) discussed on how to deliver and maintain a coherent performance that captivates the audience. This aspect has inspired a number of studies in organisational studies. For instance, Urick (2014) utilises the dramaturgical theory and impression management in order to illustrate how and why an individual may choose to act or not act in a way that fits the generation's "illusion" of coherence. Urick (2014) explained that some individuals may "act" according to social expectations of their generation despite their own personal characteristics or preferences, while others behave in ways that distance themselves from stereotypical expectations. Moreover, individuals might "act" or engage in impression management techniques to make others within a context think that they fit a generation's "illusion". Urick (2014) maintained that this has implications for the ways human resource managers become aware of how employees can use impression management techniques to act or not act in accordance with what would fit an organisational cultural mould. In Sharma and Grant (2011) study of Steve Jobs, the late CEO of Apple Inc., they examined how storytelling was used to create an impression for Apple's followers, and the power of the narrative in generating charisma such that the audience (followers) can develop a sense of attachment of Steve Jobs to the people,

places, objects, and events that make up their everyday lives. In more recent study, Darr and Pinch (2013) examined the sales floor as a stage and utilised dramaturgical approach to show how the fundamental ingredient of economic transactions, the situated constitution of social obligation, is achieved. Thus, the act of “selling”, offering goods and/or services, and the act of “buying”, offering money in return for gaining possession of those goods and/or services, through the main involved actors, buyers and sellers, are reciprocal and place obligations on each party at different stages of the sales processes. This dramaturgical analysis viewed the acts of selling and buying as flexible and interactive scripts, which help to build trust and rapport that in turn secure the obligation of the exchange partner to continue with the sales process (Darr and Pinch, 2013).

A Goffman-inspired approach to studying organisational life is thus “to study not only what people do, but how they rationalize or explain the whys and wherefores of that work” (Manning, 2008: 684). In this way, by engaging with the performances of everyday organisational life (which can at times be theatrically dramatic), one can become more reflexive in searching for where the (truthful) actions take place, and with what intents and consequences. In this next section, we apply this line of thinking to raise questions on how we can study risk management in construction beyond prevailing techno-rational approaches.

## **APPLYING DRAMATURGICAL ANALYSIS IN QUESTIONING RISK MANAGEMENT IN CONSTRUCTION**

Following these insights from the literature on the use dramaturgical analysis as applied in organisational scholarship, we consider the possibilities of adopting such an approach to the study of risk management in construction. In this section, we explore more how these concepts can help us raise questions on the 5Ws and 1H (what, why, who, where, when, and how) that could open up future research in understanding risk management in construction.

### **What constitutes risk management? The tools of risk management as part of the wider setting for impression management**

The literature is replete with studies that seek to develop methods, techniques and tools for identifying and assessing risks, and for creating managerial interventions. A Goffman-inspired analysis would prompt us to examine these techniques and ask what other roles such tools play in shaping decision-making and organisational. For Goffman, techniques and tools are not necessarily designed to guide action, but they also serve to constrain actions. As Manning (2008) stressed, “organizational artefacts such as mission statements, goals and objectives, strategic plans and the like function as tools to reduce choice, not to guide it” ( 681). He added that such tools are merely “background knowledge, only on occasion front stage and immediate” (Manning, 2008: *ibid.*). Thus, these techniques form part of what Goffman (1959) would call the ‘setting’:

...there is the ‘setting’, involving furniture, décor, physical layout, and other background items which supply the scenery and stage props for the spate of human action played out before, within, or upon it. (Goffman, 1959, 32-33)

Indeed, the effectiveness of a technique lies not in the technique itself, but in the use of technique in practice. Rather than to take these tools as rational, objective instruments that guide decision-makers as passive recipients of such tools, a Goffman-inspired analysis will question how these tools as props of the wider performance

setting can help organisational actors stage their characters 'successfully' with a view to create an impression (as opposed to reality) on others, whether the 'others' (audience) relate to stakeholders internal or external to the organisation.

### **Why risk management? From the management of risk to the staging of risk**

It is accepted wisdom that risk management is a critical part of project management. The purpose of doing risk management, as we are often told, is to maximise the positive opportunities and minimise the negative consequences of uncertainty (Osipova and Eriksson, 2013, and; Lyons and Skitmore, 2004). Moreover, there is the rhetoric that the business environment we inhabit today is characterised by high levels of risk and complexity (Zwikael and Ahn, 2011). This is certainly how the construction industry is often portrayed, as a risky business due to its complexity, the fragmented nature of multiple stakeholders, long production times and complex interactions. Furthermore, projects are usually depicted as high-pressure environments, driven by compressed schedules, inadequate budgets, designs, and frequently changing requirements; managing such risk and eliminating such uncertainty is therefore crucial (Taroun, 2014).

Such a view takes as given the existence of risk as a thing, and downplays the possibility of risk as a symbol. Parton (1996: 98) suggests that: "risk is not a thing or a set of realities waiting to be unearthed but a way of thinking." For instance, in Ulrich Beck's Risk Society, he argued that society is becoming riskier not because the world is inherently more risky. Rather, it is the constant anticipation of risk, what he called the staging of risk, which produces the illusion that we are riskier. Beck (1992) also argued that the solution to mitigating risks lies not in the development of yet more sophisticated methods, for these methods can sometimes result in the fallacy that risks are being addressed when what is only addressed is the calculative assessment of risks. Thus, a Goffman-inspired dramaturgical analysis would allow us to open up the 'black box' of risk management to question more deeply why we stage risk in organisations and to what intents and purposes. In this way, a Goffman-inspired analysis would not take as given that risk is something to be simply managed out.

### **How would we study risk through a dramaturgical approach? Bringing back life to the techno-rational instruments of risk management**

Traditionally, managing risks in projects involves the systematic process of identifying, assessing, and responding to project risk (see e.g. PMI BoK). These processes require different activities (actions), which require individual(s) to do (perform) these processes (actions and roles). However, if we took the staging of risk seriously, then this would transcend the mere development tools and techniques, to consider more deeply different approaches as a form of acting on a stage in interaction with others (e.g. the audience, a point we will turn to in a while). Such actions are constrained within a set of structural frames which enable and disable certain lines of action, known as "scripts".

Scripts even in the hands of unpractised players can come to life because life itself is a dramatically enacted thing. (Goffman, 1959, 78)

Therefore, we argue that by focussing on the development of techno-rational instruments in taming organisational risk, we take the life out of the realities of staging risks in organisations. It is therefore important that we move beyond prescribing risk management tools and approaches, to bring to life in de-scribing the dynamic realities of risk management through such engaged forms of scholarship as ethnography.

### **Where do we do risk management? Examining the regions of risk management performances**

By treating risk management as a systematic process identifying, assessing, and responding to risk, prevailing scholarship on risk management in construction ignores the organisational spaces and places where risk management is supposedly taking place. Recent scholarship has begun to question where risk management takes place across various levels of project performance. For instance, Teller *et al.*, (2014) suggest that practitioners need to address risks at the portfolio level in addition and different to addressing risks at the project level. Teller *et al.*, (2014) also argued that we (wrongly) continue to treat risk management at the portfolio level in the same way as we do for projects.

To this end, Goffman's analogy of the stage, and the regions of the front-stage and back-stage, would be instructive. It is important to recognise and classify different regions in the risk management processes because in different regions different actions are being played. Thus, the front stage and back stage should be identified in risk management, and with it questions can be raised as to where the truthful performances (and performative effects) take place.

Therefore, the systematic process of identifying, assessing, and responding to project risk should be evaluated in different regions in order to examine other aspects such as political and social elements, which are downplayed in most of technical and formal approaches of risk management. In addition, dramaturgical analysis considers actors and examines how individuals subjectively and interactively construct what risk means in a specific social context.

### **Who are the actors and audiences in risk management?**

Extant research on risk management in construction have often assumed that the role of the rational, purposive actor in making objective decisions about the management of risks. As we already argued, this ignores the subjective dimensions of risk management, and overwhelmingly takes an individualistic approach to understanding risk management in construction (Osipova and Eriksson, 2013). As we discussed above, risk management as we view it is a performance that stems out of a social interaction, between that of the team of organisational actors performing and creating an impression on the audience. More recent project management scholarship has begun to raise questions on the heterogeneous landscape of actors and audiences in the staging of risk management. Van Os *et al.*, (2015), for example, state that risk differs among stakeholders and these variations are based on differences in knowledge expertise, roles and responsibilities, and interests. In addition, Osipova and Eriksson (2013) argue that these variations and collaboration of many different actors are important in order to obtain a comprehensive view and avoid a narrow and biased perspective of project risk.

Thus, risk management should involve examining how stakeholders have come up with different views and interpretations on the project risks, and how these discrepancies and responses could themselves be problematic and threats in other stakeholders' eyes (Busby and Zhang, 2008). Busby and Zhang (2008) argue that the stakeholders need to recognise and be clear not only about the risks for themselves, but also the risks for others. This view is being reflected in examining risk discourse study by (Van Os *et al.*, 2015). According to Van Os *et al.*, (2015), the identity of the project team and the goals of the project are being threaten by project risks, consequently, the project team tried to eliminate risk by withholding information from

the stakeholders they regarded responsible for inflicting risks on the project. This opens a space to consider the term discourse, which refers to the way people talk about phenomenon (e.g. risk) in actual conversation (Whittle and Mueller, 2011).

Based on dramaturgical analysis, Goffman (1959) talks about crucial roles and argues that there are some discrepant roles, which bring a person into a social establishment in a false mask. Goffman (1959) introduced these discrepant roles namely, the role of 'informer' who pretends to the performers to be a member of their team, is allowed to come backstage and to acquire destructive information, the role of 'shill' who acts as though he were an ordinary member of audience but is in fact in league with the performers, the go-between or mediator, the 'non-person' who plays this role are present during the interaction but in some respects do not take the role either of performer or of audience, nor do they pretend to be what they are not, and 'service specialist' who specialise in the construction, repair, and maintenance of the show their clients maintain before other people. Therefore, the dramaturgical analysis can facilitate the identification of different stakeholders and roles with a view to produce more holistic accounts of risk management as a social performance.

### **When concerns about risk changes over time: moving beyond atemporal accounts of risk management**

While the development of tools for managing risk ignores the spaces in which risk management takes place, existing scholarship on risk is also relatively atemporal. More recently, scholars like Osipova and Eriksson (2013) have argued that notions of risk changes over the course of the project life cycle, and this requires ongoing adjustment of our assessment and mitigation of risks. Shi *et al.*, (2015) also argued that approaches to risk management ought to dynamically change, as they suggested carving up a project into four stages, including i.e. pre-preparation, preparation, implementation, and operation. Shi *et al.*, (2015) indicated that different stakeholders would have different interpretations of project risks across these various stages. Like acts in a theatrical performance, a dramaturgical approach to risk management will prompt us to raise questions over how concerns about risk change over time, and with what consequences.

## **CONCLUSIONS**

In this paper we argued that the extant literature on risk management in construction is overwhelmingly technical, where scholars have predominately been concerned with the development of rational, objective instruments with a view to tame risks in projects. The social and subjective aspects are, as a result, often downplayed. In this paper, we have taken a social interactionist view of risk management, inspired by Goffman's dramaturgical analysis. We do so in order to open up the 'black box' of risk management in construction projects, and to raise various questions in terms of how risk management is staged in everyday organisational life.

By invoking the dramaturgical the metaphor of life as theatre, we seek to move beyond structuralist, individualist, and instrumentalist accounts of risk management to render problematic the actors and audiences that participate in the social interaction of risk management. We also call for deeper, more engaged forms of scholarship to situate how risk management is acted out in everyday organisational routines by delving more thoroughly into the various performance regions of organisational life. In so doing we also urge for students of risk management to resist thinking about risk management as a consequence of decision-makers passively accepting the outcomes

of objective risk analysis, to consider risk management practices as an active, ongoing accomplishment of managing impressions on others, whether these 'others' are internal or external audiences to the organisation in question.

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# RISK HANDLING OPTIONS: IS INSURANCE A FAIR OPTION TO TRANSFER CONSTRUCTION RISKS IN TANZANIAN CONSTRUCTION INDUSTRY?

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Risk handling options have been fairly studied and include avoidance, reduction (mitigation); transfer (sharing) and retention. The decision on the type of handling option to be adopted depends on the ranking results. Risk transfer is one of the handling options that can be practiced through acquiring insurance covers. Insurance transfers construction insurable risks into the arms of insurers. The main objective of this study is to examine insurance covers available for use in the construction industry and their use in risk treatment. The study is of exploratory type covering two sectors mainly construction and insurance. The population of the study includes construction stakeholders and insurance agencies. The sample size preferred was 120 respondents. Mixed sampling techniques were used to select respondents and literature review and questionnaires were employed to collect the data. Out of 120 questionnaires administered only 57 fairly filled for use in data analysis. Descriptive statistics were used to analyse the data. Findings reveal that there are about 15 insurance covers used for various purposes in the construction industry at varying degrees. Furthermore, Contractor All Risks (CAR) insurance cover is frequently used with RFI between 1.0 and 0.80 while Performance Failure, Contractor's Equipment Coverage, Workers Compensation, Third Party Liability and Equipment Breakdown are used on average with  $0.8 \leq \text{RFI} \leq 0.60$  and the rest are used less frequent. The study concludes that insurance as one form of risk transfer option has adequate covers for the construction industry but only a paucity of these covers is adequately acquired by stakeholders.

Keywords: construction, insurance, risk management, risk transfer

## INTRODUCTION

A number of risk handling options have been determined by various studies (Akintoye and MacLeod, 1997; Schieg, 2006; Yusuwan *et al.*, 2008; Berg, 2010; Akbıyıklı *et al.*, 2011; Naphade and Bhangale, 2013; Habib and Rashid, 2013; Chinenye *et al.*, 2015; Desai and Kashiyani, 2015). These risk handling techniques have been used in mitigating severity of risks through formal and informal risk management process. One of the risk handling options that is fairly adopted is risk transfer through insurance. Several insurance covers suitable for the industry have been put forward by researchers' worldwide (Miller, 2007; Chengwing, 2008; Whitmore, 2008; Naphade and Bhangale, 2013; Desai and Kashiyani, 2015). Most of these studies advocate that insurance is the best option for risk transfer or sharing. Similarly, researchers such as that of Akintoye and MacLeod (1997), Odeyinka (1999) (cited in Perera *et al.*, 2008), Perera *et al.*, (2008), Kikwasi (2011) and Aigbavboa and

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Musundire (2015) reveal that insurance is one of the main methods of construction risk transfer in the construction industry. In addition, Perera *et al.*, (2008) and Aigbavboa and Musundire (2015) have determined factors influencing use of insurance covers. The fact that risk transfer through insurance is widely used by contractors and consultants in risk management, it is high time to explore how the industry can optimize the use of it, and particularly in Tanzania where this area of research is untapped. This study seeks to initiate the research debate on insurance covers and expand on previous studies by investigating on available insurance covers suitable for the construction industry as well as the extent of their use.

## REVIEW OF LITERATURE

### Risk handling options

Development of risk handling options is a step devised to minimize or eliminated the consequences of risks in construction. Risk handling options have been extensively studied (Akintoye and MacLeod, 1997; Akbıyıklı *et al.*, 2011; Schieg, 2006; Yusuwan *et al.*, 2008; Berg, 2010; Naphade and Bhangale, 2013; Habib and Rashid, 2013; Desai and Kashiyani, 2015; Chinenye *et al.*, 2015). Common risk handling techniques are risk avoidance, reduction (mitigation); transfer (sharing) and retention (acceptance/assumption). In addition Habib and Rashid (2013) present another approach of risk management techniques used in their study as shapes & mitigate (SMT), shift & allocate (SAT); Influence & Transfer (ITT) and Diversify through Portfolio (DTP) which they relate to the project outcome. PMI (2013) Classifies risk handling options into risk strategies for dealing with negative risks or threats and those for dealing positive risks. While strategies for dealing with negative risks remain to be those listed in other studies, strategies for dealing with positives risks are exploit, enhance, share and accept. The use of any of these handling measures depends on the outcome of the analysis and ranking of the risk. Qualitative and quantitative analysis determine the probability of occurrence of risk and its potential severity. Table 1 below presents severity matrix that assists project managers to decide on the handling option to follow.

Table 1: Risk severity matrix

	Significance		Consequences				
			1 Trivial impact	2 Minor impact	3 Moderate – Minor impact	4 Major impact	5 Catastrophic
Probability	1	Rare	Low	Low	Moderate	High	High
	2	Unlikely	Low	Low	Moderate	High	Very high
	3	Moderate	Low	Moderate	High	Very high	Very high
	4	Likely	Moderate	High	High	Very high	Extreme
	5	Almost certain	Moderate	High	Very high	Extreme	Extreme

Source: Adapted from Berg (2010)

Organizations have various risk attitudes that influence their decision on adoption one technique over another. According to PMI (2013) risk attitude of organizations are influenced by risk appetite, tolerance and risk threshold. Berg (2010) state that a risk may be considered acceptable if: the risk is sufficiently low that treatment is not considered cost effective, or a treatment is not available, or a sufficient opportunity exists that outweighs the perceived level of threat. Furthermore, Berg (2010) points out that a risk may be considered for reduction if the likelihood of occurring or

consequences of the event can be reduced. According to Whitmore (2008) insurance is a third-best method of disaster risk management, after avoidance and reduction.

### **Risk transfer and Insurance**

Risks can be transferred through many ways including securing of insurance covers. Berg (2010) points out that transferring the risk in whole or in part may be achievable through moving the responsibility to another party or sharing the risk through a contract, insurance, or partnership / joint venture. Naphade and Bhangale (2013) conclude that all risk can be transferred. However, authors such as Akbıyıklı *et al.*, (2011) and Perera *et al.*, (2008) argue that only known, financial and insurable risks are transferred through insurance. There is a general agreement among researchers that insurance is a risk management tool in the construction industry. Alabi and Dorcas (2011) identify top ten risk mitigation measures from which obtaining insurance for all political risks and insure all of the insurable force majeure risks are acknowledged for effective risk mitigation. Wang and Chou (2003) report that contractors usually use three methods to transfer risk in construction projects namely insurance, subcontracting to subcontractor, and modifying the contract terms and conditions to client or other parties.

PMI (2013) identify mitigation as one of the risk response to threat and explain that it can reduce the probability of occurrence through using proven technology to lessen the probability that the product of the project will not work, reducing the risk event value through buying insurance or both. Akintoye and MacLeod (1997) reveal that transfer of risks by contractors is through domestic and specialist sub-contracting and insurance premiums while for project managers is through professional indemnity. Perera *et al.*, (2008) disclose that in the Sri Lankan construction industry risk is managed mainly through insurance. Likewise, Banaitiene and Banaitis (2012) found that performance bonds and warranties, resource reservation and insurance, and risk transference to another project party were risk response techniques frequently used in construction projects. Habib and Rashid (2013) studied the influence of risk management technique on project outcome and found that Influence and Transfer Technique (ITT) was the most significant technique. Naphade and Bhangale (2013) reveal that majority of construction companies rely on insurance policies for different risk scenarios. In Tanzania, Kikwasi (2011) found out that risk transfer involving provision for insurance and guarantees, and, fixed contracts were the handling options mostly preferred by consultants.

Aigbavboa and Musundire (2015) investigated the efficiency of CAR insurance policy and determine that it protects the client's interests effectively, contractor's interest effectively and assist the contractor in risk management by recognizing potential risks and reducing the probability of such risks. Several insurance covers are available for use in the construction industry as revealed in the works of Miller (2007), Chengwing (2008), Yong-shi and Yi-bin (2010), Akbıyıklı *et al.*, 2011, and, Desai and Kashiyani (2015) and these are:

4. Builders Risk Insurance: Insurance coverage needed during construction to cover the value of the building itself, should the building being constructed be damaged.
5. Commercial General Liability (CGL) Insurance, Excess/Umbrella Liability Insurance: Third party liability supplied under r CGL and is generally limited to claims against the insured for "bodily injury" or "property damage" resulting from an "occurrence.

6. Workers Compensation: Workers' compensation insurance covers injuries and occupational diseases picked up at work.
7. Pollution: This covers contractors' pollution liability exposures.
8. Professional Liability: This covers losses of many kinds, from cost overruns, delayed completion, bodily injury and sick-building syndrome to environmental pollution resulting from professional services offered by architects, engineers, agency construction managers, project managers and owners' representatives.
9. Controlled Insurance Plan (CIP) or "Wrap-Up": This cover is a single insurance program for all parties involved in the project for the duration of the project term. . Most wrap-ups include workers compensation, general and excess liability, and builders risk coverages (auto liability and contractors equipment are not included) and can include project architects/engineers errors and omissions coverage and other optional coverages.
10. Equipment Breakdown (Boiler and Machinery): Covers equipment being installed as part of the construction project in case damaged in the course of construction.
11. Commercial Crime Coverage: Designed to insure against certain types of losses that are not covered by a standard commercial property policy, such as employee dishonesty/theft and forgery.
12. Contractors Equipment Coverage: designed to address the mobile nature of contractors' equipment and the unique hazards to which the equipment is exposed.
13. Construction All Risks (CAR)/Erection All Risks (EAR): This cover is for 'all-risks' of physical loss or damage to material, supplies, equipment, fixtures and temporary structures that are used in construction, fabrication, installation, erection or completion of the project.
14. Delay in start-up (DSU)/Advanced Loss of Profit (ALOP): DSU cover is designed to secure the portion of revenue which the principal requires to service debt and realise anticipated profit.
15. Professional indemnity insurance: This insures contractors with design responsibility (i.e. under design and build contracts) against liability arising out of professional negligence.
16. Public liability insurance: This provides cover for liability arising out of death or personal injury to third parties or damage to property belonging to third parties.
17. Workers' compensation insurance - This insures the contractor against liability for the death or personal injury to its employees (usually on site) when performing the works.
18. Force Majeure: insurance cover to protect against certain risks of force majeure, i.e. acts of nature – hurricane/earthquake/flood.
19. Performance Failure/Design Risk: Designed to cover loss event that arises from defective design, materials, or workmanship.
20. Political Risks: Political risk insurance is provided by private insurers as well as multilateral and bilateral agencies.

It is evident from the above list that a number of insurance covers have been devised for use in the construction industry. However, the coverage of risks by an individual insurance depends on their policies. According to Perera *et al.*, (2008) and Aigbavboa and Musundire (2015) CAR covers physical damage to work and third party liability.

In Tanzania CAR on top of these covers damage to materials and equipment which include force majeure. In other respect public liability covers same damages as third party liability therefore the number of covers can be reduced by formulating inclusive insurance covers policies. Despite the availability of these insurance, the decision to acquire insurance cover should be supported by knowledge of the extent of coverage and value of compensation. Naphade and Bhangale (2013) cautions that the one who will be negotiating insurance needs should be conversant with the principles of insurable interest, umbrella faded, indemnity, contribution and subrogation. Miller (2007) urges that given the complex and specialized nature of the typical modern-day construction project, it is imperative that any party involved with a construction project sit-down with its insurance agent and attorney and make sure that it has the proper insurance coverages in place to minimize its non-insured exposures. Akbiyıklı *et al.*, 2011 points out that whether insurance can be used as a solution depends on: the insurability of the risk; the adequate and tailored policy; the comparison of the insurance premium and the potential loss of risks; the trust and confidence of insurers about their solvency and claim service; and no other alternative risk transfer solutions available.

Perera *et al.*, (2008) and Aigbavboa and Musundire (2015) reveal that the motives behind use of insurance are client's requirement, conditions of contract, contractor's own interest, construction industry environment, and, knowledge and experience. This implies that insurance is both mandatory and optional. According to Akbiyıklı *et al.*, 2011 in a typical construction project insurance always considered are: material damage, third party liability, materials in transit, damage to constructional plant, non-negligent indemnity and consequential loss. On the other hand (Akbiyıklı *et al.*, 2011) there insurance covers not usually included but obtainable such as employer's liability/workmen's compensation, motor, professional indemnity, inherent defects and contract performance guarantee bond. In Tanzania form of contracts in use provide for CAR insurance. However, workers compensation, performance and advance bonds /guarantees are acquired to fulfil clients requirements or as part of practice.

Compensation from insurers that is not meeting the expectations of insured can be an obstacle for opting for insurance. Perera *et al.*, (2008) evaluated CAR policy and determines that 47% of CAR claims were settled by the insurer and 53% of claims were rejected by insurers due to poor knowledge and experience on risk management on the part of local contractors, insufficient and erroneous supplementary data and foreseeable damage.

## **METHOD**

The study used exploratory type of research with the objective exploring information on risk treatment using insurance covers an area not yet researched in Tanzania. Using this type of study, data on use of available insurance covers was gathered from a relatively small sample. The population of the study comprised of regulatory boards, clients, consultants, insurance agencies and contractors. The sample size envisaged was 120 comprising of 35 contractors, 30 consultants, 25 clients, 25 insurance agencies and 5 regulatory bodies. Mixed sampling methods were used namely: purposive, random and snowball sampling. Purpose sampling was used to select regulatory boards and clients; random sampling was used to select consultants and contractors; while snowball sampling was used to select insurance agencies.

Data for the study was collected using review of literature review and questionnaires. Work done on the subject matter and the gap were determined through review of literatures. Questionnaires containing open and closed questions on respondents' demography, awareness of insurance covers, and frequency of using insurance covers were self-administered to selected respondents. One Twenty (120) questionnaires were sent out and 67 were filled and returned. Out of 67 filled questionnaires only 57 were fairly filled for use in the study equating to 47.5% success.

The collected data was analysed using the Statistical Package for Social Sciences (SPSS) software version 16.0. Data was analysed using descriptive statistics mainly frequencies and group statistics. Furthermore, for ranking purposes, the Relative Frequency Index (RFI) was used. Relative Frequency Index (RFI) is calculated as follows:

$$RAI = \Sigma W/AxN$$

Where; W = weight given to each variable by respondents

A = highest weight

N = total number of respondents.

For the purpose of this study A=5 and N=57

Relative Frequency Index (RFI) comparison table was used to assess the results by taking into account the average scores and the RFI as indicated in Table 2 below:

*Table 2: Relative Frequency Index (RFI)*

Average Score	RFI	Frequency of Use
4.0 to 5.0	0.80 to 1.00	High (H)
3.0 to < 4.0	0.60 to <0.80	Medium (M)
1.0 to <3.0	0.20 to <0.60	Low (L)

*Source: Adapted from Chileshe et al. (2007)*

## ANALYSIS AND RESULTS

Analysis in this part sought to establish respondents' demography, awareness of insurance covers and industry's frequency of using available insurance covers.

### Respondents' profile

Information of respondents who participated in the study reveal that majority of respondents were from the construction industry (80.7%) followed by insurance (19.3%). This participation was influenced by consultants (31.6%) followed by contractors (22.8%), clients (21.1%) and regulatory bodies (5.3%). Experience of respondents was remarkable with most of them having experience of over 10 years (40.4%) followed by over 5 years (6 to 10 years (31.6%), 2 to 5 years (24.6%) and less than a year (3.5%).

### Awareness and use of insurance covers

Table 3 presents information on awareness and use of insurance covers for respondents' who participated in the study.

Table 3 Respondents awareness and use of insurance covers.

Awareness	Frequency	Percent
Aware and use	45	78.9
Aware but not use	12	21.1
Total	57	100.0

Results reveal that majority (78.9%) are aware and use insurance covers. For those who are aware and make use of insurance covers, about 63.6% use these covers frequently while the rest (36.4%) use them less frequent. In relation to awareness of insurance covers, Yong-shi and Yi-bin(2010) determine that out-of-date ideology and lack insurance awareness in the construction industry in China limit the performance of engineering insurance. On the other hand, few respondents (10%) who responded to open ended questions indicated that use of insurance as a risk transfer option is deterred by inadequate knowledge of available insurance covers among contractors and cost resulting from paying insurance premium.

### Types of insurance covers and practice

Table 4 presents information on available insurance covers and the extent of their use in the construction industry. Types of insurance covers available for use for as risk transfer option in the industry were extracted from literatures. An evaluation of use of different insurance covers was done using 5=very frequent, 4= frequent, 3= average, 2= rarely and 1= None.

Table 4 Respondents frequency of use of insurance covers

S/N	Insurance cover	N	Mean	Std. Dev	RFI	Rank
1	Contractor all risks	57	4.09	1.229	0.818	1
2	Performance failure	57	3.33	1.618	0.666	2
3	Contractor's equipment coverage	57	3.28	1.485	0.656	3
4	Workers compensation	57	3.25	1.651	0.65	4
5	Third party liability	57	3.09	1.661	0.618	5
6	Equipment breakdown	57	3.09	1.392	0.618	6
7	Money in Transit	57	2.96	1.669	0.592	7
8	Builders Risk policy component	57	2.95	1.807	0.59	8
9	Commercial general liability	57	2.65	1.587	0.53	9
10	Delay in Start up (DSU)/Advance loss of profit	57	2.63	1.577	0.526	10
11	Commercial Crime Coverage	57	2.56	1.593	0.512	11
12	Force Majeure	57	2.49	1.465	0.498	12
13	Public Liability	57	2.37	1.397	0.474	13
14	Political risks	57	2.32	1.649	0.464	14
15	Pollution Liability	57	2.02	1.232	0.404	15

Results reveal that there are about 15 insurance covers used for various purposes in the construction industry at varying degrees which implies that the insurance market is well developed for transferring of insurable risks in the construction industry. Among insurance covers in use, Contractor All Risks (CAR) insurance cover is frequently

used with RFI between 1.0 and 0.80. This finding is in consistence with the argument of Perera *et al.*, (2008) that CAR is among the insurance covers that its policy has been accepted worldwide as a comprehensive cover used in construction. Furthermore, Performance failure, Contractor's equipment coverage, Workers compensation, Third party liability and Equipment breakdown are used on average with RFI  $0.8 \leq 0.60$ . This implies that contractors, consultants and clients are limiting projects to covers provided in forms of contracts. While contractor's equipment coverage, Workers compensation, Third party liability and Equipment breakdown are fairly covered under CAR, this finding reveal the neglect of construction workers which their insurance is left to the liberty of the employer. On the other hand, majority of respondents do not value other insurance covers such as Money in Transit, Delay in Start-Up (DSU)/Advance loss of profit and Commercial Crime Coverage as a way of transferring potential risks to the insurers. Securing such insurance covers will minimize financial risks in the current construction environment. The current construction environment in Tanzania is characterized by theft of materials and fuel on construction sites, cost overrun and schedule overrun forcing clients to deduct liquidated damages.

## CONCLUSION

The construction industry can benefit from a range of insurance covers available if the parties choose risk transfer through insurance to be a major handling option in risk management. The study concludes that insurance as one form of risk transfer option has adequate covers for the construction industry but only a paucity of these covers is adequately acquired by stakeholders. Furthermore, Contractors All Risks (CAR) insurance cover is very frequently used while others are used on average or seldom.

The fact that construction environment in Tanzania is prone risks that can be transferred through insurance covers, this study recommends the following: stakeholders should be educated on available insurance covers and extent of their coverage; consultants and contractors should consider acquiring insurance covers that address most of the emerging risks in their project undertakings; provision of insurance shall be expanded in construction contracts; and formulation of insurance covers policies should be inclusive to the extent of reducing the number of covers one is to acquire for single project.

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**ECONOMICS AND  
THE  
CONSTRUCTION  
INDUSTRY**



# FRAMEWORK AGREEMENTS IN A POST-RECESSION ECONOMY

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Framework Agreements (FAs) in the UK Construction Industry emerged following influential reports into construction following influential reports into construction by Sir Michael Latham and Sir John Egan respectively. Throughout the 1990's and into the new millennium FAs were increasingly used as a procurement strategy in the construction industry due to their so-called "win-win" ethos for construction clients and contractors. This culminated in the Joint Contracts Tribunal (JCT) publishing "binding and non-binding" forms of FAs in 2005. Following a recent global worldwide economic recession it is pertinent to ask the question whether FAs represent an idea whose time has come and gone or if FAs have survived as a procurement strategy and if so, in what way. This study looks at the effect of a major economic recession on the use of FAs and questions whether or not FAs remain a viable sustainable procurement option? A quantitative survey of consultants and contractors was carried out to establish opinions of interested stakeholders. The findings indicate that whilst FAs are still used by significant stakeholders many have abandoned FAs in favour of traditional price based competition. Key factors in the UK Government's vision for the construction industry are strong integrated supply chains and productive long term relationships. The renegotiation or abandonment of FAs since the recession would suggest that the long term vision on the government is in some jeopardy.

Keywords: construction contracts, law, procurement, Framework Agreements, recession

## INTRODUCTION

Glover (2008) explained that a Framework Agreement (FA) is an agreement which is reached between two parties to cover a long term collaborative agreement. The FA in the construction context is used where a client has a long term programme of work and wishes to set up a process to facilitate individual construction projects or supply of materials during a specific period or term. Glover (ibid) cited an example of the British Airports Authority (BAA) who wished to procure £9.5 billion of construction work over a ten year period (2006 -2016) and set up FAs with a number of construction contractors. Thus FAs are typically used where construction clients have a portfolio of works to be undertaken and can be particularly useful to clients who desire to carry out a single tendering process and thereby eliminate the need for serial multiple tendering. The obvious benefit to the client is the reduction in tendering costs. Reddy and Williams (2014) discussed obtaining economies of scale through the

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use of FAs stating where a contractor or consultant is likely to obtain a steady stream of work over a period of years this is likely to be reflected in the price charged.

It is argued that the use of the FA may enable a contractor or consultant to work more effectively over time as they become more experienced and familiar with a particular type of work (Greenhalgh and Squires, 2011). FAs should also lead to better communication as parties become more accustomed with how the other party works. As procurement strategy in the construction industry better communication ought to lead to less adversarial relationships leaving the parties to concentrate on the project. Therefore the use of FAs is perceived to offer benefits to clients, contractors and consultants alike. Several researchers have detected a shift in emphasis from cost to value in the context of procurement in the last twenty years (Holt, *et al.*, 1995; Wong *et al.*, 2000, Walraven and de Vries, 2009).

Before the economic recession of the 1990's single stage competitive tendering dominated the UK construction industry, featuring short-term, adversarial relationships between client and contractor. Flanagan *et al.*, (2007, p996) acknowledged that lowest price bidding was "problematic" and cited the guidance of the Construction Industry Research Information Association (CIRIA, 1998) as a practical means to help. The understanding of deficiencies in lowest price tendering led to calls for alternative ways of doing business in the construction industry. Two influential reports (Constructing the Team 1994 ('The Latham Report') and Construction Task Force 1998 ('The Egan Report')) recommended the use of partnering arrangements including FAs to encourage long term collaboration between clients and contractors as opposed to short term adversarial arrangements. It was posited that the encouragement of long term arrangements would produce greater quality and maximise value to clients. Tennant and Fernie (2010, p685) observed "increasing examples of collaborative working practices" which they stated to be "...fashioned from the persuasive appeal of government discourse; partnering, strategic alliances and Framework Agreements ... [and] are now familiar expressions within construction vocabulary". In the fast changing environment in which organisations operate today teams and team-based philosophy are becoming increasingly commonplace (Sheard and Kakabadse, 2002). Tennant and Fernie (op cit.) consider FAs as part of the lexicon of modern day construction which shows that a relatively unknown concept has become widely accepted and understood in a short period of time.

### **Characteristics of Framework Agreements**

Bennett and Peace (2006) argued that FAs represent an extension of the partnering concept advocated by the Latham and Egan. The FA works on the basis that contractors are appointed to a framework and then a construction client considers the members of the framework as preferred bidders. Individual projects are "called off" the framework and carried out by the selected contractor in accordance with terms and conditions which are pre-arranged.

FAs generally last for a maximum of four years although it is possible for any length of time to be used. Where a construction client is a public sector organisation or entity the FA maybe subject to EU Procurement rules which restrict the maximum length of time to four years unless there are "justifiable exceptional circumstances".

Appointments to a framework generally involves an intensive and rigorous pre-qualification procedure aimed at identifying contractors who are "fit to proceed" and capable of delivering a quality output throughout the duration of the project. Those

contractors who are successful will be invited to submit a response to specimen project documents in competition with each other. Those deemed successful will be approached to enter into a FA where price and quality are negotiated and agreed in advance with respect to future projects. Clients enter into FAs for numerous reasons. Some wish to secure capacity for future projects whilst others seek to transform the way they procure construction services.

Critics of FAs have highlighted the large upfront costs which are incurred due to the nature of the intensive pre-qualification process and the fact that in some cases inclusion in a framework does not necessarily lead to orders for construction work (Broome, 2002; Doloi, 2009). Constructing Excellence have warned that clients who see frameworking as just a convenient way of shortcutting the procurement process will not reap any of the continuous improvement benefits (Construction Excellence, 2013).

### **Legal Issues and Framework Agreements**

There have been law suits generated whereby unsuccessful contractors have sought compensation for lost opportunity. In *Harmon CFEM Facades v Corporate Officer of the House of Commons* (1999) an unsuccessful contractor was awarded damages for lost opportunity. Banks and Bowsher (2011) queried the notion of whether damages were a complete remedy and suggested that the courts possess powers to set aside FAs due to "faulty procedures". Banks and Bowsher (*ibid.*) cited the Northern Ireland Court of Appeal cases of *Henry Brothers (Magherfelt) Ltd v Department of Education for Northern Ireland* (2011) and *McLaughlin and Harvey v Department of Finance and Personnel* (2011) respectively where FAs have been set aside by the courts. As these cases occurred in Northern Ireland they are not necessarily binding in England and Wales although they are highly persuasive.

At the time of writing the implications of the Northern Ireland Court of Appeal decisions means that procurement law, especially those matters concerning FAs in the public sector, is not completely settled. However, one must be mindful of Akenhead J's comments in *European Dynamics SA v HM Treasury* (2009) who said "One has to bear in mind that if any public procurement could be stopped by injunction because there was merely a serious issue to be tried, without more, the public authorities would be invariably targeted by the unsuccessful tenderers and public procurement would or could grind to a halt".

In summary it would appear that whilst the courts are somewhat reluctant to set aside FAs, they can and will do so in certain circumstances.

Despite the potential legal difficulties referred to previously it would appear that FAs have gained popularity during the last 20 years for both private and public sector clients. Flanagan *et al.*, (2007); and Kadefors *et al.*, (2007) highlighted the deficiencies of awarding work based on the lowest tender with the latter re-stating the connection between lowest tenders selection and the incidence of arguments and disputes involving variations. Kadefors *et al.*, (*ibid.*) considered that partnering arrangements (including FAs) encapsulated a different approach from traditional methods of procuring construction work. Qualities such as communication, honesty and commitment were felt to be more important rather than lowest price. Watt, *et al.*, (2010) found that past project performance and technical expertise to be the most important factors in contractor selection and they reported that tender price had been overtaken in importance by factors which were directly linked to project value.

These studies suggested that there has been a marked change in the way contract evaluation is carried out in the construction industry during the last twenty years. Though it would appear that cost is still an important consideration, some researchers emphasised a move away from cost being the dominant feature in procurement to a more holistic approach where clients make decisions based on value (Ohno and Harada, 2006, Scott et al 2006, Waara and Bröchner 2006, Abdelrahman *et al.*, 2008, Elyamany and Abdelrahman 2010, Yu and Wang 2012). However recent work by Loosemore and Richard (2015) stressed that many construction clients lack "sophistication and insight" and are locked into a lowest price mentality when procuring construction works. Loosemore and Richard (*ibid*) maintain that in the reality of the modern day construction the potential for investment in innovation is restricted to the relatively few large companies who are lucky enough to deal with sophisticated clients who procure buildings on a frequent basis. The vast majority of the industry are left to work with clients who procure buildings very rarely, who want the lowest possible price for their investment and who do not see them as a key long-term asset in the success of their core business. This view supports a contention that only a few large enlightened organisations have moved past the lowest price mentality and that the majority of those involved in the construction industry remain steadfastly adhered to traditional ideas and practices.

### **Economic conditions and Framework Agreements**

Prior to 2009, the UK had experienced five major recessions in the post war period. The usual economic definition of a recession is two or more quarters of successive negative growth in Gross Domestic Product (GDP) In January 2009 the government confirmed that the UK economy had entered recession as GDP had fallen consecutively during the 3rd and 4th quarter of 2008 (Office of National Statistics, 2009). Rhodes (2015) reported that in 2014 construction output was £103 billion representing 6.5% of the UK's Gross Domestic Product (GDP). It was stated that construction output in 2015 was still below the first quarter of 2007 by 2% (Rhodes, 2015).

It has been argued that FAs once established ought not to be renegotiated as a renegotiation represents a move away from the key principles of partnering (Bennett and Peace, 2006) Since the publication of Bennett and Peace's influential work there has been a significant downturn in the global economy and turbulence in world financial markets. This led to a number of construction clients both private and public sector abandoning FAs in order to secure savings on construction projects.

In 2013 the UK's Local Government Association published guidelines to its members (UK Local Authorities) entitled "Making savings from contract management" in which it heavily promoted the idea of renegotiation to secure lower prices. The central argument is that in times of austerity contractors may be more willing to share the pain of reduced funding (LGA, 2013, p5). The LGA also recommended the use of review or removal clauses in procurement contracts as without such clauses contractors have less incentive to renegotiate (*ibid.*). Numerous case studies were presented by the LGA featuring significant savings achieved through renegotiation.

A research question to be asked is whether FAs have any role in modern construction procurement since the recession. This question is relevant to all practitioners and academics involved in construction management as it is important in that it may influence how construction is procured in the foreseeable future.

## METHODOLOGY

According to Seymour *et al.*, (1997) research into the subject of Construction Management ought not to be constrained to any particular approach. In this study a mainly quantitative approach based on a survey questionnaire was used. However, according to Gomm (2008) the idea of doing research is "to provide readers with vicarious experience of other people's lives" so qualitative semi-structured and open questions were added to give what Patton (2002) calls a richness and vividness to the subject matter. It is acknowledged that the benefits of a mainly quantitative approach relate to scientific respectability and the confidence attached to this, however this approach relies on hard data and therefore lacks the richness and depth of some qualitative approaches (Denscombe, 2003).

Denscombe (2003) considers that the survey questionnaire to be suitable for data collection where a breadth of study is required and a current state of affairs needs to be established. A total of 300 questionnaires were sent out by email to participants. As Flanagan *et al.*, (2007, p992) observed "the term 'construction industry' is very complex". For the purposes of this study the participants were chosen from Building Magazine's top 150 contractors and 150 consultants respectively. Before sending out the electronic questionnaires a brief pilot survey was sent out to one firm of consultants and one contracting firm. As a result of the pilot minor changes were made to the questions. Neither firm involved in the pilot took part in the full survey.

The questions probed the nature of construction activity, whether the respective businesses operated nationally or regionally and whether the businesses operated in the private sector or public sector. Further questions were asked about experiences of FAs and participants were invited to share their experiences both positive and negative. Many participants indicated that their FAs had been renegotiated and the authors felt that this represented an interesting area for further study. Finally the participants were asked whether they thought the recession had affected FAs and whether they felt that FAs would play a role in construction procurement in the future.

The importance of this work should be seen in light of the UK Government's vision for the future outlined in Construction 2025 and other policies. It is a question that attempts to separate the reality from the rhetoric.

## DISCUSSION

A total of 99 questionnaires were returned (n=300) A response rate of 33%. Of these 58 were from consultants and 41 from contractors. Of the 58 consultants 25 indicated they that operated nationally, 31 operated regionally and 2 did not answer the question. Of the 41 contractors 14 said they operated nationally and 27 indicated that they operated regionally. Of the consultants who said that they were regionally based (n=31) the largest group (14) were based in the South East, 9 in the Midlands, 6 in the North West, 2 in the North East and surprisingly none were recorded in the South West, Scotland, Wales and other places respectively. Of the 27 "regional" contractors 10 were based in the South East, 7 in the Midlands, 6 in the North West , 2 in Scotland, 1 in South West, 1 other (stated as "Northern Ireland") and 0 for Wales. These returns show a good mixture of nationally and regionally based participants taking part in the survey.

One of the questions asked for participants' main sector of business. Most consultants put when asked to identify answers such as "General projects" or "All" Contractors who answered this question were more specific and the results are shown in table 1.

Participants were asked whether they had been involved in FAs during the last 5 years. The answer to this question revealed that 22 (out of 58) consultants said "yes" and 13 (out of 41) contractors indicated that they had been involved in FAs. This represents percentages of 38% (consultants) and 31% (contractors) respectively. Of the 22 consultants 8 indicated that they operated in the Private Sector; 9 in the Public Sector and 5 indicated both. For the Contractors the corresponding figures were 4, 6 and 1 respectively. This was pleasing because it confirmed that there was a good range of participants who were involved with FAs.

*Table 1: Contractors Main Activity*

Type of business	
"General" or "All"	9
Commercial	12
Retail	6
House building	9
Refurbishment	1
Infrastructure	1
Heavy Engineering	1
Did not indicate	2
Total	41

Further questions asked participants to consider greatest strengths and weaknesses of FAs respectively. The majority of consultants and contractors both ranked "long term collaborative agreements" as the greatest strengths of FAs whilst there was a difference between consultants and contractors where weaknesses were considered. Most consultants considered "the reduced competition due to exclusion of otherwise competent contractors" to be the biggest weakness whilst contractors felt that the resources and time consumed in bidding for inclusion with no actual work guaranteed" to be the greatest weakness.

The next question dealt with whether or not renegotiation of FAs had taken place in the last five years. Interestingly approximately one third of consultants and contracts said "yes" which means that there has been no renegotiation in the majority of FAs. This was an interesting point because it seems to run contrary to what has been reported in the technical press.

Further questions probed whether or not tender selection criterion had changed in the last five years. 68% (40 out of 58) of consultants said "yes". 71 % of contractors (29 out of 41) agreed with this. A follow up question was used to explore reasons with the majority of participants giving the main reason as the desire of clients to achieve cost savings due to the economic conditions. This would confirm a view that the use of procurement methods is affected by economic conditions. This might be felt to be a truism but the interesting point is that not all of them are affected. The next question dealt with what should happen to FAs during economic recession contractors. The findings are presented in Table 2 below:

Table 2 Use of Framework Agreements in economic recession

	Adhere to	Re-negotiated	Abandoned	Other, please state
Consultants	11	6	3	3
Contractors	4	4	2	1*

(Note: 2 contractors did not answer this question)

Although the majority of consultants support the view that FAs ought to be adhered to in times of recession this standpoint appears to have less support from contractors. The reason might be that contractors who lower prices to secure work are locked in to long term disadvantageous FAs.

A related question sought to find how participants felt about how FAs might fare in the future i.e. whether their use might increase /remain the same or decrease in use. The majority of consultants (9 out of 22) felt that the use would remain the same but only slightly less (8 out of 22) felt that they would decrease in use. Only 22% (4 out of 22) felt that use of FA would increase. In the case of contractors 6 out of 13 felt that use would remain the same and 6 (out of 13) predicted a decrease in use. Only 1 though that the use of FAs would increase. Whilst the number of participants is small it gives an interesting insight into the likely future use of FAs.

A final question invited consultants and contractors to make comments. Most comments indicated that whilst they expected FAs to be used as a procurement method for the foreseeable future both consultants and contractors felt that enthusiasm for FAs had waned. Reasons varied but many contractors expressed the view that having spent a large amount of time and resources to enter the FA they were disillusioned that in many cases the procedure did not translate into extra orders. Consultants expressed the opinion that some clients has used the FAs not as they were originally intended but as a mechanism to drive down construction costs to levels that were unviable for contractors. Comments were made (by both contractors and consultants) that economic uncertainty would lead to more renegotiation and in some cases complete abandonment of FAs but that where strong measurable collaborative working had been carried out then FAs would continue. Many felt that the four year period under EU legislation to be too long and ought to be reduced to two years. Many consultants involved in public sector FA expressed views that uncertainties regarding procurement law needed to be resolved in order to restore confidence.

## CONCLUSIONS

Despite the widespread publicity and the publication of Latham, Egan and other reports, the use of FAs is not as commonplace as one might have otherwise assume. The results of the survey illustrate a deep difference between consultants and contractors. Many consultants see the use of FAs as an opportunity to save their clients money on projects whilst contractors are reluctant to be locked in to unviable long term arrangements. This position is not helped through the uncertainty of recent case law decisions. Solutions are possible but they have to involve realistic time scales for agreements to work and a move away from the dominance of low cost tendering and suicidal profit margins. In respect of FAs in the public sector clarification of legal rules would be beneficial to all construction industry stakeholders. The Government's key policy document which sets out the how it sees the future of the UK construction emphasises the need for the industry to be "underpinned by strong integrated supply chains and productive long term

relationships" (Construction 2025, p18). This implies that FAs are a key part of achieving the goals of Construction 2025 and yet this study, despite its small scale nature, suggests a dichotomy between the vision of the government and the willingness of the construction industry to participate fully in achieving the vision of Construction 2025.

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# FROM CRISIS TO OPPORTUNITY: TURNAROUND STRATEGIES OF LARGE IRISH CONSTRUCTION CONTRACTORS DURING THE PERIOD 2007-2015

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The sudden change in environmental munificence level in the construction sector during the period 2007 – 2015 provides a natural experiment to investigate strategic and operating actions of firms, particularly during an environmental jolt. Statistics on business failures corroborate that neither academics nor practitioners have succeeded in guiding strategic action during periods of environmental jolt. Despite the recent increase of turnaround research in the general management domain, its use in the construction management realm remains underexplored. To address this research gap, five exploratory case studies of an ongoing PhD study were used to examine the turnaround strategies of construction contractors during a period of economic contraction and growth. The findings show that, although retrenchment is often considered to be a short-term strategy, this is clearly not the case; with the majority of contractors maintaining the strategy for 6-7 years. During the same period, internationalization became critical, with the turnaround process shifting towards strategic reorientation that altered the firms' market domain. The case studies further suggest that strategic and operational actions resonate quite well with contemporary practice-based approaches to strategy making. The findings provide valuable assistance for construction contractors in dealing with organisational decline and in developing a successful turnaround response.

Keywords: contemporary strategy, internationalization, organisational decline, retrenchment, turnaround strategies.

## INTRODUCTION

Since the onslaught of the 2007 economic recession, the identification of pertinent managerial responses to organisational decline has become increasingly important. Indeed, response strategies have become an important method of dealing with turbulent environments (Tansey *et al.*, 2014), and are one of the most important decisions that senior management must make (Ketchen and Palmer 1999). To put into context, the recent economic recession has affected numerous industries including construction, manufacturing, and business services (Price *et al.*, 2013); however, some industries such as oil production, agriculture, and the food sector, have proved less susceptible (Audas and MacKay 1997; Athey 2009). In relation to the Irish construction industry, construction output peaked in 2006 at €38.6 billion and

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declined for 6 consecutive years to reach a trough in 2012 at €9.1 billion; representing a decline of 76%. Subsequently, output has increased year-on-year to an estimated value of €12.5 billion for 2015 (SCSI 2015).

While organisational decline and turnaround research have been examined extensively (cf. Trahms *et al.*, 2013), comparatively little research has addressed turnaround strategies during recession, particularly in the realm of construction management. Furthermore, current theory related to turnaround situations have discussed strategies and actions relative to mechanistic strategy paradigms (e.g. Lim *et al.*, 2013); however none (as far as we are aware) have related the theory to more contemporary views of strategy. In this study, we address this gap by providing an in-depth analysis of firms' turnaround strategies (strategic and operational) during the period 2007-2015, whilst also exploring a contemporary practice-based approach to strategizing practices, where ontological and epistemological questions about what constitutes strategy, who the strategy makers are, and what strategy making entails. To do so, we leverage off the 2007 economic recession to demarcate dramatically different periods of construction munificence, and draw on five exploratory case studies of large Irish construction contractors.

## CONCEPTUAL BACKGROUND

Under the rubric of strategic management, the fundamental question surrounding strategy scholars and practitioners over the past few decades is how firms achieve and sustain competitive advantage. However, within recent years more theoretical effort has been made to understand how firms 'turnaround' from organisational decline (cf. Trahms *et al.*, 2013; McKinley *et al.*, 2014) and more contemporary ideas of 'where strategies come from?' (cf. Jarzabkowski 2005; Chia and Holt 2009).

### Organisational decline and the turnaround process

Organisational decline is an omnipresent concern in modern society (Trahms *et al.*, 2013), and according to McKinley *et al.*, (2014: 106) 'its effects are visible from the Rust Belt cities of the Midwest, to the failed housing estates of Ireland, to the fate of bookstore chains like Borders'. Moreover, in light of the recent economic recession and the associated weakness in the global economy, it is not surprising that research in the strategic management literature has focused a lot more on organisational decline and the turnaround process. Analogous with this, authors have expanded the focus to include domains such as, managerial cognition (e.g. Chen and Hambrick 2012), strategic leadership (e.g. Bradley *et al.*, 2011), resource orchestration (e.g. Trahms *et al.*, 2013) and turnaround innovation (e.g. McKinley *et al.*, 2014).

Following on from the foundational works of Pearce and Robbins (1993), Trahms *et al.*, utilised 40 empirical studies from the decline and turnaround literature since 1993. Building on Pearce and Robbins' review, they proposed an expanded model of organisational decline and turnaround, by incorporating recent insights to the turnaround process, whilst also assuaging the key criticisms of previous turnaround research. One such critic of Pearce and Robbins (1993) two-stage model was Arogyaswamy *et al.*, (1995) who argued that turnaround is not always rigid-beginning with retrenchment and being sequentially followed by strategic recovery actions. Indeed, given the significant development of the new expanded model, its use is warranted in order to help assess the turnaround strategies of construction companies relative to the 2007 economic recession.

For the purposes of this paper, the scope will centre on the 'firm actions' section of the organisational decline and turnaround model (cf. Trahms *et al.*, 2013). This part of the model introduces the firm's actions in response to the organisational decline, namely, operational and strategic actions. Operational actions (used as a synonym to retrenchment actions), are those actions undertaken to achieve short-run cost and asset reductions (Michael and Robbins 1998). Cost reductions generally reduces cash outflows, and often involves employee reductions to reduce firm labour costs (Barker *et al.*, 1998; Tansey *et al.*, 2014), whilst asset reductions involve the elimination of business units or other physical assets such as plant, machinery or facilities (Ndofor *et al.*, 2013).

Empirical evidence of the effect of retrenchment in the turnaround process has been inconsistent and has arrived at ambiguous results. For example, Robbins and Pearce (1992) found retrenchment to be inescapable, and indispensable in achieving turnaround for firms in decline. In producing evidence to the contrary, Barker *et al.*, (1998) concluded that successful turnaround was almost entirely due to revenue gains rather than cost and asset reductions. Strategic actions, on the other hand, are those actions that focus on changing or adjusting a firm's domains (products and markets) and how it competes within those domains (Barker and Duhaime 1997; Ndofor *et al.*, 2013). For instance, Morrow *et al.*, (2007) found that firms can change its strategy by reconfiguring existing resources and capabilities into new product offerings, or it can acquire new resources and capabilities externally through strategic alliances.

### **Contemporary approaches to strategy**

Before exploring the more modern contemporary approaches to strategy, it is important to firstly place this research in the context of the strategy process perspective. According to Chia and MacKay (2007) strategy process research entails 'how a particular organisational strategy emerges', while strategy content research focuses on 'what strategic decisions are taken'. Indeed, Web and Pettigrew (1999) argued that strategy content (e.g. Porter 1985) revolve around the domain of states and positions to conceive the fit between the resource base of a firm and its strategic location within a competitive environment. By contrast, the 'processual' approach to strategy theorizing tends to focus internally, on the activities of individuals and organisations, and the causal relationships and sequence of events that lead to organisational change (Van de Ven 1992).

Chia and MacKay (2007) note that critics of the strategy process research have begun to emerge from more contemporary scholarship (e.g. strategy as practice, practice based view, strategy without design), which offers an alternative perspective that is clearly distinct from the traditional strategy process view. A number of authors charge that not enough is understood about micro-level particulars of managerial activity (Regner 2003) or the work of ordinary strategic practitioners in their daily routines (Whittington 1996), hence the secondary schism of more contemporary approaches away from strategy process research. While a full review of this broader literature is outside the scope of the study, it is nevertheless important to briefly rehearse some of these newer streams.

The strategy as practice approach (hereafter 'SAP') could be viewed as complementary to the mainstream strategy process research, with strategy process research concentrating on reciprocal relationships between managerial actions and context, and strategy practice research focusing more on managers and the associated routines and procedures used to endorse strategy (Jarzabkowski and Wilson 2002).

The SAP perspective put forward by Jarzabkowski (2005) offers a more contemporary practice-based approach to strategy making, and examines human action, focusing on the actual work of strategists and strategizing, right down to the mundane 'micro-activities'. SAP research conducted by Regner (2003) found that strategy making tends to be more inductive rather than deductive. Similar to the SAP perspective, the practice-based view (hereafter 'PBV') of strategy scholarship includes the qualitative work in SAP, but in order to understand practices fully, it also adds the quantitative dimension (e.g. performance) as well (Bromiley and Rau 2014). Considering the resource-based view (RBV) emphasis is on things that firms cannot imitate, Bromiley and Rau (2014) stipulate that the PBV of strategy examines imitable activities or practices, which are amenable to transfer across firms. Another contemporary approach known as the 'strategy without design' perspective, was proposed by Chia and Holt (2009) and contends that successful strategies may accidentally emerge from the everyday coping actions of numerous individuals, none of whom intended to contribute to any predetermined strategy design, i.e. strategy could still emerge unconsciously, unplanned or undirected, in practice. They further contend that 'strategy' often involves locally embedded coping initiatives in which the fundamental concern is the mitigation of immediate pressing problems, with little thought about broader eventual outcomes.

## RESEARCH METHOD

On the premise of the foregoing discussion, this study aims to examine firms' turnaround strategies (strategic and operational) during the period 2007-2015. Consequently, the research method adopted in this study consists of five exploratory case studies of large Irish construction contractors. The selection of the five cases was based on a criterion sampling strategy relating to annual turnover for the year 2007, and was largely based on the thresholds set out by the European Commission (2005), whereby 'large' firms are deemed to have an annual turnover greater than €50 million. Regarding the five cases, two of the larger firms (Cases A and B) are predominately building / civil engineering companies, with two other firms (Cases C and D) being purely building companies, and the smallest of the five firms (Case E) a civil engineering company. The case study approach was chosen as it is most suitable for the 'how' and 'why' research questions (Yin 2014), whilst also providing an in-depth investigation of particular instances of phenomenon (Fellows and Liu 2008).

Semi-structured interviews were conducted with 'strategists', who referred to here are all senior management; either CEOs, MDs, or executive directors, who, for part of their formal role and duties, are involved in developing strategic direction (Higgs and Dulewicz 1998). For transcription purposes and to allow for a consistent flow during the interview discussion, each interview was recorded (with the participant's permission) and lasted between 80 and 150 minutes. Interview transcripts, along with audio files, company documents and case notes were uploaded into Computer Assisted Qualitative Data Analysis Software (CAQDAS). The interview protocol sheet consisted of two main sections; the first relating to general company information, and the second, response and recovery strategies (turnaround strategies) to the economic recession 2007-2013. The latter section on turnaround strategies utilised 10 strategic themes which were generated from an extensive review of key empirical strategic management studies. The more in-depth questions were developed from the conceptual ambiguities highlighted from an integrative review of mechanistic, organic, and contemporary strategy paradigms. Additionally, the conceptual turnaround framework proposed by Trahms *et al.*, (2013), also influenced

the protocol design and thus provided a platform for a more in-depth analysis and framing of the results.

The analytical strategy used in the study was guided by an abductive approach, which according to Blaikie (2000), refers to the dialectic, combination or relationship between deductive and inductive approaches. To suit the research needs of this study, the first cycle coding method adopted consisted of 'eclectic coding' which according to Saldana (2013) best fits as an exploratory method and entails a compatible combination of two or more first cycle coding methods. The next stage in the coding process involved a higher level analysis, namely second cycle methods (pattern and longitudinal coding), which are 'advanced ways of reorganizing and reanalysing data coded through First Cycle methods', and are necessary before moving on analytically (Saldana 2013: 207). The latter stage in the analytical process is post-coding and pre-writing, which Saldana (2013) refers to as the transitional analytic processes between coding cycles and the final write-up. More importantly, these serve as possible heuristics to explore the condensed categories and thus formulate assertions/theories.

## DISCUSSION

Analysis of the data resulted in the emergence of 16 categories, however due to space restrictions, the extent of the discussion will be focused on two main categories: cost retrenchment (operational actions), and marketing (strategic actions); which under the framework proposed by Trahms *et al.*, (2013), encompass the stage 'firm actions'. A brief synopsis of the turnaround strategies for the five case firms is also provided in Table 1.

### Cost retrenchment-operational actions

Three out of the five contracting firms (Cases A, C and D) initiated drastic cost-cutting measures early into the recession (all three cases started cuts in 2008), with all cutting salaries, bonuses, company cars, and employee numbers. This result is echoed by other studies (e.g. Robbins and Pearce 1992; Michael and Robbins 1998) wherein it was found that an aggressive retrenchment response should be used to activate the turnaround process. Even though retrenchment is the quickest way to achieve survival (Ndofor *et al.*, 2013), these three firms suffered the steepest declines in turnover during the recession period. This concurs with Nixon *et al.*, (2004) who found the level of downsizing to have a negative impact on firm performance. On a positive note, Cases A and D started to implement salary increases for the first time in 2015, some eight years after the recession started. The other two contracting firms (Cases B and E) were not as aggressive and started implementing some cost-cutting measures a year later. Both firms started cutting direct employee numbers in 2009/2010, as their large civil contracts finished, with one of the firms implementing bonus cuts in 2010 (accounted for 30% of salary); however both firms tended to maintain salary levels and company cars. Indeed, both of these firms' turnover for 2015 was only 15% off their peak values recorded at the start of the recession, while the three firms that took drastic cost cutting measures recorded turnover figures for 2015 as being 45-65% off their peak values. Regarding retrenchment actions and their respective timing, differences across the five cases may be explained by the fact that those firms who instigated earlier and more drastic cost-cutting measures (Cases A, C and D) were heavily involved in the residential and commercial sectors, and thus were directly exposed to the collapsing property market, while the other two firms (Cases B and E) were predominately involved in the civil engineering sector. Indeed, for all the five case firms, none have fully recovered yet. In this respect, 'recovery is said to have

been achieved when economic measures indicate that the firm has regained its pre-downturn levels of performance' (Pearce and Robbins 1993: 624).

The case data confirmed that the utilisation of cost retrenchment across the firms was linked to demand declines, in a deteriorating industry; however, it was also conceded that the firms became leaner, and as such, reduced inefficiencies across the business. In an effort to secure work and remain competitive in a declining market, most of the firms had to tender 15-20% below cost, therefore, initial strategizing focused on cost-cutting initiatives. Consistent with contemporary strategy approaches, depiction of 'how' the case firms retrenched during the recession was also evident. For instance, the two larger firms (Cases A and B) utilised their annual strategy forums, as a means of conveying the imminent cuts to staff, while the other firms adopted a more contiguous approach through personal meetings.

*Table 1: Turnaround Strategies of large Irish Contractors*

Case	Turnover		Main Firm Actions		
	% decline /growth	Years. of decline	Years. of growth	Operational Actions	Strategic Actions
A	72/115	2007 - 13	2013 - 15	Employee cuts in 2008. Started salary cuts in 2009. First increase in salaries in 2015. Cut bonuses in 2011 and reintroduced in 2015.	New international markets - UK in 2009, Poland in 2010.
B	51/175	2007 - 11	2011 - 15	Employee cuts in 2009. Cut bonuses completely in 2010; to reintroduce them in 2016.	New international markets - Middle East in 2012. New domestic markets - West of Ireland in 2008, Small works sector in 2008, Northern Ireland in 2011.
C	83/250	2008 - 10	2010 - 14	Cut salaries, employee no's, bonuses, and co. cars, in 2008.	New international markets - UK in 2012. New domestic markets- South of Ireland in 2014. New marketing manager in 2008.
D	79/240	2008 - 11	2011 - 15	Cut salaries, employee no's, bonuses, and co. cars, in 2008. Reintroduced increases in 2015.	New international markets - Middle East in 2007, UK in 2009, Germany in 2011. New UK non-executive director in 2010.
E	50/160	2009 - 12	2012 - 15	No major cost cutting, just employee layoffs in 2009/10.	New international markets - UK in 2010, Middle East in 2011, Poland in 2011. New domestic markets - small works in 2010, enabling works for private sector in 2012. New business development manager in 2014.

Regarding reductions in the firms' human capital, firm-clearing mechanisms consisted of; an initial wave of lay-offs, lay-offs as projects finished, temporary lay-offs, disengagement incentives (e.g. redundancies), and natural wastage (e.g. retirements). Exploring one case firm in particular, the 'practice' of initial cost retrenchment entailed executive directors (responsible for strategic determination) visiting every project in their jurisdiction over a two week period; meeting staff on a personal basis, and communicating immediate cost retrenchment actions. This first wave of operational actions involved 'selective' human capital reductions of 30-40 staff (20% cut overall), a 10-20% reduction in salaries at all levels, along with the removal of bonuses, and a

reduction in company perks. Moreover, as the turnover declined, selective human resource downsizing (cf. Nixon *et al.*, 2004) continued with the removal of a whole hierarchal layer of middle management (senior surveyors and contracts managers). In this respect, structure followed strategy, and thus provided a revised pattern for management, with increased workloads and respective working hours becoming the norm for the continuing workforce (survivors). Subsequently, during 2014 and 2015, the layer of middle management was reinstated in the firm, however, no increases in salaries or bonuses were reported.

### **Marketing-strategic actions**

During the period 2007-2012, all case companies diversified into new international markets; mainly during the firms' years of decline. Due to its relatively low entry barriers, the UK market proved to be the most popular choice across the majority of the firms (Cases A, C, D and E), followed by the Middle East (Cases B, D and E), and Poland (Cases A and E). Cases A and D, who already had a small amount of international experience were first to expand into the UK market in 2009, both targeting private sector works through client led opportunities. Due to the longevity of certain large civil engineering projects, Case E didn't need to expand into the UK until 2010; while Case C tended to put all its resources into improving its market share in the public building works sector in Ireland, thereby not expanding into the UK market until 2012. Certainly, the UK market proved successful for those firms who diversified, with all attaining growth in contracts awarded, and also increasing project values. These results are consistent with the findings of Barker and Duhaime (1997), who highlighted successful turnarounds through strategic reorientation that alters the firm's market domain. However, in the case of the Middle East market, two of the firms (Cases D and E) had to abnegate. For one of the firms, the evidence suggested that this was caused by their Irish joint venture partner going bankrupt, while for the other firm, they conceded that it was germane to a very prolonged tendering process. Similarly, expansion into the Polish market so proved futile for two Irish firms. In one of the cases, the job was under-valued, they encountered payment problems, and their Polish partner went bankrupt. In the other case, the firm overstretched itself with too many projects (mainly due to the domestic decline), there was a poor dispute process, and the client proved very difficult to deal with.

Similar to cost retrenchment, strategic reorientation of the case firms stemmed mainly from the economic collapse, and the deteriorating domestic construction sector. In addition, several cases recalled other motives, including; to retain existing staff, client led opportunities competitors were expanding, and to future proof the business for the next recession. Highlighting components of practice-based approaches, portrayal of 'how' the case firms expanded into the UK market was also apparent. For example, Case C pursued private building works by utilising their existing industry relationships, while Case E pursued public civil engineering works by simply siphoning through e-tenders to identify opportunities. Exploring Case C in particular, the 'practice' of utilising existing relationships, entailed executive directors contacting quantity surveyors, architects, and clients whom they had worked with before in Ireland, and who had diversified into the UK also. This resulted in the firm successfully getting on tender lists, however, it wasn't until their third or fourth project that they tendered for, that they won. As such, it could be argued that there diversification into the UK market was dependent on their 'relational assets'. Cases C and E also conceded that they availed of external assistance from Enterprise Ireland in the form of financial grants. The case data confirmed that in addition to relationship

management above, resource management through a combination of resource configuration and integrating new resources, was also evident in practice (also found by Morrow *et al.*, 2007). For instance all firms utilised their mobile resources and brought over a core Irish management team for initial projects. Subsequently, in order to reassure clients of their long-term commitment, all firms opened new offices. Interestingly, a year after entering the UK market, Case D appointed a UK native as a non-executive director in 2010, which had the added benefit of establishing more client relations and increasing respective tender invites.

### **Resonance with contemporary perspectives**

Theoretically, the findings resonate quite well with the contemporary strategy paradigms depicted earlier. Similar to the findings of Jarzabkowski and Wilson (2002), the SAP perspective was used successfully to identify contextually-meaningful patterns by incorporating interpretative contexts within which strategic action occurs. More specifically, the practice of 'allocating resources' by the case firms for market entry, clearly shapes strategy making, and thus shares components of the Bower-Burgelman (B-B) process model of strategy making (cf. Mirabeau and Maguire, 2014). Given the quantitative information provided in Table 1, along with the in-depth qualitative information of the case firms' strategic processes (aligns with the SAP movement); collectively they meet the requirements of the PBV approach, which according to Bromiley and Rau (2014) provide the output that practitioners will find valuable. Furthermore, the operational and strategic actions adopted by the case firms are not secret, idiosyncratic, nor technologically complex, however, they are generally imitable and amenable to transfer across firms, thus aligning with the PBV. Indeed Chia and Holt's (2009) idea of strategy without design, also resonates with some of the findings herein. For instance, strategic success for the case firms (e.g. UK market) was not attributable to the pre-existence of a deliberate planned strategy, rather, their actions involved locally embedded coping initiatives in which the fundamental concern was the mitigation of immediate pressing problems (i.e. survival), with little thought about broader eventual outcomes.

## **CONCLUSIONS**

Our goal in undertaking this study was to investigate the turnaround strategies (strategic and operational) of 5 large Irish construction contractors during the period 2007-2015, whilst also exploring a contemporary practice-based approach to strategizing practices. This responds to recent calls 'to examine potential turnaround actions in a greater number of industry environments'...'in industries going through cyclical contractions due to a recession' (Ndofor *et al.*, 2013: 1132).

The main pattern of findings show high levels of cost retrenchment to have a negative impact on firm performance. Even though retrenchment is often considered to be a short-term strategy (Robbins and Pearce 1992), this is clearly not the case; with the majority of contractors maintaining the strategy for 6-7 years. During the same period, internationalization became critical, with the turnaround process shifting towards objectives of growth and development; in the form of strategic reorientation that altered the firms' market domain. In this sense, the evidence concurs with Arogyaswamy *et al.*, (1995) and Trahms *et al.*, (2013), who argued that turnaround is not always sequential. The findings also suggest that the strategic and operational actions taken by the firms resonate quite well with the SAP, PBV, and the 'strategy without design' contemporary approaches to strategy.

The findings provide valuable assistance for construction contractors in dealing with organisational decline, and in aiding the selection and timing of appropriate strategic and operational responses. A key direction for further research would be to examine similar actions to this study, however, with failed construction firms. More importantly, this research provides an axiom for academic researchers in their future studies in this field.

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# CONSTRUCTION INDUSTRY AND (DIS)ECONOMIES OF SCOPE

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This paper explores the presence, causes and effects of the economies of scope in the construction industry. From the cost efficiency viewpoint, the bid and win rates are regressed by factors, including the number segments in a public procurement, in which a construction business operates, using the public procurement data of the Hokkaido Regional Development Bureau from fiscal years 2006 to 2012. We found that the bid rates of diversified firms are higher than those of specialized firms. Therefore, the winning probability of a firm decreases as their number of operational segments increases.

Keywords: competitiveness, modelling, procurement

## INTRODUCTION

The construction industry is well known to benefit from the economies of scope and scale. Some government levels offer preferential treatment in procurement auctions to balance monopolization. Take for example California's small business preference program, which provides small firms with a 5% bid discount. The effect of these bid preferences on auction outcomes was analysed by Krasnokutskaya and Seim (2011). Nakabayashi (2013) also examined the extent to which small business allocations increase government procurement costs (e.g. lack-of-competition cost exceeding the production inefficiency cost). These studies elucidated the issue of preferential treatment of small businesses in the construction industry. However, they have not addressed the cause of disparity.

The economies of scope, which are similar to the economies of scale, are efficiencies gained from variety rather than volume (Panzar and Willig, 1977, 1981). In some economies of scope, combining two or more product lines in one firm is less costly than separately producing them. The concepts of the economies of scope (and scale) are very popular and serve as powerful explanations in the modern strategy of businesses and management (Goldhar and Jelinek, 1983; Porter, 1985; Chandler, 1990; Besanko et al., 2009; Organization for Economic Cooperation and Development, 2011).

The present study considered a range of businesses offered by a construction firm based on the public procurement data of the Hokkaido Regional Development Bureau from 2006 to 2012. This study also explored the presence, causes, and effects of the

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economies of scope in the firm's business range. Against intuition, the result is that the construction firm in question does not have any economies of scope in the aspects of cost and success probability. Instead, they have the diseconomies of scope in the given situation.

We draw on the situation of the diseconomies of scope in the construction industry up to the abovementioned section. A firm generally decides to set a segment of the construction industry, and then determines whether or not to participate in a bid within the resource. Multiple licenses are affordable, but they only generate sufficient revenue to employ human resources in each segment. In view of the technical and financial limitation, a firm cannot easily transition from one specialised segment to another, but it can in the medium to long term. Therefore, we consider the causal relationship based on the reason of the diseconomies of scope or segment concentration efficiency and the explanation of the existence of a multiple-segment firm even though the correlative relationship between the estimated cost and the number of segments is shown. This is related to the academic debates of the economies of scope in the construction industry. Japan has 483,639 construction firms. Many of these are small and medium firms, which face scale and scope issues that are difficult to solve; hence, the need for a solution. This serves as the background of this paper.

The remainder of this paper is structured as follows: Section 2 reviews the economies of scope and the lack of previous construction management studies considering this viewpoint. Section 3 explains the (dis)economies of scope according to empirical estimation. Section 4 describes in detail the actual situation of the relevant market. Section 5 investigates the origins and consequences. Section 6 provides the conclusions.

## PREVIOUS STUDIES

The economies of scope are defined by Panzar and Willig (1981) as follows:

Let  $T = \{T_1, \dots, T_l\}$  denote a nontrivial partition of  $S \subseteq N$ . That is,  $\cup_i T_i = S$ ,  $T_i \cap T_j = \emptyset$  for  $i \neq j$ ,  $T_i \neq \emptyset$ , and  $l > 1$ . There are *economies of scope* at  $y$  and at factor prices  $w$  with respect to the partition  $T$  if  $\sum_{i=1}^l C(y_{T_i}, w) > C(y_S, w)$ .

The *diseconomies of scope* are obtained if the inequality is reversed. This concept is clear, and the definition leads to the cost subadditivity that,  $C(Y_1, Y_2) < C(Y_1, 0) + C(0, Y_2)$  where  $c(\cdot)$  is the cost of a firm, and  $Y_1$  and  $Y_2$  are the inputs (i.e. the existence of quasi-public, sharable inputs for the economies of scope). Some of the particular key strategies for the economies of scope are vertical integration and self-production of shared-input services. The diseconomies of scope can be motivated by technological and managerial constraints (e.g. large multi-product production that requires a costly oversight).

The economies of scope in the construction industry were referred to by Gann (1996) in terms of a comparative study of the manufacturing processes between industrialised housing and car production in Japan. The study stated that that the Japanese industrialised housing producers have analytically learned from other manufacturing processes (e.g. auto manufacture), particularly in delivering a wider range of choices for their customers. However, the study also noted the limitation and necessity of further research in the relationship between the standardization of parts and flexibility

in the final production. Furthermore, this future study would require a deeper analysis based on the performance data.

The network effects in the construction industry are unique because of the independence of each project and the competitive tendering procedures used (Dubois and Gadde, 2000). The efficiencies arising from the customer–supplier collaboration are not similar to the economies of scope. However, the cause of the mechanism, which is being linked to the multi-sector business offered by construction firms, is similar. These findings require additional quantitative exploration from a reversed perspective.

Gibb (2001) surveyed and reported real case studies to discuss standardization and pre-assembly. His study claimed that the “success or failure of standardization and pre-assembly will depend on the pragmatic response of industry to an urgent need—and industry’s ability to predict what the developing needs be”. From the viewpoint of the economies of scope, the effect is not automatically achievable. Therefore, this issue must be empirically researched.

Other studies have also focused on the impacts of information technology (Brochner, 2006). However, very few studies have estimated and considered the effects of the economies of scope in the actual construction business. The economies of scope/scale on the professional construction service firms are analysed by using qualitative data from interviews obtained in a subjective perspective (Jewel et al., 2014). However, the real market output results from the conduct of the construction firm with the (dis)economies of scope in terms of the revealed preference (objective perspectives) are required. Therefore, this study seeks to contribute to the discussion on the economies of scope in the construction business from the viewpoint of real public procurement data.

Similar to the prior research situations in construction management, we first explored the existence and extent of the (dis)economies of scope in the construction industry based on the empirical study of real-world data. We then explained in detail the actual situation of the (dis)economies of scope. Our strategy comprised data extraction, estimation modelling, results and interpretation.

## **DATA AND ANALYSIS**

### **Bidding and win rate**

Estimating the cost function of each firm to compare the segregated cost with the integrated cost was impossible because of the limitations of our data structure. However, rich and unique public procurement data were available for use in each specific project segment. We considered a field of construction business of these segments in terms of the economies of scope.

We explored whether or not economies of scope exist for public procurement participants that bid across various construction divisions based on the results of the actual public procurement data shown as a revealed preference analysis. We estimate the effect of the number of construction segments on the successful bid situation and the bid and win rates by using the procurement data of the Hokkaido Regional Development Bureau from fiscal years 2006 to 2012. Table 1 shows the data statistics.

The statistics of the Hokkaido Regional Development Bureau procurement data was presented in a predetermined price (i.e. upper price limit). This price was pre-

calculated for public procurement requests for construction bids based on work and design specifications and construction drawings (Article 29-6, Public Accounting Act).

Table 1: Descriptive statistics

	RATE	WINRATE	KUBUNSU	NOOFPARTICIPANTS	PREDETERMINED	Number	
Mean	0.9454	0.9152	2.1372	9.0259	1.54E+08	Y2006	18322
Median	0.9613	0.9347	2	8	97800000	Y2007	13337
Maximum	3.0556	1.0857	6	43	8.39E+09	Y2008	8776
Minimum	0.1033	0.4654	1	1	2400000	Y2009	7605
Std. Dev.	0.0854	0.0634	1.0694	5.1557	2.37E+08	Y2010	11348
Skewness	2.7906	-1.2308	0.9568	1.1039	11.2018	Y2011	9005
Kurtosis	50.2686	6.1759	3.7513	5.4097	221.6269	Y2012	6783
Sum	71068.99	11827.4	160665	678528	1.16E+13		
Observations	75176	12924	75176	75176	75176		

Firms must also have licenses to do construction business, guarantee construction quality and technology, and maintain the loan redemption credibility in Japan. Licenses are divided into 28 segments to promulgate the specialised construction technology. The segmentation is based on the construction technology, application and facilities. The licenses are affordable, but they only generate sufficient revenue to employ human resources in each segment. Firms cannot easily transition from one specialised segment to another because of these technical and financial limitations.

First, we formulated the relationship between the number of construction segments and the impact of the cost of a successful bid by defining a simple linear cost function with the dummy variable for the successful bidder among the participants (the winning bidder = 1; otherwise = 0). We then simply considered some rates of the project's predetermined price as the project cost (i.e. cost = rate × predetermined).

The firms' bid rates will likely decrease if the economies of scope reduce the cost and the number of segments provide the economies of scope. We analyse this inference using the following formula:

$$Rate_i(\text{or } Win_i) = \alpha_{1,1} + \beta_{1,1}NOOFSEGMENTS_i + \beta_{1,2} \log(BIDLAST_i) + \beta_{1,3}NOOFPARTICIPANTS_i + \varepsilon_1, \tag{1}$$

where, subscript  $i$  is the project number; Rate is set to the bid rate of the firm's project (i.e. the bid price divided by the predetermined price);  $Win$  is the winning rate (i.e. the winning price divided by the predetermined price);  $NOOFSEGMENTS$  is the number of segments in which a firm participates;  $NOOFPARTICIPANTS$  is the number of participants in the project;  $BIDLAST$  is the bid value of the firm (the last bid value is used if multiple bids are placed; and,  $\varepsilon_1$  is an error term. The coefficients to be determined are  $\alpha_{1,1}$ ,  $\beta_{1,2}$ , and  $\beta_{1,3}$ . Table 2 shows the results. We considered subsets of the coefficients in these tests. A variable is not considered in that model if its coefficient values are null (i.e. column).

Table 2: Estimation of the bid and win rates

Dependent Variable:	RATE		WINRATE	
	n=75176		n=12924	
Method: Least Squares	Coefficient (Std.Error)	Coefficient (Std.Error)	Coefficient (Std.Error)	Coefficient (Std.Error)
C	0.9417 *** (0.0007)	1.2491 *** (0.0063)	0.9123 *** (0.0013)	0.8953 *** (0.0111)
NOOFSEGMENTS	0.0017 *** (0.0007)	0.0017 *** (0.0003)	0.0013 *** (0.0005)	0.0008 * (0.0005)
LOG(BIDLAST)		-0.0154 *** (0.0003)		0.0024 *** (0.0006)
NOOFPARTICIPANTS		-0.0030 *** (0.0001)		-0.0044 *** (0.0001)
R-squared	0.0005	0.0797	0.0005	0.0901
Adjusted R-squared	0.0005	0.0796	0.0004	0.0898
S.E. of regression	0.0854	0.082	0.0634	0.0605
Akaike info criterion	-2.0827	-2.1652	-2.6781	-2.7717

The results in Table 2 indicate that the coefficients of both the bid and win rates are positive and statistically significant, but the coefficients of the project size (i.e. the last bid price) and the number of participants are negative and statistically significant. These coefficients are not different with or without the other variables of the project size ( $\text{LOG}(\text{BIDLAST})$ ) and the competitive situation ( $\text{NOOFPARTICIPANTS}$ ). Therefore, firms that engage in more public procurement construction segments generate higher last bid (i.e. the last bid divided by the predetermined price) and win (i.e. the win bid divided by the predetermined price) rates.

### Win probability

Second, we formulated the relationship between the number of construction segments and the probability of a successful bid as a logit function with the dummy variable for the successful bidder among the participants. We then estimated the selection probability of a winning bid among the participants as follows:

$$y_i = \alpha_2 + \beta_{2,1}z_{1,i} + \beta_{2,2}z_{2,i} + \beta_{2,3}z_{3,i} + \beta_{2,4}z_{4,i} + \varepsilon_2, \quad (2)$$

where,  $y$  is equal to 1 in the case of a successful bid in the project, or 0 when firms participate in the bid but do not win;  $z_1$  is the number of construction segments;  $z_2$  is the project scale (i.e. logarithm of the last bid price of the participant for the project);  $z_3$  is the number of participants; and  $z_4$  is a dummy variable for the year (the dummy variable is 1, otherwise, 0, when the date of the bid is in a specific year). The correlation between the number of participants and the last bid price of the participant for the project may cause bias in the estimation. However, the correlation coefficient for these data is 0.1071, which is not sufficiently high to cause problems. The parameters to be determined are  $\alpha_2$ ,  $\beta_{2,1}$ ,  $\beta_{2,2}$ ,  $\beta_{2,3}$  and  $\beta_{2,4}$ . Assuming that the  $\varepsilon$  variables in accordance with the extreme values of type  $i$  and using observation data based on the log-likelihood function,  $P$  is the odds rate and  $z$  is the collective term of the abovementioned variables,  $z_1$  to  $z_4$ :

$$\log P = \sum \left[ y_i \log \left( \frac{\exp(\alpha + \beta z)}{1 + \exp(\alpha + \beta z)} \right) + (1 - y_i) \log \left( \frac{1}{1 + \exp(\alpha + \beta z)} \right) \right]$$

It is possible to estimate the model parameters with the maximum likelihood. Table 3 presents the results. The results indicate that the coefficient for the number of construction segments ( $\text{NOOFSEGMENTS}$ ) is negative and statistically significant in the first column. Therefore, this finding shows that the probability of success decreases with an increasing number of construction segments, which is in contrary to the definition of the economies of scope.

We estimated the win probability using not only the number of construction segments, but also the logarithm of the last bid price of the participant for the project and the number of participants (the second column) to verify this. We further refined the model by additionally considering the fiscal year (third column). The coefficients of the predetermined price, number of participants and number of construction segment were all negative and significant. In addition, the economies of scope were still unobservable even when the fiscal year was considered (third column). These results are consistent with those of the "Bidding and win rate" section in that firms engaging in multiple segments generate higher bid rates (and, therefore, win rates), resulting in a lower probability of winning bids.

Table 3: Logit estimation of the winning probability

Dependent Variable:	WINPROB		
Method: Least Squares	n=75176		
	Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)
C	-1.5230 *** (0.0216)	1.4027 *** (0.1711)	1.5374 *** (0.1754)
NOOFSEGMENTS	-0.0231 *** (0.0091)	-0.0645 *** (0.0097)	-0.0661 *** (0.0097)
LOG(BIDLAST)		-0.0656 *** (0.0094)	-0.0683 *** (0.0095)
NOOFPARTICIPANTS		-0.2197 *** (0.0029)	-0.2182 *** (0.0030)
Y2006			-0.1215 *** (0.0383)
Y2007			-0.1711 *** (0.0394)
Y2008			-0.1431 *** (0.0423)
Y2009			-0.0685 (0.00435)
Y2010			-0.0052 (0.0415)
Y2011			-0.0510 (0.0425)
McFadded R-squared	0.0001	0.1144	0.1149
S.E. of regression	0.3773	0.3516	0.3916
Akaike info criterion	0.9178	0.813	0.8126

## MOTIVATION OF FIRM BEHAVIOUR

### Source for the diseconomies of scope

The diseconomies of scope in the construction industry may occur because the specialization of the segmentation enhances the efficiency of doing business in the construction industry. Increasing the number of segments may force firms to make advancements in their respective segments. We estimated the regression between the average bid rate of each business and the bidding participation to check this assumption. We then used the following equation to test this hypothesis:

$$Rate_{Ave,k} = \alpha_4 + \beta_{4,1}NP_k + \beta_{4,2}\frac{NP_k}{Segments_k} + \varepsilon_4, \quad (4)$$

where, variable  $NP$  is the number of bids in which a business participated.  $Segments$  is the number of segments, in which the firm operates. Table 4 shows the results.

Table 4: Relationship between each firm's rate and participation

Dependent Variable:	Firm's Avr.RATEi	
Method: Least Squares	n=3680	
	Coefficient (Std. Error)	Coefficient (Std. Error)
C	0.9548 *** (0.0020)	0.9558 *** (0.0020)
NP	-9.69E-05 ** (4.46E-05)	
NP/Segments		-0.0002 *** (0.0001)
R-squared	0.0013	0.0025
Adjusted R-squared	0.0010	0.0022
S.E. of regression	0.1055	0.1054
Akaike info criterion	-1.6600	-1.6612

The results in Table 4 indicate that the coefficients for the *NP* and *NP/Segments* are both negative and significant. The magnitude of the latter was much larger than that of the former. Therefore, costs were reduced for jobs that receive many bids, especially from firms participating in few segments. The results were also correlated given that the variables were correlated. However, this finding still indicated the presence of the diseconomies of scope.

### Reason for multiple segments

Firms may seek multiple segments despite the diseconomies of scope because of the risk of business fluctuation in the construction industry. Firms can stabilise the revenue flow by increasing the number segments, in which they participate in. We estimate the regression between the number of bids won by a firm and the number of segments, in which the firm operates, to check this assumption. We used the following equation to test this thinking:

$$WinNumber_k = \alpha_5 + \beta_{5,1} NP_k + \beta_{5,2} NOOFSEGMENTS_k + \varepsilon_5, \quad (5)$$

where, *WinNumber* is the number of bids won by the firm. Table 5 shows the results.

Table 5: Relationship between the number of bids won by each firm and the number of segments, in which they operate

Dependent Variable:	WinNumber		WinNumber
Method:Least Squares	n=3680		n=3680
	Coefficient (Std.Error)	Coefficient (Std.Error)	Coefficient (Std.Error)
C	0.5308 *** (0.0649)	-0.6013 *** (0.1589)	-15.6859 *** (0.8774)
NP	0.1459 *** (0.0048)	0.1357 *** (0.0055)	
NOOFSEGMENTS		0.9812 *** (0.1538)	14.0538 *** (0.6918)
R-squared	0.7272	0.7345	Method:Two-Stage Least
Adjusted R-squared	0.7271	0.7344	Squares. Instrument
S.E. of regression	3.4826	3.4358	specification: Number
Akaike info criterion	5.3340	5.3072	Participation

The results in Table 5 show that the coefficient for *NP* is positive and significant, which is natural given that more participation should lead to more wins. Furthermore, the coefficient of *NOOFSEGMENTS* (the number of segments) is also positive and significant. Therefore, firms win more bids when they operate in more segments. However, there may be a correlation between *NOOFSEGMENTS* and *NP*. Therefore, we applied the two-stage least squares method with *NP* as the instrument variable. The third column is the result, in which the coefficient of *NOOFSEGMENTS* is positive and significant. Therefore, the decentralization of a segment's project generates the diversification of risk in the construction industry. The risk diversification explains why a firm seeks for multiple segments despite the diseconomies of scope.

## DISCUSSION AND CONCLUSION

The construction industry has some features, such as local outdoor production, single-item-order production and labour-intensive production, which enhance the division of business. This industry also has other features, such as multiple building materials, complex process works and required schedule managing, which enhance the business integration. In light of these various factors, it is worth recognizing that the cost characteristics of the industry enhance efficiency from the viewpoint of both business and social welfare through optimal resource utilization.

This study considered the variety of construction segments of a firm in public procurement. We also explored the presence, causes and effects of the diseconomies of scope. From previous work regarding the network effect of the construction industry, there has been little presence of permanent networks. On the contrary, the temporary networks had substantial coordination because of project independency (Dubois and Gadde, 2000). We quantitatively verified the claim by using the procurement data of the Hokkaido Regional Development Bureau from fiscal years 2006 to 2012. The effect on the successful bid selection was regressed by the number of construction divisions and other control factors, such as the project size and the number of procurement participants. As a result, the bid and win rates of firms operating in multiple segments were higher than those operating in fewer segments. This result was verified through the probability of winning bids, as it decreased as the number of segments in which a firm participated increased.

The cause of the diseconomies of scope in the construction industry was also considered. One hypothesis was that the specialization of the segmentation enhanced efficacy in the construction industry. We performed a regression analysis between the average bid rate of each business and the number of bids, in which a firm participated to check this hypothesis. The results showed that the costs are reduced for jobs that received many bids, especially from firms participating in few segments.

This study has three main implications for construction management. First, the result of this study based on an empirical analysis indicates that the bid rates of the diversified firms are higher than those of the specialised firms. Therefore, the probability that a firm wins decreases as their number of operational segments increases. In line with this result, policy measures to enhance the industrial total productivity should include a plan to promote for specialised firms. Some government levels have preferential treatment programs in procurement auctions for small and medium firms, as had been mentioned in the first section. Furthermore, our result supports the type of policy program not only for the small and medium firms, but also skilled and sustainable firms in the construction industry.

We draw on the situation of the diseconomies of scope in the construction industry up to the abovementioned section. A firm generally decides to set a segment of the construction industry, then determines to participate in a bid within the resource. The correlative relationship between the estimated cost and the number of segments is shown. However, we consider the causal relationship based on the reason of the diseconomies of scope or segment concentration efficiency and the explanation of the existence of a multiple-segment firm because of two aspects. First, we researched on the origin of the diseconomies of scope from the viewpoint of the segment concentration efficiency. Second, we dealt with the reasoning of the existence of a multiple-segment firm.

Third, considering these findings, the factors of (dis)economies of scope and scale in terms of the business segment (e.g. managerial issues, climate conditions, and geographical situation) need to be investigated in detail. Extending this examination to other areas, to the country as a whole, and across other global regions is another challenge related this study. To consider the future research, data gathering is one of the key issues.

To further comprehend the cause of diseconomies of scope, for our next step, we will interview both diverse and specialised construction firms. Both statistical analysis and anecdotal evidence are useful for the development of construction management theory

and empirical study. Additionally, if it is possible, we would like to try to conduct a social experiment to verify the diseconomies of scope in both the laboratory and the field. Whether or not the findings of the diseconomies of scope in the construction industry are applicable in the worldwide situation is a global issue that needs to be investigated. However, the mechanism used in this article can be applied to construction industries in all countries, and is worthy of future research.

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# FACTORS INFLUENCING MALAYSIAN CONSTRUCTION FIRM'S ENTRY MODE DECISIONS INTO INTERNATIONAL MARKETS

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International construction firms raise their level of competitiveness in the global markets by exploiting opportunities using the right entry modes (EM). The objective of this research is to determine the significant factors influencing Malaysian construction firms' EM decision in international operations. The firm's EM decision was the dependent variable and four groups of factors (country, market, firm, and project) were the predictor variables. Using a sampling frame provided by the Malaysian Construction Industry Development Board, 62 firms responded to the questionnaire survey. The findings indicate that a majority of firms adopted a combination of equity (EQ) and non-equity (NEQ) modes. A multinomial logistic regression analysis was used to establish a predictive model for the EM decision, where the probability of choosing both modes can be determined with firm factor as the strongest predictor. The model is of significance for construction firms to determine appropriate EM strategies. Firms have to increase their level of knowledge, information, and experience related to project management competency, specialist expertise, and technology, organisational capability, risk management, reputation, and performance together with research and development activities. These strategies are effective when firms increase their knowledge, information and experience to adopt suitable EM.

Keywords: entry mode, international markets, Malaysian construction firms

## INTRODUCTION

A firm commonly faces questions to select a location or country to plan the right timing of entry and to adopt an appropriate entry mode to expand into international markets. Changes in technological innovation, communication, information and reduction in trade barriers have caused dramatic international market expansion of firms including Malaysian construction firms. The increasing size and complexity of projects have increased the need of the construction firms' participation in international markets (Comu *et al.*, 2015). A worldwide trend towards international market expansion has driven huge research efforts. Extensive studies on construction firms have been carried out on international market entry strategy (Ling *et al.*, 2008; Chen *et al.*, 2009; Polat and Donmez, 2010; Comu *et al.*, 2015). There are challenges related to country factors such as global competition with other foreign companies in host country (Wong, 2012), market factors such as the effects of globalisation and

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liberalisation and impacts of financial crisis, firm factors, for example, unsound business plan, lack of resources, knowledge and information on market structure and accessibility (Awil and Abdul- Rashid, 2001; Wong, 2007) and project factors, for example, increasing project size and complexity (Comu *et al.*, 2015). Idris and Tey (2011) revealed that the Malaysian firms adopted joint ventures abroad mainly to expedite profit generation and market penetration. Thus, it is compulsory for construction firms to have a global mind-set, supported by strong resources in terms of sufficient human capital and technological innovation and most importantly, strong financial capacity. This study focuses on factors (related to country, market, firm and project aspects) that influence Malaysian construction firms' decisions to adopt suitable entry modes (EM) in their international operations.

### **Entry Mode (EM) decisions**

Entry mode (EM) is an institutional arrangement for organising and conducting an international business transaction or in a simple and a widely accepted term, a decision concerning “how” to enter the market. Root (1994) described the EM decisions as various arrangements to make possible the entry of a firm’s products, technology, human skills, management or other resources into a foreign country. Previous studies have shown that choosing a suitable EM is crucial to ensure the performance of projects (Chen and Messner, 2009). For the selection of a suitable EM, Ozorhon *et al.*, (2007) suggested the incorporation of an extensive environmental scanning, determination of opportunities and threats in international markets, followed by their matching with the firm strengths. However, each EM decision comes with its own benefits and risks, since each EM arrangement requires a different level of resource commitment, investment risk and strategic flexibility (Chen and Messner, 2011). Ahmad and Kitchen (2008) looked into international expansion strategies of Malaysian construction firms focusing on the EM choices and motives for investment. These firms used international joint ventures (JV), which permits firms to access locally-based complementary assets and markets. In this study, the EM decisions were categorised under EQ and NEQ modes based on the definitions used by previous researchers (Chen *et al.*, 2011). The strategic alliance, local agent, licensing, representative office, JV project and sole venture (SV) project were grouped under non-equity (NEQ) modes, while JV Company, SV Company, branch office/company, BOT/equity project and wholly-owned subsidiary were grouped under equity (EQ) modes. Since a comprehensive theoretical framework of both EQ and NEQ has not yet emerged, as claimed by Gudergan *et al.*, (2012), this study chose the EQ and NEQ modes in measuring the EM decision to contribute empirical aspect of the EM strategy.

### **Factors influencing EM decisions**

Numerous researchers have proposed different plans in crafting the right EM decisions. In this study, the factors related to the EM decisions were grouped under country, market, firm and project themes based on previous studies.

#### *Country factors*

There are many important characteristics of internationalisation from the country policy or regulation perspectives related to the firm’s EM decision including investment risks (Agarwal and Ramaswami, 1992), economic and social uncertainties, such as corruption, political risks, and international competition in the host country (Musso and Francioni, 2009; Teixeira and Grande, 2012). Much of these country risks reflect the uncertainty over the continuation of present economic and political

conditions and government policies that are critical to the survival and profitability of a firm's operations in that country. Teixeira and Grande (2012) found that in the presence of markets with high levels of corruption, the firms prefer low equity (joint ventures with local partners) or non-equity (exports and contracting) EM choices. Nevertheless, it also reveals that, in some specific cases such as cultural proximity, even when there is pervasive corruption, the multinational corporations may enter via wholly-owned subsidiaries.

However, institutional export support (Musso and Francioni, 2009) and support from home country office together with political backing by the home government were anticipated by firms operating in international markets (Ling *et al.*, 2008). In addition, the bilateral business activities for construction works in international markets were found highly promoted by the host country governments instead of the home government (Lu *et al.*, 2014). Thus, the home and host government support on export promotion was found to be one of the important variables in determining foreign market EM decisions. They have adopted the NEQ modes such as, by having representative or branch offices to sustain their overseas' revenue (Chen, 2005). It was found that the Chinese contractors have established a permanent EM in Nigeria (Zhao and Atchike, 2015) through project financing by Chinese government concessional loans. Thus through this arrangement, the representative office is independent of the branch office and is organised to help the company headquarters in identifying potential projects in the foreign market.

#### *Market factors*

The EM decisions are also affected by external factors such as the market environment, for example, the level of globalisation, industry risks related to production inputs and investment risks (Puljeva and Widen, 2007). Firms have chosen the FDI mode to establish long term market presence, even if economies of scale were not promising (Agarwal and Ramaswami, 1992). It is expected that firms are attracted to a country with promising opportunities and potentials. However, there were firms that entered relatively lower potential markets by adopting sole venture mode to fulfil their firm's strategic objective to operate in international markets (Bartlett and Ghoshal, 1986).

#### *Firm factors*

There are vital needs for the construction firms to improve their dynamic capabilities and competitive advantages in order to grab the opportunities and face the challenges in international markets (Ling *et al.*, 2009). These internal factors are related to the firm's environment (Puljeva and Widen, 2007). These factors have important characteristics of internationalisation in influencing the EM decisions that include firm's dynamic capabilities (number of employees, the relative size of the subsidiary and technology of the business) (Chen and Chang, 2011) in order to achieve the targeted profit and sustainable growth. Agarwal and Ramaswami (1992) stated the importance of choosing the right EM, as it requires significant resource commitment that may lead to financial burden and time loss, and is influenced by ownership, location and internalisation advantages. Thus, firms prefer the complete control of their foreign operations because overall profit maximisation requires that their foreign ventures be tightly subordinated to the parents.

The size of the firm is based on the number of employees and international experience by the number of years the firm has been conducting business abroad (Ferreira *et al.*, 2013). Korkmaz and Messner (2008) in their study indicated that firm's size includes

experience and reputation to measure firm's resource capabilities. Logically, larger firms have more ability to raise the needed resources for large scale and complex projects assuming more risks when they invest in international projects. In relation to EM decisions, Argawal and Ramaswami (1992) found that larger firms preferred EQ modes. Firms with specific resource capabilities acquired the competitive advantages. Musso and Francioni (2009) revealed that the EM decisions were primarily influenced by firm-specific factors, above all organisational culture. Meanwhile, institutional factors have made significant contributions to the understanding of the EM decisions of Japanese manufacturing firms and partly overrided the effect of firm-specific factors proven in the earlier study (Kawai and Jonas, 2009). The EM decision was found to be influenced by the firm's long-term orientation that were more likely to use permanent entry than mobile entry when home market size is insignificant, and uncertainty avoidance, firm size or multinational experience is significant (Chen and Messner, 2011). Ling *et al.*, (2008) found that the most effective EM decisions are: setting up wholly owned foreign subsidiaries (EQ mode) and forming joint venture projects (NEQ) with local firms which are influenced by providing a superior product or service and paying close attention to client satisfaction.

#### *Project factors*

Ling *et al.*, (2008) have included project duration, financing, equity, price competitiveness and host country subcontractors, in their study as the project factors influencing the EM decisions. Moreover, project size was also referred to in terms of project value (Eyboosh *et al.*, 2011) together with project time-scale (Ofori, 2003; Park and Papadopoulou, 2012) to determine construction performance (Korde *et al.*, 2005) or construction project success (Gudien *et al.*, 2013). In analysing projects, Bauml (1997) used average project size as a rating factor. For example, if there are few projects with a very large scope, the firms could face excessive risk concentration. On the other hand, a large number of smaller projects can have the effect of diluting management resources, thus reducing control. Products in construction are unique and different in characteristics compared to products in other industries. In construction, the product refers to the physical product and/or services offered to the client. Product and/or service differentiation is one of the strategies in achieving client's satisfaction. Competitors might not pose any risk to the firms or as a barrier to delay the firms' entry if they were able to offer products/services that were different and unique from the competitors, which further enhanced their level of competitiveness (Polat and Donmez, 2010).

## **METHODOLOGY**

A quantitative approach was adopted using self-administered questionnaire survey. A qualitative approach using interviews were also carried out to validate the quantitative findings and the developed decision model. However, the findings from the interviews are not presented in this paper. Managers from construction firms were targeted to be enquired for their opinions and perceptions regarding the international market entry strategies adopted by their firms. The units of analysis are the Malaysian construction firms engaged in international business activities with foreign market experience. They were registered as Grade 7 with the Malaysian Construction Industry Development Board (CIDB). This study used a sampling frame from CIDB, where 115 firms were engaged in international projects in various sectors, such as buildings, infrastructure, branches of engineering such as mechanical and electrical, power transmission and plant facilities, and oil and gas. The respondents were the top managers of these construction firms. They were asked to choose the EM adopted by

their firms based on a given list of EM grouped under EQ and NEQ modes. Under EQ modes, there are joint venture (JV) company, sole venture (SV) company, branch office/company, BOT/Equity and wholly-owned subsidiary. Under the NEQ modes, there are strategic alliance, local agent, licensing, representative office, JV project and SV project. A categorical type of scale was used to measure the EM decision: 0= EQ modes; 1 = NEQ modes; and 2 = BOTH modes.

Based on literature review, 44 factors were selected and grouped under four independent (predictor) variables; country, market, firm and project factors. Amongst the country factors used in this study are attitude and intervention of host governments, the similarity of host country/market, proximity, economic and non-economic risks and other foreign competitors in the host country. Market factors include profit potential/attractiveness, competition intensity, product/service growth, entry barriers, innovative and entrepreneurial opportunities and market demand. Under firm factors there are competencies (project management, specialist expertise and technology), superior management and organisational dynamic capabilities, risk management attitude, reputation, performance based on ROI/sales/assets, research and development (R&D), size, assessment of market signals and opportunities, international experience, long-term and strong management strategic orientation and financing capacity. Finally, some of the project factors include product differentiation, brand name, reputation, project size and types, and project technical complexity. Analysis for the dependent variable was then carried out using MLR modelling against the four independent variables.

## **ANALYSIS AND DISCUSSIONS**

Sixty-two managers holding various posts were involved in the survey. The distribution of the respondents is Vice President (3.2%), General Manager (4.8%), Managing/Project/Technical Director (12.9%), Senior Project Manager (4.8%), Senior Project Engineer (3.2%), Project Coordinator (3.2%), Project Manager/Planner (9.7%), Project Engineer (24.2%), Contract/Quantity Surveyor/ Financial Manager (14.5%) and other managers (19.4%). They were directly involved in their firm's international operations and acquired years of experience in planning, managing and controlling construction projects in international markets. About 26% of the respondents acquired more than ten years of international experience, 29% with the experience between 5 to 10 years and 45% with experience between 1 to 5 years. Based on their experience in years and from performing different leading positions within their firms, the respondents were all knowledgeable about international operations to give reliable opinions in the survey. The descriptive analysis shows three types of EM decisions adopted by the firms: (1) firms that chose equity modes only (EQ), (2) firms that chose non-equity modes only (NEQ) and (3) firms that chose both equity and non-equity modes (BOTH). An MLR analysis was carried out in this study as an appropriate multivariate procedure to describe and test relationships between the dependent variables (EM decisions) and the independent variables (predictors) as described in the following section.

### **Firms' Entry Mode (EM) decision**

An enquiry related to the EM decision required the respondents to select the EM adopted by their firms, which were grouped under equity (EQ) and non-equity (NEQ) modes. Joint venture (JV) company, wholly owned subsidiary (WOS), branch office/company, sole venture (SV) company and Build-Operate-Transfer (BOT) are

grouped under EQ modes, while under the NEQ modes, there are strategic alliance, licensing, local agent, representative office, SV project and JV project.

### **Multinomial Logistic Regression (MLR) analysis**

Generally, an MLR is used to obtain the maximum likelihood estimates of the main effect and interaction parameters. For the EM decisions, the dependent variable consists of a nominal variable with more than two levels. In this case, three type of choices are allowed for MLR analysis to be used (Mooi and Sarstedt, 2011). The MLR model for EM decision was established to determine the effect of an increment of each of the independent variable (factor) on the type of the value that occurs for the variable for the EM decision, i.e., value 0 (equity modes only - EQ), value 1 (non-equity modes only - NEQ) and value 2 (both types of modes - BOTH). Similar MLR models were used by Agarwal and Ramaswami (1992) in which all three of these models fit the data well. The analysis involved: (1) determining the predictive ability of the model, (2) model evaluation and (3) assessing the contribution of individual predictors. Two additional tests namely a test of homogeneity of variance (Levene's test) and analysis of variance (ANOVA) were also carried out.

#### *(1) Predictive ability*

A classification table was established to describe the predictive ability of the EM decision model to indicate how well the model predicts group membership by distinguishing the firms that adopted the EQ mode, NEQ mode and BOTH modes in their international operations. The result shows that the EM decision model has an acceptable predictive ability of 58.3% to predict correctly the firms that adopt "BOTH" modes. It also predicts correctly those firms that adopted the EQ modes 21.1% of the time and those firms that adopted the NEQ mode 47.4% of the time. The overall accuracy of classification shows that the model correctly classified 43.5% of the firms. Thus, the model has a moderate ability to predict the correct category for each EM decision based on the selected (well fitted) predictor variables. It is expected that the firms prefer to adopt both types of modes depending on their firm's resource capabilities and technical competencies.

#### *(2) Model evaluation*

The classification table for the EM decision did not give any measure of significance, and it was not easily comparable to measures of fit in linear regression. In the MLR analysis, four groups of predictor variables were regressed against the firm's EM decision to adopt EM in their international projects. Thus, the following measures of model fit were carried out.

First, Pearson and Deviance statistics tests for Goodness of Fit (GoF) revealed that both results are significant: [ $\chi^2(108) = 114.421$ ] with a significance level of 0.322 ( $p > 0.05$ ) and [ $\chi^2(108) = 117.466$ ] with a significance level of 0.251 ( $p > 0.05$ ). Hence, both tests indicate that the data fits the model. The results from the GoF tests for the EM decision model indicate sufficient evidence to claim that the model is worthwhile. Thus, the assessment of the GoF of the model determined the appropriateness of the model. Second, Cox and Snell R-square, Nagelkerke R-square and McFadden R-square tests indicate the amount of variation in the dependent variable (EM decision in choosing EQ, NEQ or BOTH modes) which are explained by the predictor variables. The values suggest that between 7.1% and 16.3% of the variability is explained by the set of predictor variables towards the EM decisions. The MLR provides the maximum likelihood estimates of the main effect and interaction parameters. Finally, the likelihood ratio tests were carried out to ascertain the significance of predictors of the

EM decision model. The Sig. value for each predictor (0.227, 0.642, 0.065 and 0.356) indicates that there is no significant main effect on the EM decision ( $p$ -value  $< 0.05$ ). However, when the cut point for  $p$ -value was set to be  $< 0.10$ , only the firm factor has a significant main effect towards the dependent variable with Sig. value of 0.065 [ $\chi^2(2) = 5.460, p < 0.10$ ]. The ratio test shows that only one predictor (firm factor) was statistically significant, indicating that the model was able to distinguish between firms that choose BOTH modes.

### *(3) Assessing the contribution of individual predictors*

An assessment of the contribution or the impact of each predictor on the likelihood of the firm's EM decision provides information on the importance of each of the predictors in the EM decision model. The decision model was established with NEQ modes as the reference category and contains four independent (predictors) variables (country, market, firm and project factors). Coefficients (B) and Wald statistic values were used to identify the strong predictors and to assess the successive accuracy of a model by evaluating its ability to predict correctly the category for cases for which the outcome is known. Out of four predictors, for EM decision model (BOTH modes), only firm factors with Sig value of 0.043 ( $p < 0.05$ ) contributed significantly to the predictive ability of the EM decision model for equity of the "BOTH" modes. Thus, for a firm's EM decision using "BOTH" modes, depends on the firm factors.

The result shows that the predictor variable for firm factors corresponds to the B values of 2.590. Based on the "coefficient of predictor variables in the equation", a fitted EM decision model (BOTH modes) is:  $\text{Logit}(p) = 1.470 + 2.590\text{Firm}$ ; where  $p$  is the probability of choosing to adopt both types of equity modes with firm factors as the strongest predictor variables.

The interpretation of the odds ratio (OR) of the values was provided by the Exp (B) value in which the B values were used in the equation to calculate the probability of a case falling into a specific category of the EM decisions in this case, choosing "BOTH" modes. The strongest predictor is the firm factor ( $B = 2.590, p < 0.05$ ), recorded OR of 13.327 ( $\text{OR} > 1$ ). This indicates that a firm with more knowledge on firm factors is 13.327 times more likely to adopt BOTH modes as compared to a firm with less knowledge on firm factors, with all other factors being equal. For each increase in firm factor score, the odds of a firm adopt BOTH modes increase by a factor of 13.327 relative to the NEQ modes. In simple terms, the more knowledge a firm has on firm factors, the more likely a firm will adopt BOTH modes.

### *Test of homogeneity of variance*

Levene's test was carried out to compare the factors influencing the decisions between EQ, NEQ and BOTH modes by the firms. It established whether there is any similarity between the equity modes (EQ), non-equity (NEQ) modes and BOTH modes categories. The Levene's test showed: country factor ( $p = 0.713$ ); market factor ( $p = 0.721$ ), firm factor ( $p = 0.913$ ) and project factor ( $p = 0.594$ ). All values are greater than 0.05. Thus, the assumption regarding the homogeneity of variance is acceptable in which the variances of across groups for all factors are homogeneous.

### *Analysis of variance (ANOVA)*

ANOVA F-tests were carried out to find whether there exist statistical differences between the EM decisions and the factors. It revealed that there exists no statistical difference between all types of EM decision and all four factors: country: [ $F(2, 59) = 1.225, p = 0.301$ ]; market: [ $F(2, 59) = 0.851, p = 0.432$ ], firm: [ $F(2, 59) = 0.018, p = 0.982$ ] and project: [ $F(2, 59) = 0.347, p = 0.708$ ]. Since all  $p$ -values are greater than

0.05, the four groups of predictor were normally distributed with no statistical difference between types of EM decision. The MLR model for the EM decision has a good predictive ability in determining the firm's EM decisions. The predictive model indicates that a firm's knowledge on firm factors significantly influenced the firm's decision to adopt both EQ and NEQ modes in their international operations. The most significant firm factors influencing EM decisions are financial capacity, competencies (project management, specialist expertise and technology), superior management and organisational dynamic capabilities, management of risk attitude, reputation, performance based on ROI/sales/assets, and R&D. Tjosevik and Refsland (2012) emphasised that foreign operations require huge financial capital investments. Difficulties in assessing loans, other forms of financial assistance, incentives and supports lead to issues in financial capacity (Che Senik, 2010) such as delay in the target markets and lack of commitment and engagement of the supply of other resources. It was established that efficient human resource management in delivering a quality product or service through achieving on-schedule and within-budget goals using modern project management tools (Gunhan and Arditi, 2005), was found important and symbolised by the firm's strong brand name (Lu *et al.*, 2013). Argawal and Ramaswami (1992) found that large firms preferred EQ modes. In general, larger firms have the strong financial ability to raise the needed resources for large-scale and complex projects. Since there was a mixture of different sizes of firms, both EQ and NEQ modes were adopted. Positive risk management attitude was used when they invested in high-risk international projects. By having a high level of international experience among their managers, the firms' ability to compete in international markets was increased (Ahmad and Kitchen, 2008) and also supported by increasing activities in R&D. As the level of knowledge increases, the risks involved in international markets is subsequently minimised. Thus, firms need to update and seek relevant market information or knowledge about particular destinations and engage in extensive R&D on market potentials (Che Senik, 2010).

## CONCLUSIONS

An empirical contribution from this study is the establishment of the EM decision predictive model for construction firms represented by  $\text{Logit}(p) = 1.470 + 2.590\text{Firm}$ ; where  $p$  is the probability of choosing both types of equity modes. It shows a significant relationship between the EM decision and firm factors as the strongest predictor. The predictive model suggested that in order for construction firms to adopt both EQ and NEQ modes, they are required to increase their level of knowledge, information, and experience related to firm factors such as project management competency, specialist expertise and technology, organisational capability, risk management, reputation and performance together with R&D activities. The findings from this study are in line with the development of internationalisation strategy by the Malaysian government (CITP: 2015-2020) to define EM strategy. The findings enhance the existing body of knowledge related to international market entry by contributing to a deeper understanding of the EM decision for construction firms in Malaysia and beyond. Further research could also examine other dimension of entry strategy, for example, the entry timing (ET) by determining the ET decision dimensions and factors influencing this decision.

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# DISCOURSES OF COMPETITIVENESS IN THE CHINESE CONSTRUCTION SECTOR

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The transition of China to a socialist market economy has transformed the expectations placed on the construction sector and the parameters used to evaluate performance. Terms such as ‘competitiveness’ and ‘enterprise’ increasingly dominate the discourse of construction sector performance in a way which was unthinkable thirty years ago. This paper explores the policy discourses on construction sector improvement since the 1950s. The particular focus lies on the changing ways in which contractors are defined and positioned and techniques suggested within the unfolding policy discourses. This paper identifies four main policy discourses since the 1950s, which are soviet style construction (1950s-1970s), enlivening contractors (1980s) socialist market economy fitness (1990s) market behaviour regulating (2000s-). It further argues that, in the academic literature, the Chinese policy discourses about contractors were hidden by predefined categories drawing from western competitiveness discourses.

Keywords: competitiveness, contractors, discourse analysis, policy

## INTRODUCTION

Since the introduction of the open door strategy in 1978, the Chinese government has tried to introduce elements of competition. During this process, policies emerged that conveyed a changing set of expectations for the contractors. Correspondingly, the academic literature started to focus on the competitiveness of contractors and the practices that might help their development. However, the current literature lacks any systematic analysis of the changing nature of the policy discourses and their implications for practice.

This research aims to explore the policy discourses since the 1980s and their similarities and differences, if any, with those found in the academic literature. Initially, the existing academic literature relating to the competitiveness of Chinese construction firms was reviewed and critiqued. It is argued that the literature is heavily influenced by western competitiveness discourses and policy discourses. This is followed by a consideration of methodology, drawing loosely from Foucault’s (1978/1991) concept of governmentality. The adopted analytic model focused on the expectations and accompanying techniques suggested for the construction sector, with particular focus on contracting firms. This is followed by an indicative analysis of the policy discourse from the 1950s to 2010s. Finally, the discussion and conclusion section focuses on the changing expectations of how contractors should operate.

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Western discourses of competitiveness reflect and reinforce the notion that firms have to compete within the 'marketplace' if they are to survive and prosper. More recently emphasis is increasingly given to the need for firms to adapt to changing circumstances, otherwise construed as a dynamic business environment (Green e.g. 2008). This provides the essential starting point for reviewing the existing literature on the competitiveness of Chinese construction firms. It will be argued that this literature is heavily influenced by Western discourses of competitiveness and the changing policy context within China. These of course are not unrelated, at least in terms of their respective discourses.

Influenced by the national strategy of 'socialist market economy', academic research on the competitiveness of the Chinese contracting firms started to flourish in the early 2000s. The resulting literature was heavily influenced by the discourses of market-based competition. For example, Wang *et al.*, (2006) on the basis of a questionnaire survey argued that the primary aim of the contractors are profit maximization. They also emphasised the importance of construction quality improvement and being competitive in the pricing of bids. These are hardly radical ideas from a Western perspective, but their gradual introduction into the Chinese context is hugely significant. Lu *et al.*, (2008) also adopted the terminology of 'competitive advantage' to set out their expectations of how contractors might operate. They further recommended eight supposed 'techniques' which might bring success. The lexicon of terms was derived directly from Western discourses: project management skills, organization structure, resources, competitive strategy, relationship, bid, marketing, and technology. Precisely what these terms might mean is perhaps less important than the fact that they are now being talked about. Ling *et al.*, (2012, 40) further argue that contractors 'need to be competitive in order to survive and grow'. Their lexicon of recommended techniques is nuanced slightly differently, but is essentially derived from the same Western discourse of competitiveness. Examples of key phrases include: differentiation, focus, cost leadership, a variation of tactics, relationship formation, and relationship cultivation. Phrases such as 'differentiation', 'focus' and 'cost leadership' can be seen to be derived from Porter's (1985) ever-popular contribution.

But the arguments offered were not solely imitative of Western sources, they also made specific reference to Chinese government policies. For example, Lu *et al.*, (2008) refer to the Chinese Government's 'lay-off' policy and to their determination in promoting 'modern construction'. Government policies were also mentioned as part of the justification for an increasing focus on 'human resources'. Shen *et al.*, (2004) were especially notable in referring explicitly to mechanisms which had been introduced into the debate through governmental policy documents. These mechanisms included the business license and qualification system, quality monitoring system, project supervision system, tendering system, qualification management system, initial capital system and owner responsibility system. Clearly there is something occurring that is rather more nuanced than Chinese contractors adopted supposedly 'Western' management techniques. There would appear to be an evolving discourse relating to the Chinese construction sector which has yet to receive any degree of systematic analysis.

## METHODOLOGY

The proposed research aims to explore the policy discourses in the Chinese construction sector. Drawing loosely from Foucault (1978/1991)'s concept of governmentality, discourse analysis has been applied to policies issued in the Chinese construction sector from the 1950s to 2010s. The concept of governmentality is argued to be a useful tool to analyse policy discourse. Dean (1999) developed four concepts, 'visibility', 'techniques', 'knowledge', and 'identity' for the purposes of analysing policy discourses. Visibility refers to which problem to solve, while techniques denotes the mechanisms or regimes advocated for the purpose of solving the problem. Knowledge refers to the types of thought that should be brought to bear by the techniques. Finally, 'identity' refers to what forms of self are proposed. Oels (2005) applied these four concepts to demonstrate how the governmentality of 'climate change' was exercised in a series of policy reports. Schweber (2013) similarly applied the four concepts to analyse which kind of governmentality embedded within BREEAM. Given the aim of the research to understand the policy discourses surrounding contractors, particular attention will be given to the expectations of construction sector, contractors and construction professionals and accompanied techniques. Techniques here means the mechanisms recommended for use in guiding the contractors.

## CHINESE POLICY DISCOURSES FOR CONSTRUCTION

This section will use the analytical framework to analyse the policy discourses relating to the Chinese construction sector since the 1950s to 2010s. This section will argue that there are four main policy discourses about contractors, which have been labelled: soviet style construction (1950s-1980s), enlivening contractors (the 1980s), socialist market economy fitness (1990s) and regulated market behaviour (2000s). Each period is characterised by different advocated goals for contracting firms and correspondingly different recommended techniques. To avoid confusion caused by translation, the Chinese words of the key texts of expectations and techniques will also be given.

### *1950s-1980s: Soviet-style construction*

This section analyses the key policies issued from the 1950s to 1980s. These include the Provisional Regulation on Basic Construction (Finance Economy Committee, 1952) and Decision on Strengthen and Develop the Building Industrial Industry (the State Council, 1956). It is argued that soviet style construction is the main policy discourses in this period. In the Provisional Regulation on Basic Construction (Finance Economy Committee, 1952) construction activities were called 'basic construction' (基本建设). They were further defined as 'affiliated works caused by the fix assets enlarge and reproduction, include new construction, rebuild, and recovery.' (Finance Economy Committee, 1952, p 1). No clear concept of the construction sector can be found in these documents.

The goal set for the contractors, which were referred to as 'building installation organizations' (建筑安装组织), was to 'execute the task of industrial construction' (Central People's Government Commission, 1953). Contractors were expected to improve technology, organization and management level. A military style can be observed here. This can be linked to the Decision on Transformation of Armies

(People's Revolutionary Military Committee and Governmental Administration Council, 1952), which made the building installation organizations part of the People's Liberation Army, referred as 'Engineering Troops'.

The Decision on Strengthening and Developing the Building Industrial Industry (the State Council, 1956) identified a number of techniques to help to build installation organizations to improve the technology, organization, and management level. Main mechanisms recommended include 'industrialization' (工业化); duration quota (工期定额) and budget quota (预算定额); mixed labour team (混合工作队); piece-wage system (计件工资) and welfare like school.

These recommended techniques were clearly influenced by the soviet style construction. The term 'industrialization' here conveys a sense that construction activities should be organized in a similar way to the manufacturing industry, with fixed factories and specified roles. 'Construction base' (建筑基地) was required to establish as the 'manufacturing plant', which contains all special organizations. The relations between these special organizations was interestingly described as 'subcontracting' (分包), which was a nominal designation given that 'construction tasks' were designed to be allocated by governmental departments. Duration and budget quota, with no clear definition, were recommended to improve the 'management level', which highlighting the function of 'planning' in the resource coordination. A piece-rate wage system was designed to motivate soldiers to improve productivity also demonstrates that the construction activities were treated similarly to other types of manufacturing.

#### *The 1980s: Enlivening contractors*

This section focuses on the policies issued since 1978 when the open door strategy was announced. Key policies include the Provisional Regulation on State-operate Construction Enterprises' Operational Rights Expanding (the National Construction Committee *et al.*, 1980), the Provisional Regulations on Reform on the Management Mechanism of Construction Sector and Basic Construction (the Chinese State Council, 1984), and the Guidance on Pilot Reform on Construction Management System (Ministry of Construction, 1991). This section will argue that "enlivening contractors" became the main policy discourse of the 1980s.

In 1978, the Chinese government announced open door strategy and put the economy development as its primary goal. The construction sector was then defined by Xiaoping Deng (1980), the most influential leader at the time, as 'important industry that can increase revenue for the state'. To realize the economic effectiveness, the previous 'building installation organizations' were then designed to different roles. According to the Provisional Regulations on Reform on the Management Mechanism of Construction Sector and Basic Construction (the Chinese State Council, 1984), 'engineering contracting firm' (工程承包公司), 'Construction Bank', 'designer', 'supplier' were listed as main actors in the construction sector. Among them, the engineering contracting firms were given a central role.

How to enliven the engineering contracting firms to improve the economic effectiveness was the main theme of the policy discourse in the 1980s. It should be noted that engineering contracting firms were not firms in the western common sense. In contrast, the newly named engineering contracting firms, (previously referred to as

‘building installation organizations’) were owned by either the national or local governments. The engineering contracting firms were also referred to as ‘construction enterprises’ (施工企业) or ‘state-operated construction enterprises’ (国营施工企业). The word ‘operate’ correspond to the goal to enliven the construction enterprises. Techniques, like ‘operation rights expanding’ (扩大经营自主权), ‘competition’ (竞争), ‘separation of management level and labour level’ (管理层与劳务层分开), ‘responsibility contracting’ (责任承包), ‘project way construction’ (项目法施工), and ‘construction method’ (工法), were recommended as the means of achieving improved performance.

According to the National Construction Committee (1980), the state operated construction enterprises were given broader operational autonomy. In addition to their allocated construction tasks, the state-operated construction enterprises were allowed to obtain contracts independently. Bidding and tendering practices were recommended, thus introducing the first element of market competition. Enterprises were allowed to keep 2.5 % of the project budget as statutory profit (法定利润) (National Construction Committee *et al.*, 1980). The ‘fixed salary percentage of per yuan production value’ (百元产值工资含量包干) equated to a stipulation that a fixed proportion of the income which firms should extract according to the production value short be earmarked as wages with the intention of motivating the workforce (Chinese State Council, 1984).

In the late 1980s, two main acclaimed techniques’, ‘management level and labour level separation’ (管理层与劳务层分离) and ‘project way construction’ (项目法施工) were recommended to improve the construction enterprises’ operational efficiency (Ministry of Construction, 1991). The technique of the ‘management level and labour level separation’ serves to define the distinction between ‘general contractor’ and ‘labour-only contractor’. This idea seemingly came from the observation of the Buluge Project in Yunnan, China, part of which was completed by a management team from a Japan contractor and local Chinese labourers which were hired locally hired (Zhang, 1991). As a result, ‘general contracting’ was promoted as another important practice focused performance. Qualification grades were introduced to separate the ‘management level (as the general contractor)’ and the ‘labour level’ (as the labour-only contractor) (Zhang, 1991).

The ‘project way construction’ served to emphasise that construction is delivered through projects, which it was maintained should be the central focus of the construction enterprise. From this point onwards phrases such as ‘construction site’, ‘project’, ‘project manager’ started to enter the lexicon of the Chinese construction sector. According to Qinglin Zhang (1992), the main leader for this technique, two main practices, project manager system and project independent calculation (which means accounting), were recommended (Zhang, 1992). ‘Responsibility contracts’ (责任承包) were then suggested for the purposes of managing the project managers. These might perhaps be understood as service level agreements (SLAs). During this period, the role of soldiers in the building installation organization was transformed. The word ‘fixed labour’ (固定工) and ‘temporary labour’ (临时工) were used in the Provisional Regulation on state-operated Construction Enterprises’ Operational Rights

Expanding (National Construction Committee *et al.*, 1980). The word ‘hire’ indicates a new relationship between the labour and the construction enterprises.

*The 1990s: Socialist market economy fitness*

In 1992, the Chinese State Council (1992) announced another national strategy, ‘the socialist market economy building’ (社会主义市场经济). This section reviews four key policies. By doing this, it is argued that the main policy discourse is the socialist market economy fitness at both the sector and firm level. Since the announcement of the strategy of the ‘socialist market economy’, socialist market economy fitness has become the main policy discourse. According to the Chinese State Council (1993, 1), the socialist market economy is ‘a system that, under the state’s macro-control, the market works as the main way to allocate the resources’. It was the first time the government stated its intent to delegate more power to the workings of the market. Of particular note is the high emphasis given to the role of firms in the market.

It is clear from the policy discourse that contractors were increasingly expected to behave as the independent business entities in the market. The main technique identified to realize this aim was the ‘modern enterprise system’ (现代企业制度). According to the Ministry of Construction (1995b), construction enterprises should restructure and reorganize to ‘corporations’ (公司制). This new definition positioned construction enterprises as ‘independent business entities’ and the state as the investor of the construction enterprises. In the policy documentation, operational responsibilities were delegated to the appointed managers. However, the entity of ‘party organization’ (党组织) was also cited in the policy documentation seemingly at odds with the other newly defined roles. The party organization was expected to play a core role by ensuring ‘the enterprises follow and carry out the party’s and state’s policies’ (Ministry of Construction, 1995b). Through this organization, the state was depicted as retaining control over construction enterprises. The tension between greater market autonomy and continued political control raises questions as to how this policy was implemented.

Other techniques, including ‘standardization’ (标准化) and ‘project management’ (项目管理), were also recommended (Ministry of Construction, 1995a, Ministry of Construction, 1996). ‘Standardization’ here means that construction enterprises should follow national standards. In addition, construction enterprises were called upon to develop management standards, which were referred to management procedures. ‘Job’ standard was also suggested, which referred to formal role specification. The term ‘project management’ was introduced by the Ministry of Construction (1996), replacing the ‘project way management’. This was explained as involving the creation of ‘temporary project management departments’ to manage projects.

According to the Ministry of Construction (1995b), managers were expected to work as employed operators, replacing their previous role as the ‘state’s cadres’ (国家干部). It was further suggested that the previously mentioned ‘fixed labour and temporary labour’ should transfer to permanent contracts of employment. . The project manager was re-defined as a type of professional, who was now required to obtain a formal qualification. There is of course a difference between ‘requiring’ things to be done and them happening in practice.

*The 2000s: Market behaviour regulating*

Since the turn of the century, the word ‘market’ started to dominate the policy agenda. Contractors were expected to behave as legal entities in the construction market. This section argues that ‘regulated market behaviour’ was the main policy discourse in the 2000s, accompanied by recommendations regarding law enforcement and suggestions for contractors.

Since the 2000s, regulated market behaviour became the main policy discourse. ‘In order to regulate the behaviours of...’ became a common prologue of the policies (Office of the State Council, 2001). Policies focused on two main techniques: law enforcement and suggestions for contractors. The ‘administrative punishment’ (行政处罚) was suggested by the government as a means of regulating the market behaviour. According to the Ministry of Construction (1999, p 1), administrative punishment is ‘the construction administrative legal branches to punish the citizens, legal person and other organizations who break the law, regulation, and rules’. During the 2000s, several announcements about the proposed inspection events occur in the policy documentation, including safety inspection, quality inspection. In 2010, a special inspection office (稽查办公室) was proposed (Ministry of Housing and Urban-rural Development, 2010). Finding an appropriate balance between regulation and market incentives is a challenge of course which is by no means unique to China.

The policy documentation was very clear that contractors were expected to behave legally and honestly. Techniques like contract guarantee (合同担保), legal office (法务办公室) were recommended. Ministry of Construction (2004) recommended a range of measures for guaranteeing contracts. Techniques such as bid guarantee, client payment guarantee, contractor performance guarantee and contractor payment guarantee were all recommended and hence entered the lexicon of the policy discourse. In 2007, it was suggested that contracting firms should establish their own internal legal office for the purposes of providing the firms’ management with legal advice (Ministry of Construction, 2007).

Special techniques were also suggested for dealing with concerns such as construction safety and quality. In terms of quality, it was made clear that contractors were expected strictly to adhere to the design specification (State Council, 2000). In terms of the safety management, the managers of the contracting firms were required to take full responsibility (the State Council, 2003). Later, in 2011, it was suggested that managers should conduct inspections not every day, but no less than every four days (Ministry of Housing and Urban-rural Development, 2011). These expectations elevated the hierarchical position of managers. Other techniques included the establishment of special safety office for the provision of safety training, and maintenance of safety standards.

General contracting and project management was also suggested (Ministry of Construction, 2003). Here, general contracting extends to the use new procurement method adaptation; examples mentioned in the documents include EPC, DB and Turnkey. However, contractors cannot choose their procurement methods such responsibilities rest with clients. But what contractors are expected to do is adapt to new procurement arrangements. A range of techniques were recommended for the purpose of improving project management, including restructuring and reorganising, together with the adoption of joint venture with foreign partners. During this period,

various professional identities were established. Construction management staff included roles such as constructors (建造师), cost engineer (造价师), safety officers (安全员); all of these positions were linked to certification through formal qualifications. In 2015, workers were finally referred to as ‘construction worker’, replacing the phraseology of ‘rural migrant workers’.

## DISCUSSION AND CONCLUDING REMARKS

Four main policy discourses had been identified: (i) soviet style construction (1950s-1970s), (ii) enlivening the contractors (1980s), (iii) socialist market economy fitness (the 1990s) and (iv) regulated market behaviour (2000s). In each one, expectations for contracting firms have evolved to fit the main policy aims for the construction sector (see Table 1). Correspondingly, the focus of recommended techniques changed from construction activity to firm.

Table 1 Policy discourses in the Chinese construction sector (1950s-2010s)

	1950s-1970s	1980s	1990s	2000s-
Construction sector	Soviet style construction	Enlivening contractors	Socialist market economy fitness	Regulated market behaviour
Contracting firms	Building installation organizations	State-operate construction enterprises	Construction enterprises	Construction enterprises
Goals	Finish the ‘construction task’	Investment effectiveness;	Independent corporations	Behave legally and honestly;
Techniques	Industrialization; quota; mixed labour team;	Competition; project way construction Construction method	Modern enterprises system; standardization, project management	Contract guarantee; legal office; quality and safety; general contracting; project management
Professionals	soldiers	Fix/ temporary labour	managers; project managers	Constructor cost engineer, safety officer...
Techniques	piece-wage; welfare	fixed salary percentage of per 100 yuan	Employees by contract	Qualification certificate

Interestingly, the academic literature combines the vocabulary of Western discussions of the construction sector with the content of the Chinese policy documents. Thus, while academics present contractors as market actors, the techniques they identify resonate better with the policy discourse ‘socialist market economy fitness’ in the 1990s. Techniques suggested by Lu *et al.*, (2008), like organization structure, organization resource, competitive strategy, marketing can be found in the policy discourses in the 1990s. This is same in Ling *et al.*'s (2012) paper on contractors’ competitiveness. Still more terms, such as differentiation, focus, cost leadership, from western discussions were used by Ling *et al.*, (2012). This is because the categories in the questionnaire were predefined according to Porter (1985)’s competitive discourse. In contrast, Li and Ling (2013) includes no vocabulary of western competitiveness discourses because they used Sun Tzu’s military strategies to predefine the questionnaire categories. This raises the concern that the predefined categories hidden or missed the language/ terms used by contractors.

Following the introduction of the open door strategy in 1978, various policy discourses were introduced with reference to the Chinese construction sector. This

paper used a very light touch version of Foucault (1978/1991)'s concept of governmentality to analyse the policies in the Chinese construction sector since 1949 to 2010s. Four main policy discourses have been identified found, soviet style construction (1950s-1970s), enlivening contractors (1980s), socialist market economy fitness (the 1990s) and market behaviour regulating (2000s-). The expectations for the contracting firms changed to fit the main policy aim for the construction sector. Corresponding to the expectations, the recommended techniques changed from construction activity to firm.

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# GEOTECHNICAL CHARACTERIZATION OF COST OVERRUN DRIVERS IN HIGHWAY PROJECTS: PREDICATED ON HETEROGENEOUS GROUND CONDITIONS IN THE NIGER DELTA REGION OF NIGERIA

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Infrastructure projects typically face far higher levels of cost overrun than any other form of construction or civil engineering project. An expansive range of research identifying theoretical and technical explanations for this negative trend has emerged from academe. One of the most contentious explanations for this phenomenon suggests strategic misrepresentation on the part of construction professionals and other stakeholders is at the root of this problem. Led by the seminal work of Flyvbjerg *et al.*, (2002) this body of literature espouses that cost overruns stem from deliberate deception by clients and their professional advisors as a result of both corruption and politically induced malpractice. Yet this view is challenged by those advocating more technical explanations for cost overrun. Suggesting the unintentional triggering of Latent Pathogens', which lay dormant in the complex interactive processes of infrastructure projects, lead to a series of events that culminate in cost overrun. In an attempt to better understand the impact of latent pathogens on the accuracy of project estimates in the geologic setting of the Niger Delta, cost data gathered from 61 completed highway projects has been comprehensively analysed to determine the primary causes of cost variance. The results identify that latent pathogens such as heterogeneous ground conditions and non-adherence to geotechnical best practices account for the majority of the recorded variance between the initial estimates and the projects' final account.

Keywords: cost overrun, geotechnical, heterogeneous, ground conditions, Niger Delta

## INTRODUCTION

The excessive cost overruns experienced in highway projects presents a major concern for project sponsors in the Niger Delta region of Nigeria. As a result, extensive areas of the Niger Delta are yet to be traversed by roads, due to the combination of technical challenges the region's geology presents civil engineers, and the difficulties funding bodies experience when trying to predict and control the costs associated with road construction (Ngerebara *et al.*, 2014). At the core of these difficulties, Oguara (2002) espouses is the problematic terrain, which is characterised by difficult expansive clayey subsoils. Despite the geologic challenges the region presents civil engineers, the government of Nigeria have determined that improving critical infrastructure such as roadways in the Niger Delta is fundamental to fostering economic development and improving the country's economic outlook (Niger Delta Development Commission,

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NDDC 2013). Consequently, the regions three main highway agencies have initiated a multiplicity of road projects that will be constructed concurrently across the region.

Whilst this may sound positive for the region, the local literature, however, challenges the Highway agencies to ensure this investment bears fruit, and that the roads commissioned are actually completed, given the agencies track record of failure.

Research undertaken by both Okon (2009) and Ihuah and Benibo (2014) concludes that the initiation of road projects is not the reason for poor infrastructure in the Niger Delta, rather the problem has been their completion, with funding shortfalls and poor financial management accounting for the vast majority of delayed/abandoned projects.

As table 1 illustrates, Okon (2009) identified the total length (km) of roads, and the number (nr) of infrastructure projects initiated in communities by the NDDC, a regional highway development agency in the region, between 2001 and 2008.

Together with the number of completions achieved (by km of road or number of projects). Okon's analysis revealed that only 26% of the road projects commissioned between 2001 and 2008 had actually been completed. A finding reinforced in a recent European Union (2011) evaluation of infrastructure projects in the Niger Delta region. As with Okon's research the study revealed that a significant number of road projects in the region remain incomplete with a large number abandoned.

*Table 1 Infrastructure Backlog of Uncompleted Projects in the Niger Delta*

Infrastructure type	Total no. provided	Completed	% completed
Roads	156 (3,000Km)	780 Km	26
Bridges	47	-	0
Water Supply	283	78	28
Electrification	316	137	42

Yet as Falade (2016) discovered, completion does not always indicate success, with most, if not all, completed highway projects recording astronomically high cost overrun figures. This unacceptable situation is currently being investigated by the Nigerian Senate, who have suggested these significant overruns are the result of either complacency or corruption on the part of the highway agencies in the region. A claim strongly refuted by the regions highway agencies who continue to assert that cost overruns are a direct result of the region's difficult geology. To test the agencies' assertion, it was resolved to test the hypothesis that the region's complex geology account for the significant increases in the cost of Niger Delta Highway projects.

## LITERATURE REVIEW

### The geologic setting of the Niger Delta

The Niger Delta is a tropical delta, crisscrossed by a myriad of rivers, and inland water channels (Oguara 2002). It is a terrain associated with varying geological formations, with a significant proportion having difficult expansive clayey sub-soils. Three broad conceptual geomorphic categorisations of Niger Delta soils used in engineering geologic application, are synthesized from the local literature to highlight its geologic heterogeneity. This is presented in Table 2, recognising some unavoidable overlap between the categories. Despite this, the broad divisions, adapted from literature, highlight likely geotechnical disparities in soil conditions across the region.

### Cost overruns in construction and civil engineering projects

Cost overruns in both construction and civil engineering projects, have been the focus of extensive research. Comparing transportation projects to this extensive body of

work, Flyvbjerg (2002) concluded that highway agencies record far higher levels of cost overruns than any other type of construction or civil engineering work. This has been shown to greatly impact on highway delivery and perceptions of the efficiency within public agencies. As a result, an extensive range of research providing various theoretical and technical explanations for this negative trend has been published (Flyvbjerg 2002; Cantarelli *et al.*, 2010; Love *et al.*, 2012).

Table 2: Geotechnical regions of the Niger Delta as adopted in the study

Geo-Zones	Sub-Soil types	Stratigraphy/ Description
Upper Deltaic (Zone 1) (Dry land interwoven patches of fresh water soils)	Coastal Plain Terrace Soils Deltaic Plain Soils	Dry plain sandy/clayey subsoil strata (Brown Sandy Clays)
Middle Delta (Zone 2)(Back-swamps)	Freshwater Alluvial Soils Transitional Soils	Two-layer clay sand sequence (Dark organic peaty clays)
Lower Delta (Zone 3)(Salt water swamp and coastal soils)	Tidal Flat/saltwater swamp Beach Ridge Soils	Three-layer, sand-clay-sand(Light slightly organic sands and clays)

In developed countries, isolated studies by scholars and highway agencies, for example Hinze and Gregory (1991), have statistically analysed current cost overrun trends from a technical perspective. Whereas from a theoretical perspective, two distinct schools of thought have emerged. The first espouses that psychological uncertainty and optimism bias in decision making are the root cause of the problem. A finding strongly reinforced by both the National Audit Office (2013) and UK Treasury, who issued supplementary guidance to the Green Book (2013) dealing specifically with the effects of optimism bias. The guidance advocates increasing business case estimates for standard civil engineering projects by between 3% and 44%. Whereas the second school argues cost overruns are triggered by deliberate deception by the client or their professional advisors. Despite the strong differences in perspective, both schools of thought are argued from economic and political realms. A host of scholars, arguing from this latter perspective, such as Bruzelius *et al.*, (2002), concur with the arguments advanced by Flyvbjerg and his co-authors who emphasize non-technical explanations for cost overruns, arguing that strategic misrepresentation by either/both planners and politicians are the source of financial overspend.

As a result, Flyvbjerg *et al.*, (2002), emphatically disputes the hypothesis proposed in this study, that technical explanations/errors, specifically geologic risks, provide statistically valid explanations for cost overruns in highway projects. Flyvbjerg *et al.*,’s assertions are often developed from simplistic trend analysis of cost overrun data, rather than robust statistical analysis that reinforces cause and effect relationships between variables. Cost overruns were thus described by Flyvbjerg *et al.*, as resulting from blatant lies, not errors or unforeseen geologic risks, by planners and government officials who strategically underrepresent cost estimates in project proposals, produced at the strategic business case phase of projects, to gain approval.

Several critiques of the theory of strategic misrepresentation advanced by Flyvbjerg *et al.*, (2002), are evident in the literature. For instance, Osland and Strand (2010:80) argued against both the theoretical and methodological validity of Flyvbjerg’s theories, suggesting “*the research design did not support the general conclusion that the technical explanations can be ruled out*”. Other contemporary works have empirically demonstrated and advanced other theories of cost overruns in contextualised in developed countries. These include the theory of institutional 'lock-

in' proposed by Cantarelli *et al.*, (2010), Gil and Lundrigan's (2012) 'relay race' theory of leadership and Governance, Love *et al.*, 's (2012) theory of latent pathogens and meta-organizational theories of 'Core and Periphery', again by Lundrigan and Gill (2013).

Given the strong links to the literature identifying limitations in Nigerian engineering practice, the authors have adopted Love *et al.*, (2012) latent pathogen theory as the theoretical framework for this study. Developed from their analysis of Australian construction projects, Love and his colleagues determined that 'Latent Pathogens' leading to errors, exist in all projects. Often lying dormant within the complex interactive process of the key professional players in organizations, these latent pathogens are unintentionally triggered, eventually culminating in significant cost overruns. Whilst this body of work makes a substantial contribution to disputing Flyvbjerg's assertions, the external validity and generalisability of these theories to developing nations such as Nigeria has yet to be established.

### **Practise based geotechnical triggers to cost-overruns**

Risks due to the ground have been repeatedly emphasised in the literature as a primary trigger for cost overruns in highway projects, where appropriate geotechnical risk containment steps are not taken (ICE 1999). At the pre-contract phase of highway projects several opportunities to capture geotechnical input exist, these include:

*Conceptual estimating* - Variable ground conditions typically encountered at various project locations, implies the need for a correspondingly varying profile of conceptual estimates. The use of 'off the Shelf' historical data is thus discouraged (Romero and Stolz 2009). It would therefore be unrealistic for budgetary estimates to be developed using cost per mile/Km based on historic data, without recognising differences in ground conditions.

*Designs and Detailed Estimates* - There is an evident need for adequate ground investigations, prior to the preparation of detailed highway designs and cost estimates ICE (1999). There is extensive evidence in the literature showing the link between a lack of adequate site investigation, and unexpected cost. Clayton (1995) used empirical evidence to show a very high degree of correlation between expenditure on ground investigations and cost overruns. Whereas Alhalaby and Whyte (1994), illustrated that the highest percentage of technical risk leading to cost overruns in highway projects is triggered by design and engineering problems related to unexpected ground conditions.

*Tendering and contracting* - Ground conditions have been established as a major financial risk in highway contracts (ICE 1999). Case law related to highway engineering projects is rife, with litigation following lengthy contractual disputes arising due to lack of adequate geotechnical risk containment in procurement. Adopting an appropriate mechanism for managing ground related risk in contracts and technical criteria for contractor selection has thus being advocated. These includes calls for the inclusion of ground investigation reports accompanied by appropriate differing site condition clauses in bids. (Gransberg and Gad 2014).

Consequently, it can be inferred various potential avenues for ensuring geotechnical input in pre-contract phases, necessary to minimise cost overruns in highway projects exist, as best practice guidance is evident from the literature. Yet the literature also continues to report the inadequate use of geotechnical risk containment in highway projects resulting in considerable post-contract cost overruns. As a result of the lack of a robust empirical analysis to this effect, this study resolved to explore the

statistical validity of these geotechnical risk factors in explaining cost overruns in highway projects, contextualised in the geologic setting of the Niger Delta region of Nigeria.

### **Geotechnical indices of subgrade soils in the Niger delta**

Various engineering parameters, which represent the suitability of sub-grade soils as bearing media in highway construction are inferred as the factors which are latent in any geologic setting. The general geology of the Niger Delta predominantly consists of extremely soft and highly expansive deltaic marine clay, locally referred to as the 'Chikoko clay', with a dark grey, dark brown to black coloration (Otoko and Precious, 2014). These chikoko soils have been shown to be highly undesirable in their natural forms for road construction (Fatokun and Bolarinwa, 2009). Several studies have stressed the geotechnical difficulties inherent in the Niger Delta, due to the occurrence of 'chikoko' soils, which makes adequate geotechnical measures during both the design and construction phase of projects essential, to ensure an adequate margin against the behaviour of these naturally weak soils (Ngerebara *et al.*, 2014).

The diagnosis of these soil type at the pre-contract phase is necessary if the project team are to competently estimate the cost implication of the effort/methods required to improve the geotechnical properties of soils during construction. Yet the lack of detailed ground investigations implemented to determine the standard minimum level of compaction and engineering requirements, will have cost implications that correlate with the geotechnical indices of subgrade soils at the specific project locations. As a result, quantitative geotechnical parameters such as Atterberg limits, Free Swell, Maximum Dry Density and Optimum Moisture Content, which give specific geotechnical attributes of sub-soils in relation to subsoil expansivity/compaction, may also account for the cost overrun disparity between the geo-zones of the Niger Delta.

The literature reviewed above reinforces the authors' assertion that the regions geology and lack of geotechnical best practise present the most likely triggers for the cost overruns identified on Niger Delta highway projects. A set of hypotheses to statistically test that a cause and effect relationship exists between these variables, has been proposed. Namely that poor ground conditions, exacerbated by a lack of geotechnical best practise, culminates in huge disparities between initial budgeted project estimates and final cost for highway projects in the Niger Delta.

## **RESEARCH METHODOLOGY**

The data analysis begins by geotechnically characterising the heterogeneous sub-soil configuration of the Niger Delta region, in terms of the variation in engineering index properties of subsoils between various geologic zones, and whether recorded levels of cost overruns experienced in highway projects at spatially dispersed project locations vary accordingly. The study statistically explores the geologic setting, as a potential trigger which creates a propensity for cost overruns, using correlation analysis. This is based on geotechnical data on sub-grade soils sourced from available local field work. 16 interviews were also carried out with Quantity Surveyors, Civil Engineers and Consultants from the 3 highway agencies, to determine their current geotechnical practises which were then compared to the best practice guidance provided in the literature. The interviews were recorded, transcribed verbatim and thematically analysed, using geotechnical themes presupposed as the existing cost overrun drivers in the practices of highway agencies. To explain and thus account for the pre-analysed disparity in cost overruns, the study evaluated the distinct

contributions of the geotechnical field and practised based drivers via regression analysis. Regression modelling is used to statistically analyse how much variation in the recorded project cost overruns is directly triggered due to the variation in the latent cost drivers in the geologic setting and due to the geotechnical practises of the highway agencies.

## DATA ANALYSIS

### Analysis of cost overrun data

Table 3 and 4 show the statistics and ANOVA on cost overruns experienced in these geo-zones for 61 highway projects executed by the 3 highway agencies in the region.

Table 3: Descriptives for cost overruns in the geo-zones

	N	Mean	Std. Dev	Std. Error	95% lower	95% Upper	Min	Max
Zone 1	24	117.3535	94.91760	19.37497	77.2734	157.4337	11.77	440.74
Zone 2	21	393.7971	517.46407	112.91992	158.2503	629.3439	.00	1925.40
Zone 3	16	132.3865	138.79635	34.69909	58.4271	206.3458	35.64	613.21
Total	61	216.4657	338.15194	43.29592	129.8610	303.0704	.00	1925.40

Table 4: ANOVA table of log cost overrun

	SS Actual vs Log	Df	Mean Square	F	Sig.
Between Groups	(1009241.097) 11.714	2	5.857	7.728	.001
Within Groups	(5851562.808) 43.202	57	.758		
Total	(6860803.905) 54.917	59			

The ANOVA outcome shows that there are significant differences in cost overrun between road projects executed in the various geo-zones of the Niger Delta. The question thus posed is 'What latent triggers account for the significant differences in cost overrun between the Geo-zones? This is considering that the projects were executed by 3 different highway agencies. To account for this difference, geotechnically induced latent pathogens, which are the only plausible explanations for this disparity in cost overruns are specifically investigated. Therefore, although other triggers to cost overruns are acknowledged as present in highway projects, the study is focused on geologic factors that explains the statistical differences in the geo-zones.

Given the potential correlation between escalating costs and the region's geology espoused in the literature, it is clear that further research is required to explore the validity of the agency's claim, by providing statistically valid explanations to cost overruns recorded in completed highway projects in the Niger Delta region.

### Multiple regression model for cost overruns in the Niger delta

Three sets of variables have been used to develop and optimise the regression model:

1. 3-level categorical dummy variable to account for the geo-zones. Three sets of recoded dummy variables are thus imputed into the regression model: Where Z1 = Uplands; Z2 = Swamps; Z3= Coastal, as specifications in SPSS variable data entry, with Z1 set as the control variable in the model:  
 Recoded Dummy Variable 1: Z1 = 1; Z2 = 0; Z3=0, for uplands;  
 Recoded Dummy Variable 2: Z1 = 0; Z2 = 1; Z3= 0, for swamps;  
 Recoded Dummy Variable 3: Z1 = 0; Z2 = 0; Z3= 1 for coastals.
2. The geotechnical data as obtained from local sources, is used to approximate the engineering properties of sub-grade soils at the sample project locations spatially dispersed across the Niger Delta. The data is correlated with the cost overrun data, as a preliminary basis to infer significant association. Table 5 is the

output of the correlation analysis. From the output of the analysis, only the parameters of expansivity (PI, FS, LL and PL) display relatively higher correlations with cost overruns. Compaction parameters such as the MDD and OMC, however display weaker correlations with cost overruns. Using this criterion for step wise variable entry in the model, may however yield sub-optimal results, due to potential collinearity or multi-collinearity amongst the geotechnical indices. The use of bi-variate analysis is limited, as it can only detect significant bi-variate collinearity combinations (Miles and Chelvin, 2001).

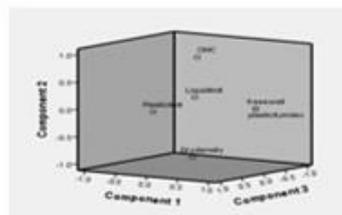
Table 5: Correlation of Geotechnical Variables Vs Cost Overrun

Plasticity Index (PI) Vs Cost overrun	.630
Free Swell (FS) Vs Cost overrun	.630
Liquid Limit (LL) Vs Cost overrun	.625
Plastic Limit (PL) Vs Cost overrun	-.716
Max Dry Density (MDD) Vs Cost overrun	-.447
Opt Moisture Content (OMC) Vs Cost overrun	.462

The researcher thus uses factor analysis to detect structure, as a useful step in eliminating multi-collinearity prior to the regression analysis (Lawrence, 2006). Principal Component Analysis is thus deployed in this instance as a factor classification tool, and not for reduction, as discernible from the pattern of loading of the analysed principal components. Table 6 shows four principal components selected, and loadings after the varimax rotation with Kaiser Normalization. The components visualised in Figure 1 maximise all 6 geotechnical indices loadings.

Table 6 and Figure 1: Rotated Component Matrix

	1	2	3	4
Plasticityindex	.997	.069	.020	.021
Freeswell	.997	.069	.020	.021
Liquidlimit	.029	.187	.040	.981
Plasticlimit	.027	.058	.997	.038
Drydensity	-.054	-.928	-.023	-.131
OMC	.079	.927	.058	.110



Based on the PCA outputs, the researcher selects the following principal groups of variables as input to the regression model: PI/FS, PL, LL, and OMC/MDD. Four regression models, representing all possible four combinations of variables are thus run in the following combinations, to test for the combination that yields the highest explanation of variance in cost overruns: PI, PL, LL, and OMC; FS, PL, LL, and OMC; PL, PL, LL, and MDD; FS, PL, LL, and MDD.

3. Interview data: The interview analysis reveals the suspected gaps in knowledge deduced from literature, presupposed as the existing cost overrun drivers in the practices of highway agencies. A linear conceptualisation of the flow of Geotechnical Input (GI) in the phases relative to standards of best practise is thus elicited from the interviews relative to the following geotechnical themes:

- Nomenclature of project phases- Well-structured and consistent?
- Geotechnical Input in budgeting -Reflective of heterogeneous ground profile?
- Geotechnical Input in designs -Desk studies, preliminary walk-overs and detailed ground investigations?
- Geotechnical Input in contract documentation- GIR and DSC clauses?

### Geotechnical Input in contractor selection - Use of GI algorithms?

The geotechnical practises in the phases of the highway projects dichotomised according to size by the different highway agencies, are represented as dummy variables, where 1(Yes) and 0(No), in the regression analysis.

### Regression analysis: Model optimisation

Table 7 shows a summary of the outcome of the explained variations for several statistically significant regression models run with different combinations of non-collinear predictor variables during the model optimisation process.

Table 7: Regression Model Optimisation showing Explained Variations

Model	R	R2	AdjustedR2	Std. Error	Predictors
1	.434a	.188	.143	.73831	(Constant), FS, LL, MDD
2	.442a	.196	.151	.73497	(Constant), PL, LL, MDD
3	.432a	.187	.142	.73907	(Constant), OMC, LL, FS
4	.442a	.195	.150	.73532	(Constant), PI, OMC, LL
5	.471a	.222	.147	.73685	Constant), coastal , PI, MDD, LL, swamp
6	.890a	.792	.754	.39596	(Constant), GICONTSEL, PI, coastal , LL, MDD, NOMEN, swamp, GIBUDG, GIDES

The initial combinations of geotechnical indices, explains a maximum of 19.6% of the variation in cost overruns. This variable combination is thus used as a basis for optimising the model with the stepwise introduction of other explanatory variables. The introduction of a 3-level categorical dummy variable to account for the geo-zones optimises the regression model, after a log-linear transformation of cost overruns to 22%. The introduction of dummy variables to account for current geotechnical practises in the highway agencies significantly optimises the regression model, as the explanatory power of the model increases from 22% to 79%. The Log-Linear regression model of cost overrun drivers predicated on ground conditions and the current geotechnical practises of highway agencies in the Niger Delta is thus:

$$\text{Logcostoverrun} = 6.501 - 0.010LL - 0.545PI + 0.363 \text{ swamp} + 0.260 \text{ coastal} - 0.435GIB - 0.139NOM - 0.471GIDS - 0.452GICS + e.$$

The authors further examine the individual contributions of the variables in explaining cost overruns in the sampled highway projects.

Table 8: Ranking of Variable Correlation Coefficients

Model	Zero-order	Partial	Ranking of Variable Correlation
Liquidlimit	-.420	-.486	1
Drydensity	.045	.029	9
Plasticityindex	-.083	-.220	6
Swamp	.212	.160	7
Coastal	.062	.269	5
uGIBUDG	-.568	-.397	2
NOMEN	-.525	-.160	7
GIDES	-.743	-.332	3
GICONTSEL	-.784	-.295	4

Table 8 shows the values of the Zero-Order and Partial Correlation Coefficients. From the ranking of the individual contributions of the geotechnical variables, Liquid Limit, which is a geotechnical index of expansivity of subgrade soil, as it transitions to a more fluid-like state in response to increasing water content, abound in the region, accounts for the highest partial correlation with cost overrun.

## DISCUSSION

Ground conditions at project locations can thus be inferred to the primary cost overrun driver accounting for unusually high level of cost overruns in highway projects

executed in the Niger Delta. The predictive transposition of the regression equation explaining cost overrun is:

$$\text{Costoverrun} = 10^{6.501 - 0.010LL - 0.545PI + 0.363 \text{ swamp} + 0.260 \text{ coastal} - 0.435GIB - 0.139NOM - 0.471GIDS - 0.452GICS + e}$$

This represents an exponential model, whereby small changes in the values of the cost overrun drivers would result in disproportionately large changes in the levels of cost overruns recorded on highway projects. This implies that positive or negative changes made to ground conditions or in the geotechnical practises of the highway agencies will produce an expected exponential increase or decrease in the level of cost overruns recorded in highway projects. However, since the inherent deltaic ground conditions at project sites cannot be changed, but only managed, the only interface based on which cost overruns can be exponentially minimised in highway projects lies in making positive changes in the geotechnical practises of highway agencies in the region, principally in budget estimation and design practises (ranked 2nd and 3rd). The outcome of the analysis thus corroborates the empirical works of Clayton (1995) and Alhaby and Whyte (1992) and their assertion that inadequate geotechnical risk management has a negative effect on cost certainty within the project environment.

## CONCLUSION

The regression analysis has been able to explain 79% of the variance in cost overruns recorded in the sampled highway projects. In the context of the Niger Delta region, this invalidates Flyvbjerg *et al.*'s (2002) assertions that cost overruns result mostly from strategic misrepresentation of cost estimates in the early stages of a project. Rather the regression modelling presented in this paper, evidence a cause-effect relationship between the extent of cost overrun and key geotechnical factors in the Niger Delta. As a result, it is suggested, cost overruns are not necessarily the outcome of calculated acts of deception, although this could be contributing to some of the variance not accounted for within the model. It can thus be concluded that difficulties associated with the wetland geology, and the limitations of existing geotechnical practises used by highway agencies in the Niger Delta, account for most of the reported cost overruns in the region. It can therefore be inferred that improved budget estimates and appropriate designs that reflect the geologic heterogeneity of the Niger Delta terrain, will counteract the propensity of highway projects to run over budget.

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# EVALUATING THE WHOLE-LIFE COST IMPLICATION OF REVOCABILITY AND DISRUPTION IN OFFICE RETROFIT BUILDING PROJECTS

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Retrofit buildings are becoming popular in the United Kingdom as well as many parts of the advanced economies. Existing whole-life costing models have however, not proven to be robust enough to deal with building retrofit scenarios. Recent research has made a case for the existence of revocability and disruption in building retrofit investments. This paper evaluates the whole-life cost implication of revocability and disruption in office retrofit building projects. The potential implication of revocability and disruption are evaluated based on probability and fuzzy logic principles respectively. Two case study projects are selected to appraise the economic potentials of revocability and disruption. It was found that the average cost of revocability relative to the initial capital cost can be up to 119% over a 60-year life. It was also found that the average cost of disruption relative to the initial capital cost can be up to 12%. Future studies will utilise sensitivity analysis in assessing the relative preference of building retrofit configurations in office building projects. The external validity of this work is moderate, as the intention is to establish analytical generalisation rather than statistical generalisation for office retrofit building projects.

Keywords: disruption, office buildings, retrofit, revocability, whole-life costing

## INTRODUCTION

The retrofitting of buildings provides a sustainable opportunity to reduce primary energy-use (Holness, 2010), extend the life-expectancy (Menassa and Baer, 2014), reduce maintenance and operating costs, as well as improve thermal comfort of occupants (Ma *et al.*, 2012). Despite the social and environmental benefits of retrofitting, the economic costs of retrofit buildings are not exactly straight-forward (Gleeson *et al.*, 2011). At the heart of retrofitting is the strategic task of improving energy, waste and water efficiency in buildings (Dixon *et al.*, 2014). Energy-efficiency however, tend to be the more pressing issue, especially due to fluctuating energy prices, falling oil prices, and growing interests in renewables.

In recent times, whole-life appraisal has been more widely embraced in order to better integrate building design and out-turn costs (Flanagan and Jewell, 2005, Robinson and Symonds, 2015). A whole-life scenario provides a holistic and sustainable outlook to appraising the economic implications of built facilities (Capplehorn, 2012), and hence

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allows for a broader spectrum of variables to be examined. There are however, some difficulties in evaluating the whole-life cost estimates of building retrofits, and these pertain mostly to defining the nature and type of economic uncertainties associated with such building typology (Menassa, 2011). Some crucial uncertainties in costing of building retrofits relates to the savings estimations, energy-use measurements, weather-forecasts, changes in energy-consumption patterns, and system performance degradation. Other primary variables of uncertainties in whole-life cost estimations across a building's lifecycle include cash flow data, building-life period, investor's commitment, component service-life, and future decisions (Ellingham and Fawcett, 2006). High levels of uncertainties generally tend to diminish the accuracy of cost forecasts, and there is therefore a need for increased robustness in the representation and processing of uncertainties in the whole-life costing methodology.

Given the complex and intricate issues in whole-life cost modelling of office retrofit projects, identifying and evaluating the drivers of uncertainties provides an avenue for enhancing the integrity of whole-life costing models, and ultimately providing better decision-support for stakeholders. A common concern on the performance of existing whole-life cost models relates to the difficulty in predicting future costs. Ferry *et al.*, (1999) reckons that the estimation of future costs in built facilities, is often a product of guess work, and will be dependent on a mix of personal preferences and policy standards. In order to address these conceptual limitations in whole-life costing, it will be useful to appraise the implicit assumptions in existing models. This procedure holds potential in enhancing robustness in the whole-life costing methodology. It is also considered appropriate to focus on distinct strands of whole-life costing – future costs and initial costs. The drivers of uncertainties in the future costs and initial costs, will be discussed under the concepts of revocability and disruption respectively:

### **Revocability**

Economic revocability connotes the potential for variability in the future cost projections in a building over its estimated life. Physical revocability implies that a certain level of efficiency or inefficiency is locked into a building. The term 'revocability' is attributable to Verbruggen *et al.*, (2011). However, other works have made implicit reference to the concept of revocability in a number of ways. For instance, the Communities and Local Government (CLG, 2011) referred to revocability as "lock-in" syndrome in buildings. Modelling revocability in whole-life cost scenarios comes across as a challenging task. One approach to enhancing the capacity for physical revocability is by designing for flexibility and adaptability in buildings. Economic revocability, which is the focus in this work, pertains mostly to future cost prospects in buildings. Ellingham and Fawcett (2006) suggested an approach to evaluating economic revocability in buildings by representing cash flows over building's life using the Negative Binomial Probability distribution. Kishk *et al.*, (2004) found that the choice of probability distribution function used in describing uncertainties associated with the input variables in whole-life costing, has no significant impact on the simulated output. It is however admissible that the use of probability distribution in representing cash flow distribution is a promising and established approach in the whole-life costing of buildings. Revocability, being an inherent driver of uncertainties in future costs will be appraised in this work.

### **Disruption**

Disruption relates to the diminished building use, or un-usability, over a period of implementing a retrofit initiative. The cost of disruption is a useful consideration

prior to deciding on a retrofit intervention. Investments initiatives in retrofit scenarios tend to involve some levels of disruption to the normal operation of building occupants (Gleeson *et al.*, 2011). Depending on the scale of disruption, this could significantly alter the business case of the entire retrofit project. Verbruggen (2013) implied that, a robust scenario analysis will be vital in appraising the effects of disruption. Gleeson *et al.*, (2011) conducted a disruption analysis on retrofit interventions, and provided a 3-scale assessment of Low, Medium and High level of disruption for various retrofit interventions. Gleeson *et al.*, (2011) estimated the number of days of disruption for individual installation of retrofit technologies in a typical house building project, and suggested the time of disruption could range between 2 – 12 days. For package retrofit installations, it is expected that project management considerations will impact on the effects of disruption in retrofit projects. Given that the effects of disruption are more readily defined in qualitative terms, the fuzzy logic approach will provide a systematic mechanism to evaluate and assess the effects of disruption in retrofit building projects.

Bearing in mind, the growing interest in retrofit initiatives, it will be necessary to assess the long-term implications of revocability and disruption in buildings, with a view to evaluating their potential costs over the entire life of the building. Menassa (2011) posits that a financial appraisal framework for retrofit initiatives does not yet exist. It is therefore essential that whole-life cost modelling be re-oriented to provide a viable means for appraising retrofit building scenarios. This study evaluates the whole-life cost implications of revocability and disruption in office retrofit building projects based on two case studies, using probability and fuzzy sets principles.

### **Whole-life costing**

The application of whole-life costing in the UK began in the late 1950's. Goh and Sun, (2016) buttressed that whole-life costing allows the comparison of values which transcends problems of different lives, or different balances between capital and future costs. According to Ashworth and Perara (2013), whole-life costing serves as an aid to long-term, rational and realistic decision outcomes in building investment appraisals. The evidence from the built environment literature however, raises doubts on the ability of existing whole-life cost models to robustly appraise building projects. The distinct categories of existing whole-life costing models are the Standard whole-life costing, and the New-Generation whole-life costing models. The principles of these models, have been identified and discussed in Tokede *et al.*, (2013). The principal concerns regarding these existing whole-life costing approaches relate to the reliability of cost data (Ellingham and Fawcett, 2006), insufficient consideration of uncertainties (Caplehorn, 2012), and lack of robustness in model framework (Kirkham, 2014).

A suggested improvements to the whole-life costing framework is the embodiment of whole-life cost decisions in an options framework (Menassa, 2011). *Figure 1* below captures the potential options embedded in buildings over their entire lives. In *Figure 1*, simple options tend to have little or no initial cost, and hence future costs, are not dramatically altered from the base-case scenario. Examples of simple options, if exercised, include options to abandon, contract, expand, and 'do-nothing'. Compound options, on the other hand, if exercised, tend to involve more significant initial costs, and often have a more significant effect on the default future cost projections. Retrofit options are arguably popular among compound-option types available, and thus have huge potentials in improving building performance and long-term cost savings.

Kishk *et al.*, (2003) argues that the principles of whole-life costing are well developed in theory. There is however, compelling evidence that this is not the case, and there is scope for improving on the theoretical weakness of existing whole-life cost modelling procedures, especially in emerging building typologies. It has been inferred that whole-life costing involves a complex set of decision events, actions, outcomes, with significant interdependencies (Verbruggen *et al.*, 2011, Verbruggen, 2013), and attempts to ignore uncertainties in the model framework will lead to sub-optimal models, fostering incorrect decisions (Gluch and Baumann, 2004). The pervasive lack of confidence in existing whole-life cost models has fuelled recourse to gut-feeling and experience, rather than rely on the results from objective whole-life cost analysis (Ellingham and Fawcett, 2006). Clift and Bourke (1999) reported that only about 25% of organisations conduct whole-life costing prior to sanctioning building investments.

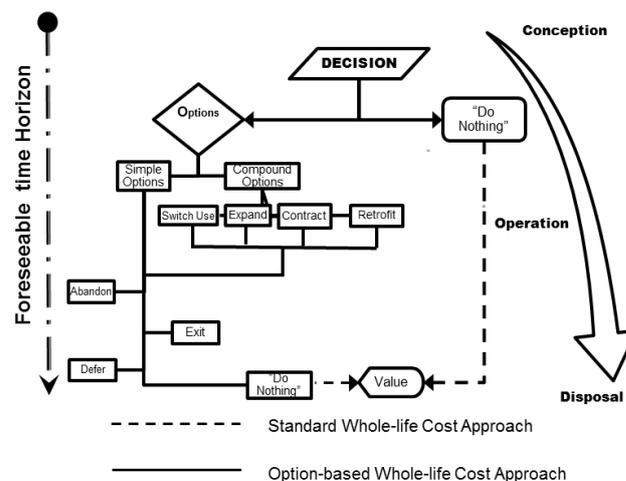


Figure 1: Mapping Whole-life Cost decisions in a Real-Options Framework

## RESEARCH METHOD

This work adopts a realist perspective in investigating the issues in whole-life cost modelling. In order to address the conceptual limitations in existing whole-life costing techniques, there is a pertinent need to examine the assumptions in the modelling framework. These can be done by highlighting and identifying the phenomena that impacts on costs. Firstly, existing whole-life cost models are implicitly developed for new-build projects. The Standard Whole-life costing model does not explicitly allow for possible variations in future costs over the estimated building life. Although, the New-Generation whole-life cost model recognises the effects of revocability, it does so in a simplistic manner, presuming dichotomous values of equal proportions in succeeding years. Besides none of these models consider the economic effects of disruption. A framework is presented, that adequately considers the implications of revocability and disruption. It is anticipated that this will enhance the robustness of whole-life cost modelling in retrofit buildings. The Case study method will provide a useful approach for assessing the effects of disruption and revocability in whole-life cost modelling.

### *Evaluating the cost of disruption*

The potential for disruption in retrofit scenarios need to be considered prior to the sanctioning a retrofit initiative (Holness, 2010). The disruption analysis for retrofit initiatives conducted by Gleeson *et al.*, (2011) provides a basis to estimate the disruption cost in retrofit buildings. The cost of disruption is an inexact measure, and

requires a structured and systematic approach. Ashworth (2004) advised that some form of human judgment will be useful in the whole-life cost modelling of buildings. The Factor Chart analysis presented in *Figure 2* is proposed to evaluate the cost of disruption in office retrofit buildings.

It is conceivable that the cost of disruption will depend on the economic use of the building. Hence, it makes for logical reasoning to evaluate the respective cost of disruption over a plausible range. Fuzzy logic has great potential in assisting scenarios where numerical valuations may be inexact or vaguely represented (Zadeh, 2008). This work adopts tolerance values ( $\mu_j$ ) specified by Ayyub and Klir (2006), as shown in Table 1. The Low, Medium and High metrics of disruption, as previously suggested by Gleenson *et al.*, (2011) will be considered as corresponding to different levels of uncertainties in the range of disruption. In using fuzzy logic, lambda-cut sets are useful approaches in quantifying variables within a continuum.

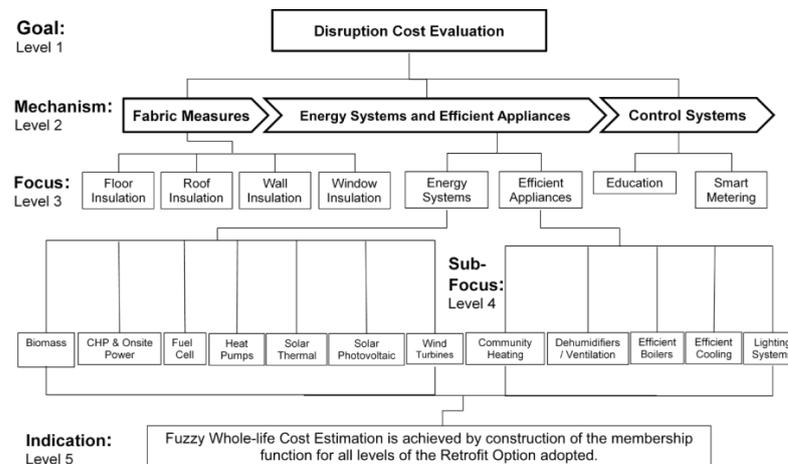


Figure 2: Factor Chart Analysis for Disruption Cost Evaluation

Lambda-cut sets are interval-valued functions that contains all the elements of the parent set, whose membership grades in the set are greater or equal to the specified values of lambda. Ammar *et al.*, (2013) stated that the lambda-cuts of 0.2, 0.5, and 0.8 provide measures analogous to the 25%, 50% and 75% percentiles of distributions.

Table 1: Table showing fuzzy set values for different levels of disruption (Ayyub & Klir, 2006)

$\mu_j$	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Low Disruption	1.0	0.9	0.7	0.4	0	0	0	0	0	0	0
Medium Disruption	0	0	0.4	0.7	0.9	1.0	0.9	0.7	0.4	0	0
High Disruption	0	0	0	0	0	0	0	0.4	0.7	0.9	1.0

An illustration of the procedures of evaluating the cost of disruption in “Retrofit Initiative A” is shown in figure 3. Based on fuzzy set values in Table 1, the disruption level of Retrofit Initiative A are estimated based on the disruption measures provided by Gleenson *et al.* (2011). Using the max-min composition operator, the overall number of disrupted days can be computed into a lower, mean and upper estimate. The individual days of disruption are computed based on the average daily income-earning potential of the building.

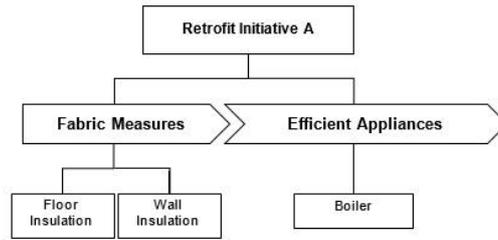


Figure 3: Illustrative Retrofit Option for evaluating the disruption cost.

$$\mu_{Floor\ Insulation} = \left[ \frac{1.0}{0.5} + \frac{0.9}{0.6} + \frac{0.7}{0.7} + \frac{0.4}{0.8} \right] \times 5\ days$$

$$\mu_{Wall\ Insulation} = \left[ \frac{0.9}{0.1} + \frac{0.7}{0.2} \right] \times 2\ days$$

$$\mu_{Boiler} = \left[ \frac{1.0}{0.5} + \frac{0.9}{0.6} + \frac{0.7}{0.7} + \frac{0.4}{0.8} \right] \times 5\ days$$

$$\mu_{Disrupted\ days\ for\ Retrofit\ A} = \left[ \frac{1.0}{5\ days} + \frac{0.9}{6.2\ days} + \frac{0.7}{7.4\ days} + \frac{0.4}{8\ days} \right]$$

$$\begin{aligned} \mu_{Disrupted\ days\ for\ Retrofit\ A} \\ = [5\ days, 6.2\ days, 7.4\ days, 8\ days] \cdot [1.0, 0.9, 0.7, 0.4] \end{aligned}$$

$$\mu_{Disrupted\ days\ for\ Retrofit\ A} = [5d; 5.6d; 5.2d; 3.2d]$$

For a £700 per day, building The cost of disruption for installing Retrofit A can be approximated as: Cost of Disruption = (£2,200, £3,300, £3,800)

### Evaluating the cost of revocability

The proposed method for evaluating the cost of revocability will follow three steps involving the derivation of the fuzzy relations matrix, aggregation of the fuzzy future cashflows, and the defuzzification of fuzzy future cash flow set. These are explained:

#### Derive Fuzzy Relations Matrix

The Fuzzy Relations Matrix is derived based on the matrix properties of a cost framework (Ross, 2009). The Standardized numerical coefficients of the Negative Binomial Probability distribution are transformed into matrix form. The benefit of a matrix transformation is to facilitate the computation of the fuzzy-derived future cash flow, and maximise the information contained in the probability distribution. The cosine amplitude formula is perhaps the best approach for transforming the numerical coefficients of the Negative Binomial distribution into a fuzzy relation matrix.

#### Generate fuzzy future cash flows

The future cash flows are estimated based on the binomial cash flow framework of the New-Generation Whole-life Costing model introduced by Ellingham and Fawcett (2006). The revocability rate of 10% is used, originally intended to provide for the inflation rate in the work by Ellingham and Fawcett (2006). The revocability rate implies a proportionate increase or decrease in future cost values in succeeding years. The future cost relations matrix is a product of aggregating the fuzzy future costs and the fuzzy binomial distributions.

#### Defuzzify into three-point estimates

Previous work by Morrell (1993) have implied that the benefit of risk modelling is diminished, if cost estimates are presented as precise single figures. Many cost estimates however, still seek to achieve precision, at the expense of credibility (Ross, 2009). It was previously implied by Gluch and Baumann (2004) that the current practice of whole-life cost modelling, which provides a single estimate, for such diverse range of data allows for vulnerability in generating erroneous results. The

defuzzification operator is a useful approach to providing a non-crisp value that represents the degree of satisfaction of the aggregated fuzzy number.

## CASE STUDY PROJECTS

According to Gleeson *et al.* (2011), the case-study approach has been the most common method used in examining retrofit initiatives. Two retrofit projects have been selected to appraise the effects of revocability and disruption in the whole-life cost framework. The first project (Building A) is a Grade II listed one-storey building in the UK. It was first constructed as a primary school in the 1930's and has recently being converted into a multi-tenant office building complex. The building comprises approximately 1,800m<sup>2</sup> of gross internal floor area. The second project (Building B) is an office retrofit building in the United States; 3-storeys tall, and is a typical masonry building unit with approximately 5,500m<sup>2</sup> of gross internal floor area. These buildings provide a useful context for assessing the whole-life costs of retrofit projects.

The data on the selected retrofit projects were obtained from documents and reports on the projects, and these were supplemented with interviews with the project teams. The energy cost is perhaps the most variable element of the future costs. Savings in energy costs also tend to be a key consideration in sanctioning retrofit projects in buildings. In order to obtain the energy use data in the retrofit buildings, dynamic energy simulation softwares were used to assess various retrofit building configuration permutations. Wang *et al.*, (2012) reckons that simulations tools are perhaps the most powerful methods available in providing abundant and detailed energy performance outputs for buildings. The IES<VE> has been used to model building energy consumption levels in Building A, while EnergyPlus has been used to model building energy consumption levels in Building B. In addition to the energy costs, there are also other maintenance and operating costs in office buildings including repairs, insurance, cleaning and waste disposal. The annual and maintenance costs were obtained from the building managers and owners of the respective projects.

## RESULTS AND DISCUSSION

*Table 2* and *Table 3* below presents the components of the whole-life costs of Building A and B, over a 60-year period, based on the proposed methodology. This work retains the separation of whole-life costing strands of initial costs and future costs. The inclusion of the cost of revocability – an additional variable to the future costs, and disruption – an additional variable to the initial cost, in the whole-life costing framework of building retrofit projects does not simply emphasize the prospects of underestimation, but also highlights the opportunities for savings. This approach provides a robust mathematical model that will be crucial for model validation and development.

The inputs of the whole-life components are the declining discount rate, as specified by the HM-Treasury (2013), which translates into 3.5% over a 1 to 30-year period, and 3% over a 31 – 60-year period. A revocability rate of 10% was adopted for both buildings, consistent with the work of Ellingham and Fawcett (2006). The future costs are the aggregate sum of the utilities costs and the maintenance costs. The ARC is obtained by dividing the percentage difference between the upper future cost (UFC) and lower future costs (LFC) over the life of the building, by the Standard Future Costs (SFC), obtained using the Standard whole-life costing framework. The cost

values in Building A is reported in *Table 2*. It can be seen that the average cost of revocability can be up to 105%, over a 60-year life in Building A.

*Table 2. Whole-life Cost Components of Building A, over a 60-year period*

BCP	CC (£,000)	LDC (£,000)	MDC (£,000)	UDC (£,000)	LFC (£,000)	SFC (£,000)	UFC (£,000)	ADC (%)	ARC (%)
1	0	0	0	0	3,996	3726	7,892	0.0	105
2	40	3.3	4.8	5.7	3,939	3697	7,768	12	104
3	219	3.5	15.5	24	3,811	3633	7,489	6.5	101
4	289	3.3	9.5	39.3	3,532	3858	6,727	3.1	83
5	580	3.5	24.7	39.3	3,549	3867	6,762	3.9	83
6	1,080	3.5	24.7	39.3	3,840	4323	7,254	2.1	79
7	763	4.6	27.5	43.6	3,214	4126	5,848	3.3	64
8	680	5.7	30	50	2,861	3541	5,264	4.2	68
9	780	4.6	27.5	43.6	2,974	3750	5,442	3.2	66
10	780	4.6	27.5	43.6	2,963	3745	5,420	3.2	66

*BCP refers to the building configuration permutation, CC – capital cost, LDC – Low Disruption Cost, MDC – Mean Disruption Cost, UDC – Upper Disruption Cost, LFC – Low Future costs, MFC – Standard Future Costs, UFC – Upper Future Costs, ADC – Average Disruption Cost, and ARC – Average Revocability Cost.*

Also, the average disruption cost (ADC) relative to the initial cost in Building A is obtained by computing the average of LDC, MDC and UDC, and dividing this by the initial cost. It can be seen from *Table 2*, that the ADC can be up to 12%. From *Table 3*, it is evident that the average cost of revocability (ARC) in Building B can be up to 119% over a 60-year life. While, the average cost of disruption relative to the initial cost can be up to 1.2% in Building B.

*Table 3: Whole-life Cost Components of Building B, over a 60-year period*

BCP	CC (\$,000)	LDC (\$,000)	MDC (\$,000)	UDC (\$,000)	LFC (\$,000)	SFC (\$,000)	UFC (\$,000)	ADC (%)	ARC (%)
1	612	0	0	0	4,668	4,441	9,041	0.0	98
2	795	0	0	0	3,620	3,007	7,197	0.0	119
3	577	0	0	0	6,075	6,581	11,423	0.0	81
4	1,101	0	0	0	4,225	4,160	8,123	0.0	94
5	1,285	6.2	15.5	25	3,084	2,667	6,087	1.2	113
6	1,288	8.2	18	28	4,020	4,030	7,697	1.4	91
7	1,468	8.2	18	28	2,766	2,465	5,428	1.2	108
8	1,150	1.9	2.9	3.3	4,180	4,132	8,030	0.2	93
9	1,335	8.2	18	28	3,842	3,917	7,329	1.4	89
10	1,518	8.2	18	28	2,702	2,424	5,294	1.2	107
11	1,170	1.9	2.9	3.3	5,558	6,253	10,352	0.2	77
12	1,362	8.2	18.5	28	2,861	2,525	5,624	1.3	109
13	1,366	10	21	31.5	3,550	3,732	6,725	1.5	85
14	1,549	10	21	31.5	2,500	2,297	4,878	1.3	104
15	1,276	1.9	2.9	3.3	5,760	6,652	10,656	0.2	74
16	1,285	1.9	2.9	3.3	4,112	4,359	7,773	0.2	84
17	1,468	8.2	18.5	28	3,063	2,924	5,929	1.2	98
18	1,510	10	21	31.5	3,809	4,166	7,145	1.4	80
19	1,693	10	21	31.5	2,890	2,814	5,569	1.2	95
20	1,805	10	21	31.5	2,984	2,874	5,765	1.2	97
21	3,420	24.6	41	55	3,301	3,844	6,093	1.2	73
22	4,485	12	24	35	2,163	2,082	4,179	0.5	97

It is reasonable to expect the cost of disruption, on average, to be more significant in the private sector establishments, compared to the public sector. This due to the profit-drive, typical of the private sector. The organisational goals, and scale of operation of organisation owning office buildings, will also influence the magnitude, and effects of the cost of disruption, in potential office retrofit building projects.

Revocability embodies initiatives within the control of building occupiers, as well as external economic conditions. Ellingham and Fawcett (2006) espoused on the external economic condition that influences the cost of revocability, which essentially refer to inflation. However, revocability as described by Verbruggen (2013) can be exercised through internal factors such as raising building users' awareness, on the cost of energy, and potential savings, drawing attention to energy-use, clear labelling

of switches and controls. Previous studies have not made concerted attempts to evaluate revocability and disruption in whole-life cost scenarios. Future studies will aim to conduct a sensitivity analysis on the whole-life cost assumptions in order to better appraise the effects of revocability and disruption over different building lives and discount rate values. Future studies will also assess the relative preference of the building configuration permutations, and compare this with results from existing models.

## CONCLUSION

This work evaluates the whole-life cost implication of disruption and revocability in office retrofit buildings. It is argued that the lack of consideration of revocability and disruption in existing whole-life cost modelling suggest the potential for underestimation of the whole-life costs of office retrofit buildings. This work proposed an approach for evaluating the cost of revocability and disruption using probability and fuzzy logic principles. Two buildings – A and B, are used to appraise the effects of disruption and revocability. It was found that in Building A and Building B respectively, the average cost of revocability can be up to 105% and 119%, over a 60-year life, and the average cost of disruption relative to the initial cost can be up to 1.2% and 12%. This work is limited in focusing on just two projects, and future work should include more samples. This will provide building clients with clearer aspirational objectives on the whole-life economic performance of office retrofit building projects

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# A SIMPLIFIED MODEL FOR PREDICTING RUNNING COST OF OFFICE BUILDINGS IN SRI LANKA

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Usually, 80% of running costs of a building are influenced by 20% of initial costs. Therefore concerns for running cost need to begin at the outset of building design. A simplified model that could predict running cost from early project phase would facilitate design development and give due consideration to life cycle costing (LCC) accuracies. Historical data on running cost for office buildings are inconsistent in Sri Lanka and affect prediction accuracies. However the current research proposes a model using simple variables to facilitate the prediction of running cost of office buildings in Sri Lanka. The study uses a mixed method approach to collect data through eight semi-structured interviews and analyses of eight office building documents. The model developed was subsequently validated using another set of eight buildings. The analyses show that operation and maintenance cost account for 75% and 25% to total running cost respectively. Major operational cost comprise utility and administration, while maintenance comprise cleaning and building services. The model primarily depends on average floor area and number of floors. These parameters are responsible for over 98% of the model accuracy and could provide a speedy and accurate estimation of running cost for office buildings.

Keywords: life cycle, cost, modelling, forecasting, office buildings

## INTRODUCTION

The main motivation for Life Cycle Costing (LCC) is to increase the possibility of cost reductions during operation while spending a little more during planning and development stage (Dell'Isola & Kirk 2003). LCC consists of the estimation of initial cost of acquisition together with operation and maintenance costs to ensure clients the most value for their investments (British Standard Institution BSI 2008). Running costs as part of life cycle cost comprise the sum of maintenance and operating costs, which is experienced during the operational phase of buildings (Lai & Yik 2008). Often, emphasis is placed on keeping initial costs of buildings to a minimum with little consideration to any long cost implications. Kehily (2010) confirms that reduction in capital costs could lead to expensive maintenance, operation, and disposal costs in buildings and the building users are very often burdened with these costs. Tuhus-Dubrow and Krarti (2010) indicated that the running costs of commercial buildings in the USA (with 30 years estimated life and a discount rate of 5%) accounts for 66% of total life cycle costs while the remaining 34% is capital cost. In another

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situation, the life cycle cost is shared equally (50%) by capital and running costs (Tuhus-Dubrow & Krarti 2010).

Most recently, Goh and Sun (2015) conclude that commercial buildings consume higher running costs than residential, institutional and other industrial buildings. In Wang, Wei and Sun (2014) study, residential buildings came second with running costs accounting for 69% of total life cycle cost. Further, Kshirsagar, El-Gafy and Abdelhamid (2010) indicated that the running costs of institutional buildings fall within the range of 52 to 61%. For industrial buildings running costs vary between 40 to 54% (Gurung&Mahendran2002). However, Wong, Perera, and Eames (2010) study found that amongst commercial buildings, running cost for office buildings varies between 72 to 81% of total costs. It can be presumed that this difference of running cost might occur due to the assumed discount rates (4-10%) and life cycles (50-60 years) of the residential, industrial and office buildings. Nevertheless, the foregoing differences in running cost contribution drove to develop a mathematical model which can explicitly quantify the running cost of office buildings in Sri Lanka at the early stage.

Considering the previous works on developing mathematical models for prediction of life cycle cost or running cost, Langdon (2006) was of the opinion that parametric models with regression analysis play a vital role in predicting running cost. In the parametric method to life cycle cost estimating, the cost drivers are related to cost by costs estimating relationships through regression analysis. For example, Kirkham, Boussabaine, and Grew (1999) applied regression technique to model the energy cost of sport centres. In the regression models, the floor area and the number of users are two independent inputs. However, its application is limited to that particular cost component. By applying this model, energy cost of sports facilities can be calculated using only two variables, the building area and the number of users at the early stage of the sports facilities.

Moreover, Krstić and Marenjak (2012) argued that a large number of life cycle cost models have been developed with different cost classification systems. For example, Al-Hajj and Horner (1998) proposed a model which contains eleven elements of cost, which can predict the total running cost of buildings to an accuracy about 1.13%. Al-Hajj and Horner (1998) opine that LCC models need to cater for actual practices and requirements of buildings, ensure accuracy, ease of use and provide estimates from different levels of available data and information. However, the foregoing model is applicable at the running stage of buildings, where there are adequate historical running cost data are available. This kind of models therefore seems less accurate and restricted to a specific life cycle. The existence of many different costs data collection systems and many different types of equipment, devices, and systems limit the establishment of a simplified model for predicting running costs at the early stage.

In Sri Lanka, the operation and maintenance support costs are viewed within a limited range where energy cost is the primary concern. It is estimated that the energy cost is 20-60% of the annual operations and maintenance cost of office buildings (Weddikkara 2001). Similarly, electricity consumption in office buildings accounts for 20% of the total electricity consumption in Sri Lanka (Sri Lanka Sustainable Energy Authority SLSEA, 2014). Energy consumption of air conditioning systems accounts for more than 75% of electricity energy balance in typical buildings in Sri Lanka (SLSEA 2014). However, there seems to be lack of estimations for total running cost of office buildings in Sri Lanka. The lack of reliable and consistent data

makes it impossible to establish running cost behaviour at the early stage of buildings. This research therefore analyses running cost of office buildings in Sri Lanka and develops a simplified regression model based on basic building parameters for predicting running cost. The study believes such an information could help to determine the optimum pay off between capital and running cost at the early stage of office building development in Sri Lanka.

## **METHODOLOGY**

The research was approached using mixed methods involving semi-structured interviews and document analysis. Eight office buildings were considered in both situations. The objective of the interviews was to determine the purpose of LCC, types of LCC data used, difficulties faced by the practitioners in determining LCC and strategies for overcoming those difficulties. Content analysis was used to analyse the interviewees' opinions. Subsequently running cost and physical data of eight buildings were collected from building information/documents. Information collected include: organization's annual reports, administrative expenditure budget records, and operating expenses reports. Standard cost categories suggested by Building Maintenance Cost Information Service (BMCIS) were modified using generic cost classification of life cycle cost introduced in BS ISO part 5 of British Standard Institution (BSI).

This was used to collect running cost data. The modified cost categories considered rent, utilities, insurance, administrative cost, and taxes and subsidies as elements of operational costs while decoration, fabric, services, cleaning, external works, and replacements of major components constitute maintenance costs. Physical data collected included: building floor area, height and number of floors. The running cost data was analysed using descriptive statistics to identify the contribution of running cost in office buildings. Regression analysis was performed in SPSS to find the relationship between running cost and building characteristics. As a first step in developing the regression model, the total running cost of each building was escalated at assumed inflation rate and then discounted for the base period. The analysis was carried out for 50 years as most of the selected buildings were estimated for 50 years of life span. The discount rate used was obtained from the Central Bank of Sri Lanka (6.5%). After the NPV calculation, a stepwise regression analysis was performed. Finally, another set of eight office buildings completed in different years were selected to verify the accuracy of the developed regression model.

## **DATA ANALYSIS AND FINDINGS**

As stated above, first part of the data collection involved interviewing professionals employed in the selected office buildings. One professional who engaged in operation and maintenance activities of the organization and practicing LCC was considered from each building. Table 1 presents the profile of the selected buildings and participants. As observed from Table, selected buildings represent different sectors: property development, banking, mixed development, finance, and administration and office. According to Table, 50% of interviewees are electrical engineers while 38% are from the mechanical engineering field. Only one participant is from the field of facilities management. In terms of these professionals' experience, 50% of participants have 10-20 years of experience while another equal percentage of 25% are in the age group of less than 10 years and more than 20 years.

## Use of LCC Approach in Office Buildings in Sri Lanka

The first part of the research explored: purposes of LCC, types of LCC data used, difficulties faced by practitioners in using LCC and strategies to overcome those difficulties. Participants indicated that the LCC is used occasionally in their organizations during operational phase of the buildings. However, the payback analysis was preferred over LCC.

Table 1: Profile of Buildings and Participants

Building	Sector of the Industry	No of Floors	Floor Area (m <sup>2</sup> )	Life Span (Years)	Interviewee	Profession	Work Experience (Years)
B1	Property development and management	37	117054	50	I01	Electrical Engineering	21-30
B2	Property development and management	13	15400	50	I07	Electrical Engineering	11-20
B3	Property development and management	17	17651	50	I08	Mechanical Engineering	21-30
B4	Banking	23	46450	100	I02	Electrical Engineering	11-20
B5	Banking	32	53882	50	I03	Electrical Engineering	11-20
B6	Mixed development	34	48000	50	I04	Facilities Management	1-10
B7	Institution in financial sector	16	55740	50	I05	Mechanical Engineering	11-20
B8	Customs administration	13	17000	50	I06	Mechanical Engineering	1-10

Participants further indicated that engineering, maintenance, procurement and finance departments use LCC more while other departments such as housekeeping, human resource and administration use it to a limited scale. There is no evidence of the usage of the LCC during design phase of office buildings, despite world trend to use LCC at the design stage. Table 2 presents the summary of views of participants on questions asked.

On the purpose for which LCC is used in participants' organizations, majority (62.5%) stated that LCC is used to select the best option among competing systems or suppliers of goods and services. Another 37.5% opined that the LCC is used to determine the affordability of major capital expenditure with significant operation and maintenance costs while 25% of interviewees used LCC for valuation.

In terms of availability and maintenance of LCC data, all participants indicated that they maintain operation and maintenance costs data of their buildings. Two of the interviewees (25%) stated that an asset registry integrated with operation and maintenance costs data is maintained by their organizations while energy databases and capital asset management systems are other ways of maintaining LCC data in organizations according to I01 and I04 respectively.

On difficulties faced in the use of LCC. All interviewees indicate that lack of accurate and inconsistent data and inconvenience involved in collecting historical data are the main difficulties faced by practitioners. A few of the participants indicated that unpredictability of the cost variables (37.5%) and lack of universal methods and standard formats for maintaining life cycle cost data (25%) are other difficulties for the LCC use. Finally, participants were further questioned to identify the strategies to overcome these difficulties. Majority (87.5%) of the interviews suggested that the conduct of awareness programs on knowledge and significance of LCC through case

studies and success stories. Another set of interviewees (62.5%) suggest providing knowledge on LCC variables that calculations, account depreciation and costing. 37.5% of interviewees was of the opinion that maintaining running cost databases could overcome difficulties. 25% of participants suggest the acquisition of quality data for the LCC analysis and improvement of the databases. Only one interviewee (12.5%) mentioned the integration of LCC analysis into procurement procedures.

Table 2: Practice and Use of LCC

Aspects of LCC	Interviewees' opinion	Source	Frequency
Purposes of LCC	Alternative evaluation	I01, I02, I03, I04, and I05	62.5%
	Affordability	I06, I07 and I08	37.5%
	Building valuation and revaluation	I05 and I08	25%
Data for LCC	Operation and maintenance costs data	I01, I02, I03, I04, I05, I06, I07 and I08	100%
	Asset registry integrated with costs data	I01 and I04	25%
	Energy databases	I01	12.5%
	Capital asset management systems	I04	12.5%
Difficulties faced by the practitioners when using LCC approach	Lack of accurate and consistent data	I01, I02, I03, I04, I05, I06, I07 and I08	100%
	Inconvenience involved in collecting historical data	I01, I02, I03, I04, I05, I06, I07 and I08	100%
	Unpredictability of cost variables	I01, I03 and I07	37.5%
	Lack of universal methods and standard formats for maintaining life cycle cost data	I01 and I05	25%
Strategies to overcome difficulties	Awareness programs on LCC knowledge and significance of LCC by case studies and success stories	I01, I02, I04, I05, I06, I07, and I08	87.5%
	Knowledge on LCC variables affecting for calculations, account depreciation and costing	I01, I02, I03, I07 and I08	62.5%
	Maintaining running cost databases in organization	I02, I07, and I08	37.5%
	Acquisition of information from regent vendors, manufacturers, and service providers	I01 and I03	25%
	Use of in-house operation and maintenance data	I01 and I06	25%
	Acquisition of data from similar industries	I01 and I06	25%
	Defining reference projects by responsible parties	I07 and I08	25%
	Implementing and maintaining CMMS	I05 and I04	25%
	Integrate LCC analysis into procurement procedures	I05	12.5%

The foregoing analyses indicate that most of the organizations (5 out of 8) use LCC among competing alternatives. Yet, lack of accurate and consistent data and the inconvenience involved in collecting historical data of the buildings are major concerns. The various strategies should be implemented to mitigate the difficulties faced by the practitioners when using LCC approach in the context of Sri Lanka.

## Analysis of Running Cost of Office Buildings in Sri Lanka

The running cost of office buildings was analysed according to standard cost classification systems of BMCIS and BSI. The components of running cost is slightly deviated from the BSI system where rental is not part of the operational cost as most of the office buildings are occupied by the owner or managed by the developer. The rental forms part of their income. The BMCIS system divides maintenance cost into decoration, fabric, building services, cleaning, and external works. Similarly, the maintenance cost of office buildings in Sri Lanka differs from BMCIS elements. The cost of decorating and fabric maintenance is categorized under general building maintenance of office buildings in Sri Lanka.

A significant difference was observed between maximum and minimum values of running cost of selected buildings. Hence, it was not accurate if considered the mean value of the sample to analyse the running cost of office buildings in Sri Lanka. Thus, the median value of the sample is considered. The difference between the median and the actual running cost of each building was calculated and considered to select the best samples to illustrate the composition of running cost. Table 3 represents the deviation (%) of running cost of each building with respect to median cost.

Table 3: Deviation of Running cost of Each Building with Respect to Median Cost

Building	Actual Running cost (LKR)	Median Value (LKR)	Difference		Category
			Median - Actual	%	
B4	353,125,841.00	378,280,222.00	25,154,381.00	7	Category 1
B5	403,434,602.00	378,280,222.00	-25,154,380.00	-7	
B6	434,450,822.00	378,280,222.00	-56,170,600.00	-15	
B2	96,164,244.00	378,280,222.00	282,115,978.00	75	Category 2
B3	119,448,300.00	378,280,222.00	258,831,922.00	68	
B8	116,542,177.00	378,280,222.00	261,738,045.00	69	
B1	833,246,551.00	378,280,222.00	-454,966,329.00	-120	Category 3
B7	722,973,123.00	378,280,222.00	-344,692,901.00	-91	

As observed from table 3, that there are three different ranges of cost deviations found among selected buildings. The running cost deviation of B4, B5 and B6 ranges around  $\pm 10\%$  on average, while the deviation of B2, B3, and B8 ranges between 65 - 75%. The buildings B1 and B7 indicated a very high deviation compared to running cost of other buildings and ranges around -100% on average. Further, physical characteristics of the selected buildings are considered, B1 consists of highest number of floors and largest gross floor area (table 1) amongst selected buildings. Therefore B4, B5 and B6 (category 1), and B2, B3, and B8 (category 2) were considered for further analysis while B1 and B7 belong to category 3 were eliminated from the analysis due to major deviations. Table 4 indicates the composition of running cost for the mean value of selected two categories of office buildings.

According to Table 4, the running cost mainly consists of operational and maintenance costs. For both categories of buildings, the % contribution of operational and maintenance costs to the running cost is equal, 75% and 25% respectively. In both categories of building, utilities and administrative cost are highly contributing elements to the total running cost with nearly 30-40% contribution. Amongst the utility cost, the electricity cost consumes higher proportion than the other energy costs such as fuel, gas, and water. The administrative cost on the other hand, includes a

higher proportion of staff cost than the other administrative costs such as property management, sundries, portorage, and waste disposal costs. The cleaning is another cost component which contributes nearly 10% to running cost in both categories of buildings. In both buildings, the general building maintenance and building services together are responsible for nearly 15% of total running cost.

Table 4: Contribution of Each Element to the Running cost

Element	Category 1		Category 2	
	Mean Value LKR	Contribution to Running cost %	Mean Value LKR	Contribution to Running cost %
Running cost	397,003,755	100.00	110,718,240	100.00
1 Operation Cost	296,590,098	74.71	82,623,354	74.62
Insurance cost	4,255,343	1.07	1,661,413	1.50
Utilities	115,007,740	28.97	42,273,008	38.18
Administrative cost	114,587,513	28.86	38,117,559	34.43
Taxes and Subsidies	62,739,502	15.80	6,197,041	5.60
2 Maintenance Cost	100,413,657	25.29	28,094,886	25.38
General Building Maintenance	24,383,333	6.14	9,866,265	8.91
Building Services	32,506,575	8.19	6,756,218	6.10
Cleaning	42,671,016	10.75	10,857,509	9.81
External Works	852,733	0.21	614,894	0.56

### Simplified Model for Predicting Running Cost of Office Buildings in Sri Lanka

Initially the regression model was fixed with selected independent variables such as gross floor area, no of floors, average floor area, building height, average storey height, electric power demand, cooling capacity, and water demand and dependent variable, running cost. All the independent variables indicated a positive linear relationship with the dependent except the average story height, which was more towards to a non-linear relationship. Therefore, without further transformation of the independent variables, the stepwise multiple regression analysis was performed. Accordingly, the regression analysis offered two models and the Table 5 represents the coefficients of the two regression models.

Table 5: Coefficients of the Regression Model

Model		Un-standardized Coefficients		Standardized Coefficients		Collinearity Statistics	
		B	Std. Error	Beta	Tolerance	VIF	
1	(Constant)	-2128539441	1491968284				
	Average Floor Area	4078359.034	710830.151	0.920	1.000	1.000	
2	(Constant)	-4964009161	648774047.6				
	Average Floor Area	3607150.063	249055.810	0.813	0.925	1.081	
	No of Floors	161567613	23361898.36	0.388	0.925	1.081	

According to collinearity statistics shown in Table 5, the tolerances are large and the Variance Inflation Factor (VIF) is considerably low. This evidences the non-existence of multicollinearity. However, there is no formal criterion for determining the bottom line of the tolerance value or VIF. A tolerance value of less than 0.1 or VIF greater than 10 generally indicates a significant multicollinearity (Chatterjee & Hadi 2012). The commonly used measure of the goodness of fit of a linear model is R2 (the

coefficient of determination) which ranges between 0-1. The best model is identified by its highest adjusted R2. Table 6 provides the statistics of the two models for predicting the running cost. Among the two models, the model with the highest R2 is selected as the best fit model. According to the R2 of the model, the goodness of fit of the model is over 98%.

Table 6: Summary of Model

Model	R	R2	Adjusted R2	Standard Error of the Estimate	Change Statistics		
					R2 Change	F change	Sig. F Change
1	0.920	0.846	0.820	1742400153	0.846	32.918	0.001
2	0.993	0.985	0.980	587201089.6	0.140	47.829	0.001

Based on the statistics, the running cost of office buildings is represented by:

$$\text{Running cost} = -4964009161 + 3607150.063 * (\text{Average Floor Area}) + 161567613 * (\text{No of Floors})$$

The selected independent variables directly contribute to the running cost of office buildings and according to predictors of the model, the running cost of office buildings can be predicted to make informed decisions at the building acquisition stage.

## VALIDATION

The above model was validated with a set of equal number of buildings of the sample size used to develop the model. The results of the validation exercise are given in Table 7.

Table 7: Validation of the Developed Model

Building Number	Actual cost (LKR)	Predicted cost (LKR)	Difference	Accuracy (%)
1	1,189,158,069.52	1,236,797,641.82	47,639,572.30	4.01
2	1,606,666,073.03	1,543,141,309.00	(63,524,764.03)	-3.95
3	6,290,814,282.27	6,624,397,792.29	433,583,510.01	5.30
4	2,485,690,132.00	2,615,121,376.73	129,431,244.73	5.21
5	5,241,438,949.96	5,358,136,753.81	316,697,803.85	2.23
6	1,883,131,797.39	1,788,784,866.66	(94,346,930.72)	-5.01
7	6,936,920,738.37	7,033,400,654.77	96,479,916.40	1.39
8	8,023,889,819.69	7,972,043,159.28	(51,846,660.41)	-0.65
Mean Value of Accuracy %				1.07
Standard Deviation of Accuracy %				3.97

The validation of the model is established based on the difference between actual cost and predicted cost, and the level of accuracy. The closer the value of accuracy is to zero, the more accurate is the model. The results demonstrate that the accuracy of the predicted running cost values ranges between -/+5 % of office buildings in Sri Lanka. The mean value of accuracy is 1.07%, while the standard deviation of accuracy is 3.97%. The validation considers the mean value of accuracy rather than the mean absolute value of accuracy. Because the mean absolute value do not lend themselves to further mathematical manipulation.

## DISCUSSION AND CONCLUSIONS

As researchers suggest, the LCC is traditionally used for various purposes such as alternative evaluation, affordability, repair level analysis, warranty and repair costs, design trade-offs, and suppliers' sales strategies (Barringer & Weber 1996; Dell'Isola & Kirk 2003; Langdon 2006). However, this research indicated that the LCC is used for selecting alternatives and determining affordability in Sri Lankan office buildings. In line with the view of Gluch and Baumann (2004) that the lack of reliable and consistent data limits the application of LCC in the building sector at the early stage of buildings, authors found that availability of accurate and consistent cost data and inconvenience involved in collecting historical data of the buildings are identified as the major difficulties faced by the LCC practitioners in office buildings. In order to address the above concerns, the research proposed a simplified model which is based basic on building parameters for predicting running cost of LCC in Sri Lanka. As Krstić and Marenjak (2012) suggest, although the data used to develop the model can be very preliminary and marginally accurate, yet the model is very helpful for focusing designers on the areas of higher costs at the design development stages. The mean value of accuracy of the developed model for predicting running cost of office buildings in Sri Lanka is much improved compared to the mean value of accuracy (1.13%) reported by Al-Hajj and Horner (1998) in their general running cost model.

Moreover, Al-Hajj and Horner (1998) determined the precision of their model by the scatter of the individual accuracies which represented by the standard deviation of accuracy. However, the standard deviation of accuracy of the developed model by this research is increased compared to the standard deviation (3.70%) reported by Al-Hajj and Horner (1998). For large building projects, the consideration of LCC needs to be given at the outset of design phase and continued throughout design. At this stage all the significant cost elements or the main characteristics of the project should be examined to determine the optimal savings on costs with a reasonable expenditure of LCC efforts. Thus, the research also analysed the contributing elements for running cost of the office buildings in Sri Lanka. The cost categorizations used are in line with BSI and BMCIS standards. Accordingly, the main cost elements of the office buildings include insurance, utilities, administrative, taxes and subsidies, general building maintenance, building services maintenance, cleaning, and external works. As per the analysis, the contribution of utility and administrative cost vary between 30% - 40%, while taxes and subsidies, cost for the cleaning, building services maintenance, and general building maintenance vary from 5% - 15%. The study therefore concludes that this proposed simplified model together with the knowledge on composition of running cost could enable the prediction of running cost and thereby ensure the effective use of LCC in the industry.

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# EDUCATION



# BENCHMARKING BIM LEVELS OF TRAINING AND EDUCATION AMONGST CONSTRUCTION MANAGEMENT PRACTITIONERS

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UK Government created a strategic deadline of 2016 for the adoption and use of Level 2 BIM on all centrally procured projects. A shift from Computer Aided Design (CAD) to Building Information Modelling (BIM) has been driven by the need to improve the way that the industry delivers projects. It is believed that BIM better facilitates opportunities for collaboration and project enhancement than traditional project information management processes. It is also thought that by improving the quality of information, and adopting a more collaborative approach through a model-based design industry such advancements can be made. The originality of this research is in developing an understanding of the current-status of BIM training and education amongst construction management practitioners. The present research uses a quantitative survey approach to investigate the current-status of BIM awareness, understanding, use, and perceptions towards readiness for the 2016 mandate. Results highlight that approximately half of the sample have received some kind of education or training although there were higher levels of BIM awareness, use and understanding. Investigations also reveal that the majority of training and education received by practitioners is self-sourced, but amongst those respondents who have not received any education or training there are expectations that employers should provide these.

Keywords: Building Information Modelling, education, skills, training, survey

## INTRODUCTION

Building Information Modelling (BIM) is presently of great interest to a range of construction stakeholders including governments, clients, practitioners and academics. Arguments for widespread implementation of BIM have emphasised the realised benefits disseminated through the publication of case studies (Barlish and Sullivan, 2012; Gledson, 2016; Bryde *et al.*, 2013). However, the introductions of such disruptive innovations are not without problems (Loosemore, 2014; Poirier *et al.*, 2015). Research to date has highlighted many barriers towards BIM implementation. Eadie *et al.*, (2013) note one such issue, to be a lack of BIM expertise both within the project team and at an organisational level. This raises questions over the quantity and quality of BIM training and education available for construction management practitioners operating within the UK Architectural Engineering and Construction

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(AEC) industry. This cross-sectional research aims to determine the status, scale and suitability of BIM training and education in relation to these issues.

## LITERATURE REVIEW

BIM is a three-dimensional geometric model that is data rich. The information contained within it can be used for other purposes such as predicting energy consumption, structural performance, cost, scheduling, clashes between systems preconstruction, and [it] can even be leveraged for facilities management uses (Kensek, 2014).

Effective use of BIM facilitates collaborative working and improves the quality of production information across the project lifecycle (Crotty, 2012). Recognising existing benefits and opportunities for further improvements in project delivery afforded by better use of project information, in 2011 the UK Government mandated the use of Level 2 BIM on all centrally procured public projects from April 2016 onwards (HM Government, 2011). However several barriers to adoption exist, and the most frequently identified in the literature can be categorised under five headings: *Legal barriers*, *Technological barriers* (e.g. interoperability) and inter-related elements surrounding *Cost*, *People* and *Training* needs.

The cost implications associated with BIM adoption have previously been identified as a substantial barrier to BIM, and various researchers (Azhar, 2011; Becerik-Gerber and Kensek, 2010; Dowsett and Harty, 2013) have discussed the cost impacts of technology procurement, training of existing staff, and the employment of better-qualified BIM-ready staff. Human or sociotechnical barriers are also identified as an under researched, and underappreciated area that must be addressed when considering adoption (Davies and Harty, 2012; Gu and London, 2010).

As with any technological innovation, issues of training and education around BIM systems has already been identified by a range of researchers as being fundamental, not only for initial adoption but for its successful application (Davies and Harty, 2013; Yan and Damian, 2008), yet much of early BIM education disseminated at industry road-show events was directed primarily at more senior, upper management staff that held some influence over the strategic direction of construction organisations. Furthermore, whilst previous efforts into individual and organisational BIM awareness, understanding, use, and perceptions towards readiness for the 2016 mandate has been undertaken by a range of researchers (Eadie *et al.*, 2013; Khosrowshahi and Arayici, 2012), and organisations (e.g. see the annual NBS 'National BIM Surveys'), such outputs, have not successfully identified industry needs in relation to BIM training and education.

Crotty (2012) and Loosemore, (2014) both argue that project-level personnel ultimately have responsibility for managing innovations into use, and that these practitioners have a tendency to focus only on innovations that can realise productivity, cost and time benefits. Therefore these are the individuals within construction organisations that will ultimately determine the success of such innovations, and who should benefit from targeted training and education that is tailored to their needs. Construction management practitioners are now more likely than ever to be interacting with model-based production information, so there is presently a need for research into the levels and effectiveness of such training and education received by these individuals to see if the potential benefits associated with BIM can begin to be realised.

## RESEARCH METHOD

A web-based questionnaire survey was designed to primarily collect quantitative data over a cross-sectional time horizon. The target population of the study was construction management professionals working for or with, contracting organisations in delivering construction projects across any tier of the UK AEC industry. Various principles of effective web based questionnaire construction including length (Fellows and Liu, 2008), question design (Bryman, 2015), and attractiveness (Dillman *et al.*, 2014), were followed and after an initial pilot questionnaire was tested, the finalised structured questionnaire survey was distributed in the early months of 2015 for self-completion initially to a handful of purposively selected construction management professionals. Thereafter a snowball sampling technique was employed with the initial participants used to provide the survey link to other individuals relevant to the research topic that matching the population of interest. The survey collected 50 full responses, however because of the sampling technique used a response rate cannot be calculated. Key to the success of the questionnaire was the incorporation of question logic that would filter respondents into one of two categories depending upon whether the respondent had previously received any form of BIM education or training. Once filtered into these sub-sets, all respondents were presented with similarly worded questions relating to BIM training and education. These would be answered either drawing upon their direct experience of BIM training and education, or from their perceptions of BIM training and education.

## FINDINGS

The majority of respondents were male (86.0%, n=43) with 11 years AEC working experience (calculated using mean scores), practicing in construction management roles (76%, n=38) for large contractors employing over 250 employees (68%, n=34) in middle management positions (38%, n=19).

54% (n=27) of respondents confirmed that they had received some kind of BIM education and/or training compared with 46.0% (n=23) who had not. 68.0% (n=34) of respondents confirmed that they were aware of, and understood the Level 2 BIM mandate; whereas 26.0% (n=13) were not aware, and 6.0% (n=3) were aware but did not understand it. Focusing only on the sub-set of respondents who were aware of the Level 2 BIM mandate, a minority (27.0%) believed the industry would be ready, with the majority (73.0%) believing that it would not.

Using inferential statistics, associations were tested between the receipt of BIM education/training received and the awareness, understanding and use of BIM [T1-3]. This part of the research was designed using categorical variables in order for the following Chi-Square tests of associations:

**T1:** *Level of BIM education/training compared against BIM awareness.*

**T2:** *Level of BIM education/training compared against BIM understanding.*

**T3:** *Level of BIM education/training compared against BIM use.*

In each test, all 50 cases were usable, but conditions for Chi-Square ( $X^2$ ) were not met due to some cells having expected counts of less than 5, therefore Fisher's Exact Tests were used. In each test appropriate null ( $H_0$ ) and alternative ( $H_A$ ) hypotheses were formulated, and results of each test showed that the null ( $H_0$ ) could be rejected in favour of the alternative.

T1 gave a Fishers statistic of .000 and interrogation of data produced in the cross-tabulation about this relationship appears suggest that receipt of BIM education/training means that respondents were likely to profess themselves as ‘fully aware of BIM’ in contrast to respondents who had not received BIM education/training (Note: the researchers are unable to account for the reasoning of the sole respondent who has identified that they have received some BIM education or training but has also advised that they are 'not aware of BIM').

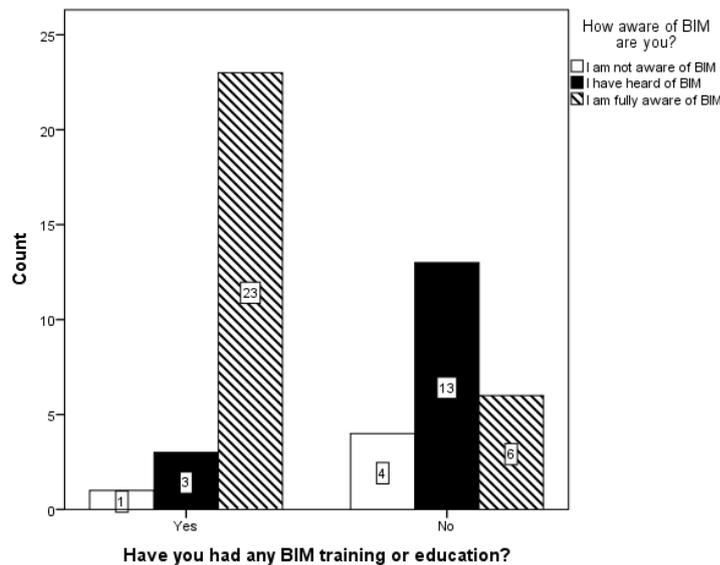


Figure 1: Levels of BIM education/training compared against BIM awareness

T2 gave a Fishers statistic of .003 and interrogation of data produced in the cross-tabulation about this relationship again, appears to suggest that receipt of BIM education/training means that respondents were likely to perceive themselves as having a high degree of BIM understanding.

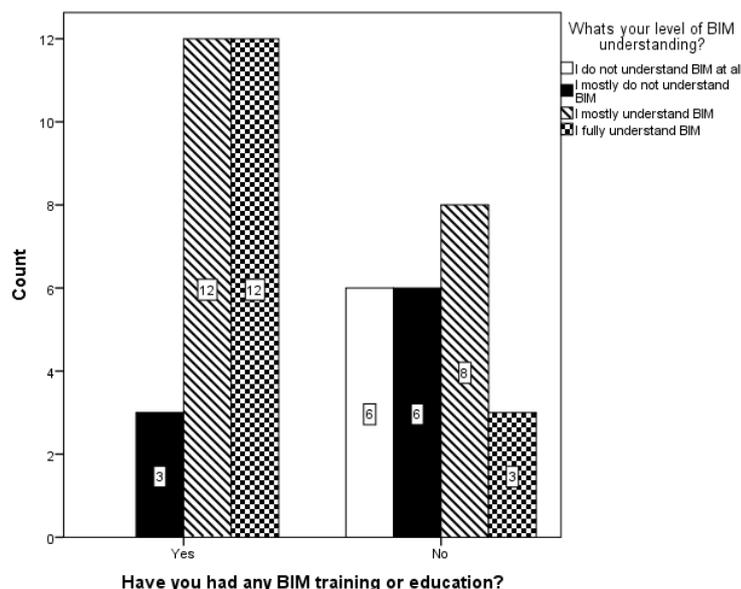


Figure 2: Levels of BIM education/training compared against BIM understanding

T3 gave a Fishers statistic of .001 and interrogation of data produced in the cross-tabulation about this relationship appears to suggest that while receipt of BIM

education/training results in use of BIM, respondents with no such BIM education or training, were much more likely to have never used BIM in any capacity.

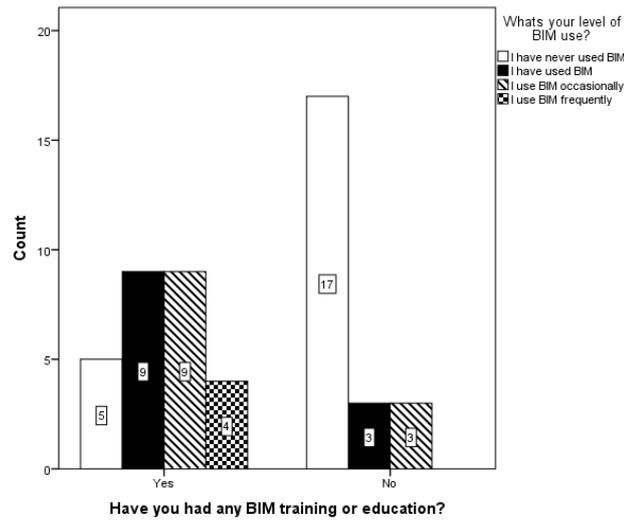


Figure 3: Levels of BIM education/training compared against BIM use

Examination of differences between respondents with and without any BIM education or training then occurred. This first section focuses only on the sub-set of respondents who have received prior BIM education or training.

**Sub-set 1: Respondents who had received prior BIM education or training (n=27)**

The drivers for such education and training were sought under the categories of ‘Compulsory’, ‘Optional’ and ‘Requested’ (by the individual). The results of this highlighted that in the majority (63.0%) of respondents have accessed training/education because it was compulsory, for 25.9% it was optional but 11.1% had to request it.

The survey was designed to collect data on the quantity of BIM education and/or training received, and identify how such content was being delivered across four broad categories: *company provided training* (White bins); *company provided education* (White bins with diagonal hatching); *self-sourced training* (Black bins), or *self-sourced education* (Black bins with checker-box hatching).

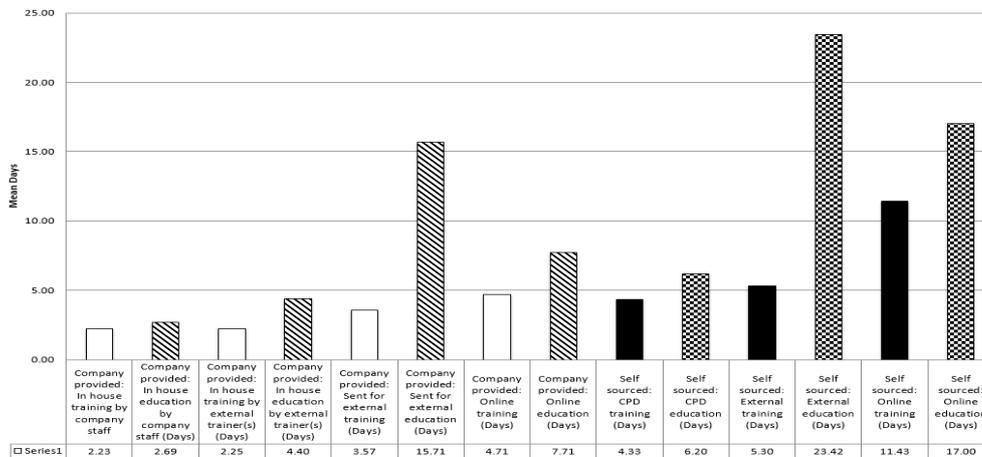


Figure 4: Quantity of training and education received in mean days

Figure 4 illustrates that amongst the sample surveyed, self-sourced ‘instruments’ (as used in this research as the term to identify the education or training ‘mediums’ or

‘channels’) are more prevalent than company provided instruments. The most frequently accessed training instrument was *'Self-sourced: external education'* followed by *'Self-sourced: online education'*, and the least frequent identified was *'Company provided: in house training by external trainer(s)'*. Furthermore, these data also show that regardless of the instrument or supplier, BIM education has been more prevalent than the more practical hands-on training.

In addition to quantity of training/education, the survey was also designed to assess respondents' perceptions of the quality of the training/education that they had received to assess which instruments are considered to provide better levels of training/education. To measure this, 5-point Likert scales were used with response options being: (1) Awful; (2) Poor (3) Average (4) Good, and (5) Excellent.

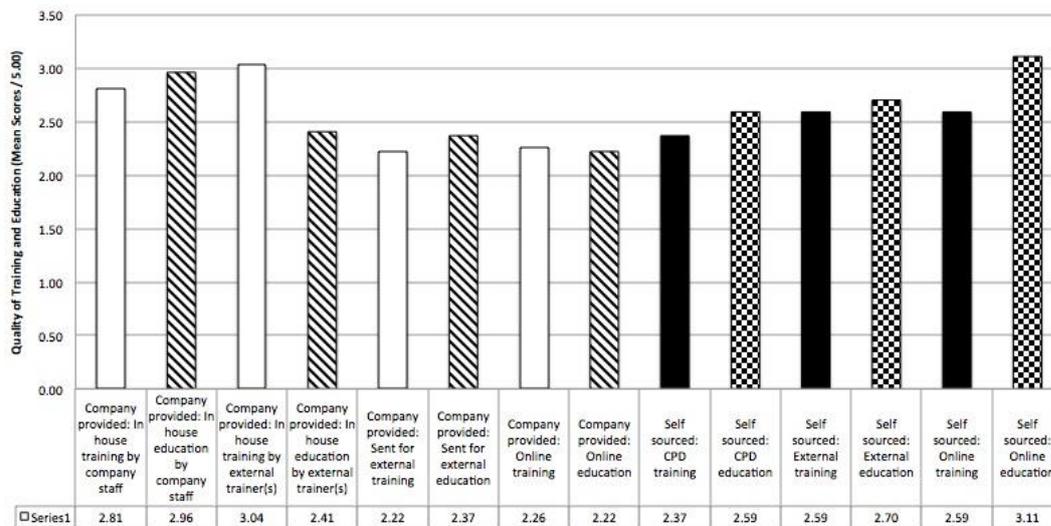


Figure 5: Quality of training and education received

This time there was no clear trend. Although the instrument that provides the highest quality was seen to be *'Self-sourced: Online education'* (3.11 / 5.00), it was followed by *'Company provided: training in-house, (which is delivered) by external trainers'* (3.04). The joint poorest performing instruments are highlighted as being *'Company provided: online education'* and *'Company provided: sent for external education'* (both 2.22 / 5.00).

With these results established, this subset of respondents were also asked whether their level of BIM training/education was sufficient or they would like more in the future. The results from this found that the majority (88.9%) would like access to further training and education, with only 11.1% feeling the training they have had was sufficient.

Notable qualitative comments provided by respondents that have undertaken BIM training or education also focussed on issues of quality and quantity:

After receiving the BIM training provided by the company, I feel that the industry as a whole will not be ready to use BIM because of people's mind-sets and [there is] not enough training going on .... Not enough people are aware of what BIM has to offer... (Respondent 32)

The only training I have received is a very basic BIM awareness course providing an overview of the governments targets and how BIM can further the construction industry. (Respondent 34)

**Sub-set 2: Respondents who had not received prior BIM education or training (n=23)**

The majority of this subset of the sample (91.3%) advised they have not had the opportunity to take any BIM training or education with only a minority (8.7%) being offered it, but opting out of receiving any.

In order to understand the attitudes towards BIM training and education amongst those that have not received either, respondents were asked whether they would consider requesting training or education from their employer or if they source their own outside of work. In this subset, there was a clear preference amongst the respondents that they would rather request training/education from their employer than self-source (73.9%). This was supported by the following qualitative data obtained from within this sub-set of respondents:

If BIM is essential for my job role I would expect my employer to provide training, just like I need a mobile phone or a laptop (Respondent 17)

Investment in training, needs to come from the top and currently isn't (Respondent 31).

These respondents were asked to rate the instruments that were their preferences for BIM training. Responses were collected using a 5-point Likert scale with the following options being available: (1) Definitely would not attend; (2) Would only attend if it was compulsory (3) Unlikely/Indifferent attendance (4) Likely to attend, and (5) Definitely would attend. The mean results from this are provided below in Figure 6 which indicates again, a trend that company provided instruments are more likely to be attended by respondents who have not yet received any BIM training.

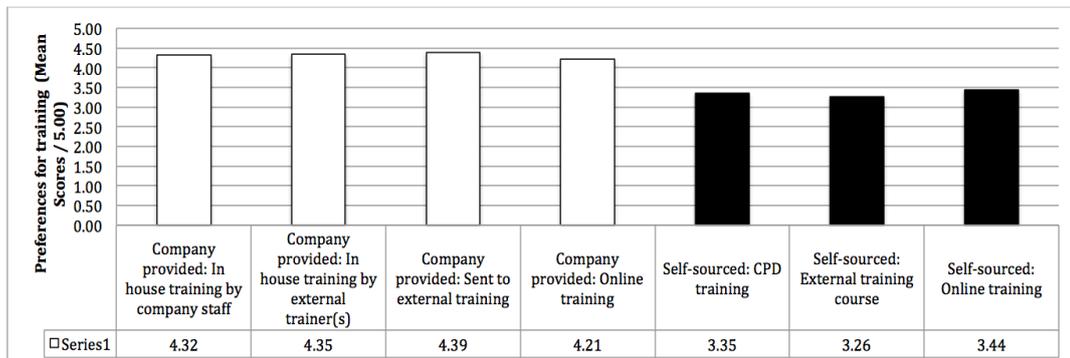


Figure 6: Preferences toward BIM training instruments (Sub-set 2)

**DISCUSSION**

Adequate and appropriate training and education in relation to BIM has been identified as one of the major recent challenges to the AEC profession (Azhar, 2011; Becerik-Gerber and Kensek, 2009) which is considered to require considerable investment (Eadie et al., 2013; Gledson, 2016). The aim of this research was to create a snapshot of the status, scale and suitability of such BIM training and education prior to the Government mandated Level 2 BIM deadline. In this regard, results identify that research participants largely believe the responses of their own employer organisations to have been lacking in terms of supply of relevant ‘internal’ BIM training and education material. In addition, respondents have identified a variability in quality of such material across both internal and external channels.

Whilst the Government mandate (HM Government, 2011) acted as a mechanism to incentivize BIM innovation adoption among the construction market, true lessons that

could be learned from initial BIM adopter projects and translated into successful training and education programmes have not always been made widely available or readily disseminated (either to maintain a competitive advantage, or in cases of failure to protect from any damage to company PR). A maturing market should now follow the Level 2 deadline, and organizations who have spent the 5 years since the 2011 Construction Strategy observing and learning may now be better placed to emerge with more developed education and training solutions (Eadie et al., in particular noted the potential for HEI providers in this area). Later adopters of BIM (the ‘second movers’) who have not developed any in-house education or training may well benefit from now engaging with such external providers. However, whether these organizations do see fit to capitalize on such opportunities and make efforts to formalize knowledge capture and knowledge management processes around BIM training and education remains to be seen.

## CONCLUSION

This study found a relationship between recipients of BIM training and education and levels of BIM understanding, awareness and use. Those who have had BIM training or education are positive about BIM, but also believe that the quantity of education and training that they have personally received is not adequate, and that across the industry there has been low levels of training and education. Despite the fact that companies should be taking a pro-active approach to training and educating their staff to equip them with the skills necessary for successful exploitation of BIM implementation, the data reveal that in this sample, the majority of BIM training and education has been self-sourced by pro-active individuals rather than organisations. In contrast, individuals who have had no education or training about BIM fully expect their employers to provide this. For much of this study aspects of education and training have effectively been grouped together, but the analysis of the results from the sample surveyed highlight that education about BIM appears to be more prevalent than the practical hands-on BIM training required by construction management practitioners.

There are however, several limitations in undertaking such survey research, particularly employing such sampling methods. Data collected via survey can be lacking both in detail and depth. The method only allows one opportunity to collect data and as such does not afford for probing or prompting of respondents to dig deeper in order to collect additional data (Bryman, 2015). However, the nature of the research instrument used means that survey research can be replicated, and in this instance where the measures used are stable, this means that this work is repeatable. Because of the immediacy of the government BIM Mandate; and its impact upon the demand for training and education needs, it is difficult to predict if the same responses would be received and should such an opportunity for research ever be undertaken again in future, at suitable time intervals following the 2016 deadline it would be interesting to compare and contrast the two sets of results, although it is important to note that in terms of external validity, because of the combined purposive/snowball sampling technique used, the results cannot be considered generalizable.

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# PROFESSIONAL PRACTICE AND CONSTRUCTION UNDERGRADUATES EMPLOYABILITY SKILLS

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Employability skills are known to be valuable to undergraduates when entering the workplace and expected by employers, yet, in construction as in many disciplines, these skills often are not well developed. However, construction professionals frequently work in complex dynamic environments and employability skills may enhance undergraduates' practitioner effectiveness. Therefore it is important tutors exploit opportunities to help undergraduates develop their employability skills. This paper examines the extent to which built environment undergraduates in a post-1992 university have opportunity to develop their employability skills through assessment. Data was gathered from students' evaluation of their development of employability skills and from written assessment feedback provided by tutors to students. Thematic analysis of the data was undertaken. Findings suggest students have limited understanding of employability skills and tutors give limited attention to their development. The examination of written feedback supported this latter point - tutors' major concerns were to develop students' subject knowledge and academic skills. It seems, then, promoting development of built environment students' employability skills may be an underused aspect of undergraduate learning provision. This suggests enhancing the student - tutor assessment dialogue offers the opportunity to better prepare students for industry and their professional practice.

Keywords: education, professionalism, undergraduates.

## INTRODUCTION

The Confederation of British Industry (CBI 2012) identify the need to enhance undergraduates employability skills, which they define as a positive attitude, self-management, team-working, business and customer awareness, problem solving, communication and literacy, application of numeracy and application of information technology. It is recognised higher education contributes to a healthy economy (Leitch 2006; Smith *et al.*, 2010) and further developing graduates employability skills has potential to enhance this contribution. Therefore it is important tutors exploit opportunities to help undergraduates develop their employability skills in readiness for the workplace. The function of higher education for society and contribution to knowledge and innovation could be debated. However, undergraduates are concerned with value for money and their subsequent employment opportunities (Kandiko and Mawer 2013).

It is the student as consumer that tends to define satisfaction rather than the value of education per se (Jones-Devitt and Samiei 2011). In the current market-driven higher

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education landscape, ignoring undergraduates' concerns potentially could be disadvantageous for an institution. Construction Management undergraduates study on professionally accredited courses, and as such there may be an assumption that they develop both subject specific knowledge and appropriate professional employability skills. To evaluate development of undergraduates' skills within this context, a doctoral study focusing on development of undergraduates' employability skills is being undertaken. In particular, the research explores how such skills may be developed through enhanced constructive alignment of teaching, learning, assessment and feedback with employability skills.

Integrating employability within the curriculum, rather than a piecemeal approach is valuable to aid learning (Knight and Yorke 2003). In some undergraduate disciplines, for example nursing, development of undergraduates' professional skills and competencies are often embedded within course delivery to students learning advantage (Bland and Ousey 2012; Wu, Heng and Wang 2015). In construction management courses this inclusion remains more opaque. The Chartered Institute of Building (CIOB) helps shape curriculum in courses it accredits (CIOB 2014) and also monitors courses through the assessment and accreditation processes. However, unlike for example professionally recognised nursing courses where undergraduates frequently are assessed through real-world situations, construction management undergraduates are not infrequently assessed through paper-based written scenarios. For construction management students, providing authentic assessment and constructively aligning assessment feedback with professional practice may help strengthen links between academic learning, professional practice and employability skills, thus supporting the development of undergraduates as effective construction industry practitioners.

The study initially sought to understand why students, in particular built environment students, evaluate assessment feedback as the weakest part of their learning experience (Lamond, Proverbs and Wood 2013). However, it emerged that assessment feedback gives little regard to developing employability skills in students, tending instead to focus on academic protocols and knowledge. Therefore focus has now shifted to explore the relationship between undergraduates' formal academic learning and professional practice competencies, and how these contribute to students' development as effective industry practitioners.

The term 'constructive alignment' (Biggs 1996) is concerned with the alignment of teaching, learning activities and assessment with Learning Outcomes in order to promote effective learning (Walton 2011). It is proposed here that professional practice should also be considered integral to constructive alignment, integral to the learning experience and which therefore includes assessment feedback. This offers the opportunity to enhance students' development as effective practitioners. It is this constructive alignment that is now the focus of this research.

Constructively aligning feedback with teaching, learning, assessment and employability skills would represent an important opportunity to enhance students' development as effective practitioners, providing direction and guidance. Constructive alignment of these has potential to enhance learning, closing the loop of assessment, student performance and professional practice. At this time of national economic stringency and debate surrounding the cost and funding of higher education (Tatlow and Conlon 2013), efficiently providing a high quality teaching and learning environment that supports students' academic and professional development is more

important than ever; enhancing development of employability skills has potential to add value to development of students' professional practice skills. In turn these would benefit students and employers. This paper presents early doctoral research, a 'work in progress'.

Assessment in undergraduate courses in the UK is designed around Learning Outcomes, which map knowledge and skills that it is intended students develop. Teaching and assessment are designed around these Learning Outcomes. At the course level, it is intended these Learning Outcomes are integrated; that they will develop in students an appropriate range of knowledge and skills with assessment being diverse across the course as a whole. This would mean that students are assessed in a range of ways that would develop and test a diversity of skills, and which may include, for example, examinations, report writing, group work and presentations. In addition, many institutions offer undergraduates curriculum enriching learning opportunities, such as site visits, field work and talks by visiting practitioners.

## **THEORETICAL PERSPECTIVES**

### **The nature and value of employability skills**

The CBI (2012) define employability skills as positive attitude, self-management, team-working, business and customer awareness, problem solving, communication and literacy, application of numeracy and application of information technology. The Higher Education Funding Council for England (2015) define transferable skills as "the transferable core skills that represent functional and enabling knowledge, skills, and attitudes required in today's workplace. They are necessary for career success at all levels of employment and for all levels of education". Although these are not the same as employability skills, this does illustrate the value placed by employers on 'soft skills'. There is then no single widely accepted definition that incorporates employability and transferable skills explicitly, but they may be considered as those skills beside technical knowledge of a subject that allow the individual to function effectively as a professional practitioner in the workplace for the benefit of employers, firms and the individual.

However, professional bodies such as the Chartered Institute of Building (CIOB) expect accredited undergraduate courses will contain a significant quantity of Mode 1 knowledge as central to the learning experience. Gibbons, Limoges and Nowotny (1994) propose two different modes of knowledge - Mode 1 "traditional knowledge ... generated within a disciplinary, primarily cognitive, context" (p.1) and Mode 2 knowledge, which is "created in broader, transdisciplinary social and economic contexts" (p.1). Mode 2 knowledge is applied, does not necessarily follow discipline boundaries and is concerned with professional practice, which is the focus of this research. The importance of creating new knowledge and encouraging links between industry and academia was recognised in the 1993 White Paper, "Realising Our Potential". It is these links that are important in helping undergraduates develop their professional employability skills, and that are important in providing employers with graduates who are able to make an effective contribution to the organisation.

Schoonmaker and Carayannis (2013) develop the definition of knowledge further and propose Mode 3 knowledge. They argue for the inclusion of civil society as well as academia, government and industry in the creation of knowledge. Together, these three modes suggest that it is difficult to define knowledge and that, potentially, knowledge has practical application, particularly when professional practice is

involved. However, as Sousa (2011) acknowledges there sometimes exists in higher education a tension between types of knowledge and their respective values.

There may, then, be a tension between academia and requirements of industry. Employers may use graduation as a means of determining the extent of Mode 1 knowledge an individual possesses and subsequently concern is around the extent to which students are able to use their knowledge in the real world. Boden and Nedeva (2009) argue that the expansion of higher education has political consequences and universities reproduce hegemonic class structure in their creation of passive employees. Certainly this is a compelling argument, but does not change the day-to-day necessities of universities and their production of graduates for industry, nor of the undergraduates who follow such courses with intention of pursuing a career in particular industries.

### **The nature and value of assessment and feedback**

In a construction management discipline, assessment, "a form of testing or evaluation" (Sambell, McDowell and Montgomery 2013: 3), is frequently designed around professional practice, and may be regarded as an important part of the context the tutor creates. Feedback is part of that context, and should promote learning (Hernández 2012). As Prosser and Trigwell (1999) recognise, context is important for learning, and it remains the responsibility of the tutor to create a suitable learning environment. Black and William (1998) found a positive impact of effective assessment, designed to facilitate learning. In recent years, definitions of employability have shifted with increased emphasis on soft skills such as communication and customer awareness as well as subject specific skills and competencies (Higher Education Academy 2015).

Student learning may be enhanced by assessment feedback as part of a two-way dialogue between tutors and students to enhance student learning (Evans 2013). Feedback is effective if it is timely, relevant meaningful and that the student can understand (Entwistle 2009) and is of an optimal volume. Positive feedback is that which helps learning (Askew and Lodge, 2000). Effective feedback should be acted upon by students' and help improve their learning experience (Shute, 2008; Higher Education Academy, 2013). It is to be noted then that a key function of feedback is to promote student learning. This research is concerned with how this feedback may be better integrated - aligned - with teaching and assessment to help develop undergraduates' employability skills.

### **Overview**

Examination of literature has thus far revealed that to develop students as effective practitioners in higher education institutions comprises a blend of transferring technical, mode 1 knowledge, and developing students effective transferable and employability skills, mode 2 knowledge. These may be delivered more effectively through the tutor being assessment literate and constructing effective assessment which tests this blend of knowledge and skills. Additionally, the tutor should be constructively aligning academic and professional knowledge and competencies through their teaching, assessment and feedback strategies may promote development of employability skills.

This paper proposes that if any of these elements are missing or weak, it is likely that students may not be able to gain the maximum benefit from the experience to enhance their professional and academic development.

## **METHOD**

The aim of the work in progress presented here was to make a limited initial exploration of students understanding of employability and transferable skills, and tutors development of these through assessment and assessment feedback.

The data gathering had two strands, one exploring students' perspective and one exploring tutors written feedback comments. First, to ask a sample of  $n = 46$  students what they understood the professional practice, employability and transferable skills to be that they each were developing on their course. The students were asked to write on a blank piece of card what professional practice, transferable or employability skills they felt developed through their course. Names or course details were not recorded although students were invited to note on the card whether they were full-time or part-time. These cards were then gathered in for thematic analysis. Cards the students produced were read, re-read multiples times and coded according to themes that emerged during this process (Pettigrew, Archer and Harrigan 2016). This was an iterative process (Guest, MacQueen and Namey 2012). Some cards contained more than one theme and these were identified and each included separately.

The second strand of data gathering was to examine written assessment feedback provided to undergraduate students on mark-bearing assessed coursework in a construction discipline. It was felt that "unobtrusive measures" (Gray 2014: 498) were valuable here as it was important to maintain discretion and anonymity whenever possible. The sample used was one of convenience, comprising  $n = 71$  items of assessed coursework that had been submitted, marked and contained written feedback on the front cover. Coursework items ranged across all undergraduate levels of study, that is, undergraduate levels 4, 5 and 6. The work used had all been made available for external examiners to view during the assessment round, and this assured a level of 'quality' as examiners had previously described the feedback as 'good'. It is worth noting that this was not a random sample, although there is nothing to suggest that the feedback comments would be different from any other work. However, it is recognised that generalizability from such a small sample is not possible. To examine the feedback, thematic analysis was again used. The themes were then examined for reference to professional skills in whatever way this might be articulated, whether semantic or latent (Braun and Clarke 2006).

Assessment should be designed around the intended learning with mark schemes designed accordingly to develop appropriate skills or knowledge in students. It was expected that as the courses are professionally recognised, so the assessment would relate to professional practice, with feedback utilized to integrate these - in short, to constructively align. It was accepted that reference to any of the areas may have been oblique, and so judgement would have to be used. There would have to be clear reference to professional practice or specific skills. It was felt that if the researcher could not recognise these then nor would students.

### **Limitations of this study**

First, thematic analysis could be considered limited in its approach. Second, the sample has two considerations, the sample size was small and also was not a random sample. Each of these may have limited the study. However, it is argued that this is suitable for this first part of the research as it identifies key issues worthy of further investigation.

## FINDINGS AND DISCUSSION

### Students' perspectives

Table 1 shows frequency of relevant common themes with examples to provide an overview of the data landscape (Guest, MacQueen and Namey 2012).

*Table 1: Themes from students' perspectives*

Mode of study	No. of students	No. identifying communication or literacy	No. identifying other skill	No. with none identified	Example
Full-time	19	1	3	15	Independent research
Part-time	22	7	2	13	Report writing
Not stated	5	0	0	5	None
Total	46	8	5	33	

Of immediate note was the limited understanding students had of professional practice and employability skills. N = 33 students were unfamiliar or unaware of what such skills comprised. They frequently wrote about development of academic knowledge within particular modules, but not skills development.

It was notable too that part-time students had greater awareness of employability skills than did the full-time students. Potentially this may be because of their greater understanding of the workplace, although this would benefit from further investigation.

Most frequently students wrote about professional writing, as this had been stressed in their subject lectures to help them understand the value of the subjects they study. Only n = 1 identified communication specifically as a skill. The students made no links between curriculum assessment and professional practice.

### Tutors feedback: Employability skills

Tutors did not make explicit reference to employability skills but tended to identify areas of note for students without identifying them as employability or transferable skills.

A total of n = 27 items, 38% of the total, made indirect reference to employability skills. The skill most commonly cited was communication, although this tended to be oblique, for example 'well presented' being a typical comment. Reference was also made to professional practice but these comments were description or analysis of what practitioners do rather than an evaluation of students efforts in such a professional capacity.

Rawlins and Marasini (2011) identify the paucity of employability skills and work experience of undergraduates as problematic. It seems from this research that employability skills tend to be delivered in a rather piecemeal way and lack focus as tutors consider the academic content of their teaching and assessing, which indeed is important. The research will consider the potential for undergraduates' employability skills to be developed through enhancing assessment and assessment feedback. It seems thus far that the nature of assessment may influence undergraduates' development of these skills, that enhancing their development through integrating assessment feedback with employability skill development is a missed opportunity.

Developing students as professional practitioners and preparing them for employment can be considered central to construction undergraduate courses. Constructive

alignment (Biggs 1996) of teaching, learning and assessment is necessary for the enhancement of the student learning experience. However, for professionally accredited courses, such as construction, which seek to develop students as effective industry practitioners, this paper proposes it is important additionally to align also with professional practice competencies to develop students' employability skills. This has potential to enhance qualitative delivery of curriculum to help develop students' knowledge and professional skills rather than focusing only on knowledge transfer (Trigwell and Prosser 2014).

It was surprising to find that neither students nor tutors are as overtly engaged with development of employability skills as might have been supposed, given the vocational nature of the courses and their industry-accredited status. Construction management, and indeed many built environment undergraduate courses, are designed around professional practice, developing skills and knowledge that industry requires.

It is interesting to see that assessment may frequently appear to be closely aligned to professional practice, but in reality may sometimes lack authenticity. This may be a consequence of courses that are classroom based and also potentially where there is concern to meet academic standards. "Authentic learning environments" ... are important in developing effective practitioner skills in nurses (Weeks *et al.*, 2013: 53), and this may therefore also be highly relevant to other disciplines.

It is also interesting to note that communication is the skill which emerges most frequently in tutors' written feedback. However, overall it seems that employability skills tend to be developed in a rather piecemeal way rather than the result of a structured strategy.

## **CONCLUSIONS**

The sample size is small and analysis limited, which therefore means these findings must be treated with caution. However they suggest the need for further research to explore this issue in depth. The research intends next to explore the nature of assessment briefs provided to undergraduates as well as examine more closely the constructive alignment of teaching, learning and assessment with professional practice employability and transferable skills.

A key function of higher education is to provide industry with graduates who are effectively prepared for professional practice. Effective practitioners should be able to make a positive contribution to the organisation as well as their own self-development. Such graduates would enhance the work of organisations for the benefit of clients as well as contributing to an efficient economy and economic growth.

Employability skills tend to be delivered in a piecemeal way, rather than embedded within the curriculum and developed unambiguously. Students are taught a range of knowledge and skills, but linking these and professional practice remains opaque. For full-time students in particular with little or no experience of professional practice this represents a missed opportunity to develop their appreciation of the industry they are to enter and skills employers expect.

This study suggests there may be opportunity to enhance the construction undergraduate learning experience in a low-cost effective way to help develop students as effective practitioners. Although courses are professionally recognised and Learning Outcomes map the knowledge that students are expected to acquire throughout the lifetime of their studies, it seems there is scope to enhance their learning further through re-evaluation of assessment and feedback. Feedback could be

enhanced to integrate student learning with skill development. Tutors, primarily concerned with technical issues, may need to consider how best this could be achieved. Possibly training or other support for tutors is appropriate here.

To be more effective in developing undergraduates' employability skills and professional practice competencies assessment should be based on:

- Constructive alignment between teaching, learning, assessment and professional practice; and
- Reference to professional practice and employability skills in feedback narrative using appropriate language that students understand.

These findings structure the next phase of this research which will examine in more detail the qualitative dimension of assessment and feedback, tutors perspectives and interpretations of professional practice competencies held by students on professionally recognised built environment courses.

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# CONSTRUCTION MANAGEMENT AND QUANTITY SURVEYING STUDENTS' PERCEPTIONS TOWARDS PRODUCTION ANALYSIS AND MEASURING QUANTITIES FOR CONSTRUCTION PURPOSES

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Students' pre-course perceptions of a module provide insight relative to their understanding and appreciation of a module and challenges that the lecturer may encounter. Furthermore, post-course perceptions can be compared with pre-course perceptions to determine the impact of the presentation of the module, if any. The purpose of the study reported on is to determine the pre- and post-course Production Analysis / Quantities perceptions of construction management and quantity surveying students, and the impact of the completion of the module, based upon a self-administered questionnaire survey conducted in a South African university. The students were surveyed at the inception and the completion of the presentation of the module at first year level. The results show that both construction management and quantity surveying students regard the quantities competencies (knowledge and skills) highly important for Quantity Surveyors and Construction Managers. The results further reveal that the Production Analysis / Quantities module will assist students in other modules such as Quantity Surveying, Site Surveying, Construction Management, and Project Management. Students are also of the opinion that the Production Analysis / Quantities module will assist them further in measuring, material management, estimating, and cost control activities. Based upon the findings it can be concluded that students have a degree of understanding and appreciation of the module Production Analysis / Quantities prior to exposure thereto, the presentation of the module had an impact on their perceptions, and they understand and appreciate the importance and role of the modules to their programmes and disciplines. It is recommended that such research be conducted on an annual basis, and a preparatory lecture 'The role and importance of Production Analysis / Quantities' should be evolved for first time Production Analysis / Quantities students.

Keywords: perceptions, production analysis, quantities, students

## INTRODUCTION

The Production Analysis 1 and Quantities 1 year module is one of the core modules of the undergraduate Construction Management (CM) and Construction Economics (QS) qualifications offered respectively at the Nelson Mandela Metropolitan University. The module is lectured to a combined group of CM and QS first year students by a quantity surveying lecturer with extensive experience in the quantity surveying profession and in teaching and learning at tertiary level. The curriculum design for

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the module is structured in order to meet the requirements of the relevant accreditation bodies of the construction management and quantity surveying students.

As the module is presented to two different built environment disciplines, there is a 'need for innovative education approaches that facilitate cross-disciplinary thinking' according to Warburton (2003), and as highlighted in both disciplines' professional registration councils' accreditation reports, the research provided an opportunity to better understand the perceived perceptions of each student group at the commencement of the academic year measured against the perceived perceptions at the end of the academic year.

Furthermore, tertiary built environment qualifications are tailored to produce diplomats and graduates that are deemed suitable by employers and the built environment in general. However, the education of students has continued to challenge both academia and the industry.

## **REVIEW OF THE LITERATURE**

### **Production analysis and measuring quantities for construction purposes**

The measurement of building elements is a key part of quantity surveying and construction management studies. The training and knowledge of the quantity surveyor and construction manager have enabled the role of the respective professions to evolve over time into new areas, and the services provided by the modern quantity surveyor and construction manager now cover all aspects of procurement, contractual, and project cost management (Lee, Trench and Willis, 2005). Competitive tendering is one of the basic principles of most classes of business. For the purposes of tendering, bills of quantities are prepared and each competing contractor is provided with the bills of quantities, all pricing the same information. Most other procurement routes, such as design and build, and management contracting in its various forms, also involve quantification of the work in some form or other, and therefore the measurement process continues to be of importance.

Computerised and other alternative measurement systems have become more and more widely used. Different systems of measurement, setting out the rules for measuring building work are used.

Students are assumed to have knowledge of elementary building construction and simple mensuration before proceeding with the measurement of a building or structure. A contractor may well produce quantities for an estimate where only the main items for the work would have been measured. This is done for internal use and any errors are for the contractor's account. It is therefore essential for the contractor to understand how the bills of quantities are prepared in order to measure and price contract variations on the project (Lee, Trench and Willis, 2005).

The main outcome of the Production and Analysis, and the Quantities module is to enable Construction Management and Quantity Surveying students to 'take-off' quantities from building drawings in order to compile bills of quantities. Students should consider the following functions of bills of quantities as mentioned by Seeley and Winfield (1995):

- Enables all contractors tendering for a contract to price on exactly the same information;
- Provides a satisfactory basis for the valuation of variations and adjustments to the final account;

- Provides a useful basis for the valuation of monthly payment certificates throughout the contract;
- Provides a full description and quantity of each element, and could form a checklist for the contractor in ordering materials and assessing requirements in terms of labour and programming the works, and
- It can also assist in the preparation of cost analysis for use in cost planning of future projects.
- Kelly, Morledge and Wilkinson (2002) state the importance of understanding the difference between estimating and cost control, and define them as follows:
  - Estimating – “The provision of an informed opinion at a particular time of what the final cost of the project is likely to be”, and
  - Cost control – “The management of the consequences of the design and construction processes so as to achieve value for money and ensure that the final cost does not exceed the budget.”

Cost control in the construction industry is a term that is used to cover a whole spectrum of activities from inception through to the final completion of the final account for the project (Ashworth and Hogg, 2007). Furthermore, Jaggar *et al.*, (2002) refer to design cost management where the building is designed as per the model to be constructed at a specific cost, and the management ensuring that the functions of planning control and feedback are successfully brought about in terms of design, cost, time, and quality. Quantities forms a key aspect in all these various activities in which case the Production Analysis and Quantities module put a lot of emphasis on.

This research examines the association between students’ pre-course and post-course attitudes and perception towards the course content. Piaget (1950) are of the opinion that individuals construct new knowledge through processes of accommodation and assimilation from their experiences, thereby incorporating new experiences into an already existing framework without changing the framework. Litzinger *et al.*, (2011) state that it is essential to prepare students to meet the professional challenges after graduation. This can be achieved by helping them build knowledge and skills that they can readily adapt to address the unusual, complex problems that they will encounter. Litzinger *et al.*, (2011) further state that knowledge should be structured around key concepts and principles to facilitate students’ abilities to access and transfer knowledge to new and novel situations.

Teachers and curriculum developers have long recognised the value of analysing the subject matter to be learned by developing learning outcomes or objectives such as well-known Bloom’s taxonomy. Over the past few decades, the emphasis in education has been on methods of teaching and learning and assessment. According to Harden (2002), attention has moved from an emphasis on the education process to a consideration of the product and the expected learning outcome of the students’ studies. Baartman *et al.*, (2007) indicate that learning is significantly influenced by the nature of the assessment as students tend to focus their learning on what they know / think will be assessed. Baartman *et al.*, (2007) further add that two aspects seem to be common in most definitions of competence. Firstly, competence defined in terms of the integration or performance of specific combinations of knowledge, skills and attitudes that will provide evidence of the required capability. Secondly, it is defined in terms of requirements linked to a specific profession or situation.

According to the South African Qualifications Act (SAQA) (2000), competence in an outcomes based education system is too narrow, because not enough emphasis is placed on the understanding or the moral issues surrounding the action. Fraser *et al.*, (2005) are of the opinion that the traditional approach has been developed to become a 'new' more holistic or integrated approach that involves assessing a combination of attributes (knowledge, capabilities, skills and attitudes) and the performance tasks at an appropriate level or standard. According to Crafford and Smallwood (2007), the five most important competencies required by quantity surveyors as ranked by clients are cost control, estimating, measurement, plan reading, and economics of construction. Educators need to be aware of what skills and knowledge their protégés have acquired and employers should be able to identify the knowledge and skills they seek (Minister of Education, 2005).

Smallwood and Emuze (2012) mention that the practice of construction management is the ability to manage the business of construction and execute projects, using the functions of management work in the form of planning, organising, leading, controlling, and coordinating. These functions entail forecasting, programming, and scheduling competencies, the ability to delegate and develop relationships, communication and decision making abilities, and performance evaluation competencies. Smallwood and Emuze (2012) further state that the top construction management skills required, pertain to oral and written communication, planning and scheduling, estimating, project administration and management, and decision making abilities in terms of alternatives, cost / benefit ratio, return on investment, and net present value.

### **Teaching and learning Production Analysis and Quantities**

The teaching methodology of the year-module Production Analysis and Quantities 1 has undergone some transformation and re-configuration over the past few years in order to make the course material and presentation more comprehensible. In the first year, students learn how to 'take-off' quantities from drawings of a simple single storey building for the purpose of preparing Bills of Quantities for a construction project. The students are also introduced to the process followed after the production of the Bills of Quantities for tendering purposes.

The module focuses primarily on the measuring of certain building elements such as site works, foundations, superstructure brickwork, ground floor construction, and external and internal finishes. The importance of exact quantities are accentuated and the effect thereof on a construction project. The module content is delivered in a traditional manner during formal lecture periods by a lecturer. Students are also required to attend practical sessions, which are administered by final year student assistants.

Springer and Borthwick (2004) point out that provoking a developmental shift from *knowing* to *thinking* would produce a long-standing need for learning. This would help students create learning experiences to develop higher-order thinking skills while generating interest in major and non-major modules. Added to this, the Production Analysis / Quantities module is focused towards concepts that are mostly resonant with the quantity surveying discipline, which could be challenging for the construction management students. It is thus important that the teaching and learning method should be meaningful and motivational to both groups of students.

## RESEARCH

### Research method

In order to explore first year students' perceptions, a quantitative research methodology was used for the purpose of this study. The sample population consisted of a total of ninety five (95) students, comprising of forty-two (42) CM, and fifty three (53) QS students registered for the module. A pre-course survey was conducted at the beginning of the first semester to determine their perceptions with respect to production analysis and measuring quantities for construction purposes. The self-administered questionnaire consisted of thirty, five-point Likert scale questions. The survey was repeated at the end of the second semester using the identical questionnaire, to obtain the post-course perceptions of both groups of students.

Eighty six (86) students responded to the pre-course survey which represents a response rate of 91% of which 45% were CM and 55% were QS students. During the post-course survey, seventy-three (73) students responded representing a response rate of 77% of which 42% were CM and 58% were QS students.

### Research findings

Table 1 indicates the importance of Production Analysis and Quantities competencies (knowledge and skills) relative to Construction Managers and Quantity Surveyors in terms of mean scores (MSs) between 1.00 and 5.00, based upon percentage responses to a five point scale of 1 (low) to 5 (high). It is evident that both CM and QS students indicated during the pre-course and post-course surveys, that the knowledge and skills competencies are of high importance for both the disciplines. Both student groups also identified that the knowledge and skills competencies are between more than important to highly important / highly important (MSs  $> 4.20 \leq 5.00$ ) for both the disciplines.

Table 1: The importance of Production Analysis and Quantities competencies

Disciplines	Pre				Post			
	CM		QS		CM		QS	
	MS	Rank	MS	Rank	MS	Rank	MS	Rank
Quantity Surveyors	4.74	1	4.85	1	4.74	1	4.88	1
Construction Managers	4.59	2	4.43	2	4.58	3	4.29	2

Table 2 indicates the perceived extent Production Analysis will assist CM students in terms of understanding and performance relative to other modules in the programme in terms of MSs between 1.00 and 5.00, based upon percentage responses to a five point scale of 1 (minor) to 5 (major). The results show that the Construction Management module was ranked first followed by Site Surveying during the pre-course survey. However, during the post-course survey, Building Economics was ranked first, followed by Construction Management. Given that the MSs  $> 3.40 \leq 4.20$  with the exception of Building Economics (post MS  $> 4.20$ ), the extent of the assistance can be deemed to be between moderate to a near major extent / near major extent. Respondents further indicated during pre- and post- course surveys that Production Analysis assists understanding and performance relative to half (50%) of the other modules between a moderate to near major extent / near major extent (MSs  $> 3.40 \leq 4.20$ ). During both pre- and post-course surveys, Environment and Services achieved MSs  $> 2.60 \leq 3.40$  – between a near minor to moderate extent / moderate extents. Furthermore, it is notable that during the pre-course survey Property

Economics was ranked last, while during the post-course survey, it was ranked third. Finally, the post-survey MS was lower than the pre-survey MS for 6 / 8 (75%) activities, and higher in the case of 2 / 8 (25%) – notably Building Economics, and Property Economics.

Table 2: Extent Production Analysis will assist in understanding and performance relative to various other modules

Module	Pre		Post	
	MS	Rank	MS	Rank
Construction Management	4.36	1	3.87	2
Site Surveying	4.03	2	2.39	8
Materials and Methods	3.92	3	2.90	5
Structures	3.72	4	2.58	6
Project Management	3.67	5	3.39	4
Building Economics	3.54	6	4.26	1
Environment and Services	3.26	7	2.55	7
Property Economics	3.23	8	3.55	3

Table 3 indicates the perceived extent Quantities will assist QS students in terms of understanding and performance relative to other modules in the programme in terms of MSs between 1.00 and 5.00, based upon percentage responses to a five point scale of 1 (minor) to 5 (major). Quantity Surveying was ranked first during both the pre-course and post course surveys with MSs  $> 4.20 \leq 5.00$  (near major to major / major extent). It is notable that less than half (38%) of the modules' MSs are  $> 3.40 \leq 4.20$  (moderate to near major / near major extent) during pre-course, as opposed to 50% during post course. The MS for the module Information Technology was  $> 1.80 \leq 2.60$  (minor to near minor / near minor extent) during both pre-course and post course surveys. Furthermore, the post-survey MS was lower than the pre-survey MS for 4 / 8 (50%) activities.

Table 3: Extent Quantities will assist in understanding and performance relative to various other modules

Module	Pre		Post	
	MS	Rank	MS	Rank
Quantity Surveying	4.83	1	4.74	1
Site Surveying	4.15	2	3.52	5
Materials and Methods	3.87	3	3.67	3
Building Economics	3.66	4	4.05	2
Property Economics	3.36	5	3.67	3
Research	3.32	5	2.83	7
Environment and Services	3.17	7	3.33	6
Information Technology	2.13	8	2.40	8

Table 4 indicates the perceived extent Production Analysis will assist CM students relative to construction management activities in terms of MSs between 1.00 and 5.00, based upon percentage responses to a five point scale of 1 (minor) to 5 (major). It is notable that during the pre- and post-course surveys, activities such as measuring quantities, cost control, estimating, preparing site layouts, and programming and scheduling were identified as the top four activities assisted by Production Analysis. It is notable that Production Analysis will assist relative to only 4 / 18 (22.2%) of the activities between a near major to major / major extent during the pre-course survey as

opposed to 3 / 18 (16.7%) during the post-course survey. Furthermore, the post-survey MS was lower than the pre-survey MS for 14 / 18 (77.8%) activities. It can be deduced that during the course of the academic year, students developed an understanding and appreciation of the importance of the Production Analysis module primarily relative to 'measuring quantities'. The activity 'resolving disputes' achieved the lowest MS and ranking during both surveys.

Table 4: Extent Production Analysis will assist relative to CM activities

Activity	Pre		Post	
	MS	Rank	MS	Rank
Cost control	4.46	1	4.26	3
Estimating	4.36	2	4.39	2
Measuring quantities	4.28	3	4.94	1
Preparing site layouts (Planning)	4.26	4	3.16	8
Productivity measurement	4.15	5	3.48	6
Material management	4.13	6	3.68	5
Quality management	4.03	7	2.65	15=
Programming and scheduling	3.85	8	3.87	4
Setting out buildings	3.77	9	2.68	13=
Resolving construction problems	3.72	10	2.68	13=
Labour management	3.64	11	3.45	7
Plant and equipment planning	3.51	12	3.03	9
Subcontractor management	3.46	13	2.77	11=
Outlining the scope of work	3.38	14	2.87	10
Health and safety management	3.15	15=	2.61	16=
Resolving design problems	3.15	15=	2.61	16=
Temporary works design	3.00	17	2.77	11=
Resolving disputes	2.49	18	2.55	18

Table 5 indicates the perceived extent Quantities will assist QS students relative to quantity surveying activities in terms of MSs between 1.00 and 5.00, based upon percentage responses to a five point scale of 1 (minor) to 5 (major).

Table 5: Extent Quantities will assist relative to QS activities

Activity	Pre		Post	
	MS	Rank	MS	Rank
Preparing Bills of Quantities	4.72	1	4.88	1=
Measuring	4.64	2	4.88	1=
Preparing final accounts	4.47	3	4.67	4
Estimating	4.36	4	4.83	3
Cost control	4.28	5	4.62	6
Preparing valuation payment certificates	3.85	6	4.64	5
Research in the built environment	3.74	7	2.93	18
Strategic planning of built environment projects	3.70	8	3.52	9
Property valuations	3.55	9	4.12	8
Resolving construction problems	3.52	10	3.05	16
Resolving design problems	3.43	11	3.14	14=
Feasibility studies	3.38	12	4.26	7
Maintenance management	3.34	13	3.31	11=
Risk management	3.28	14	3.31	11=
Value engineering / management	3.21	15	3.38	10
Tax assessment on built environment projects	3.13	16	3.14	14=
Resolving disputes	2.68	17	3.00	17
Procurement advice	2.51	18	3.29	13

Respondents indicated during the pre-course survey that the Quantities module will assist relative to 6 / 18 (33.3%) of the QS activities between a near minor to moderate / moderate extent (MSs  $> 2.60 \leq 3.40$ ), and between a near major to major / major extent (MSs  $> 4.20 \leq 5.00$ ) relative to only five (27.8%) activities. However, during the post-course survey students are of the opinion that 9 / 18 (50%) of the activities will be assisted between a near minor to moderate / moderate extent (MSs  $> 2.60 \leq 3.40$ ), and 7 / 18 (38.9%) activities between a near major to major / major extent (MSs  $> 4.20 \leq 5.00$ ). Furthermore, the post-survey MS was lower than the pre-survey MS

for only 5 / 18 (27.8%) activities. It is clear that the QS students realised the extent of the module's assistance relative to QS activities during the course of the academic year. It is further notable that 'Research in the built environment' is ranked last during the post-course survey.

## **DISCUSSION**

The respondents understand and appreciate the importance of knowledge of 'Production Analysis and Quantities competencies' to construction managers and quantity surveyors. The CM students understand and appreciate the extent to which the Production Analysis module will assist them in understanding and performance relative to other modules in their curriculum such as Construction Management, Building Economics and Property Economics. A similar outcome is experienced with QS students indicating that the Quantities module will assist them in understanding and performance relative to their Quantity Surveying, Building Economics and Property Economics modules. The respondents understand and appreciate the importance of knowledge of Production Analysis and Quantities in terms of their studies, in particular towards their major modules respectively. Furthermore, it is evident that both CM and QS students are of the opinion that their respective modules will assist them in measuring quantities, estimating and cost control relative to their working activities.

Relatively similar results were obtained in a survey conducted by Dent and Smallwood (2014) where CM and QS students' perceptions towards their Building Economics module at the Nelson Mandela Metropolitan University were surveyed. A survey conducted by Allen, Smallwood and Emuze (2013) relative to built environment students' perceptions of the Environment and Services (E&S) module at the Nelson Mandela Metropolitan University, also revealed similar results, which determined that students do understand and appreciate the importance of knowledge of E&S to their disciplines.

## **CONCLUSIONS AND RECOMMENDATIONS**

This study was initiated in order to determine the perceptions of CM and QS students regarding production analysis and measuring quantities for construction purposes. Effective teaching is fundamental to effective learning and improving outcomes for students. Descriptive standards could be explored to guide the outcomes for higher levels of competence.

It is evident that both the CM and QS students regard Production Analysis and Quantity Surveying competencies as important for both the Construction Manager and Quantity Surveyor during the pre- and post-course surveys.

CM students are of the opinion that the module Production Analysis will assist in understanding of their major module Construction Management, while the QS students indicated that the Quantities module will assist them in one of their major modules, namely Quantity Surveying. It is notable that both groups of students have indicated that the Site Surveying module will be affected during the pre-course survey, but less so during the post-course survey.

It is also notable that there is a substantial difference between the quantity surveying students' pre- and post-course survey perceptions in terms of the extent to which Quantities will assist in understanding and performance relative to various other modules.

Furthermore, quantity surveying students have realised the relevance of the module relative to the quantity surveying activities during the course of the academic year. Both CM and QS students are of the opinion that the Production Analysis and Quantities module assists in terms of measuring and preparing bills of quantities.

It is recommended that the CM and QS students should be informed during their first lecture regarding the importance of the Production Analysis and Quantities module, the impact thereof relative to their respective disciplines, and the effect thereof on other modules. Similar research should also be conducted for other modules relative to the CM and QS curricula. Furthermore, future research should be conducted to determine the perceptions of CM and QS graduates relative to the significance of the Production Analysis and Quantities modules in their workplace.

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# RETHINKING APPRENTICESHIP TRAINING FOR THE CONSTRUCTION INDUSTRY IN IRELAND

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The construction industry is of strategic importance to any economy, as it delivers the building and infrastructural needs of society; it is also a major provider of employment. The over-reliance on construction was a contributing factor to the collapse of the Irish economy and employment in construction fell to under 50% of its 2007 peak as a consequence. The decline devastated apprentice training with a reduction in excess of 90% of new registrations of construction apprentices at the lowest point. The implication of this to the industry is disquieting, given the crucial role apprenticeships play in the sector. The Irish model of apprentice training, exalted as a model of excellence when economic drivers were favourable, has been shown to be over-reliant upon employer stability and new apprentice registrations in order for it to flourish. In 2013, the Irish Government announced a review of apprenticeships, in order to address these issues. Though this review extolled the virtues of apprenticeships it failed to address the labour market issues associated with the industry. Now firmly in recovery, the industry faces a knowledge and skills deficit which has the potential to render it unable to respond to future growth. The need for change in the current apprenticeship training system is thus imperative. The paper critically analyses the Irish construction apprenticeship training system and provides a comparative analysis to international practices to identify a benchmark for a new Irish apprenticeship model for construction. The findings highlight the basis of a rethinking of Irish apprenticeship in order to futureproof training and protect against the cyclical fluctuations of the construction industry.

Keywords: apprenticeship, education, employment, Ireland, skills

## INTRODUCTION

### Overview

In the mid-2000s, the Irish economy had become increasingly over-reliant on construction. By 2007 the sector had completely exceeded a normal level of output and employment for an economy the size of Ireland's. This over-reliance on construction was unsustainable and contributed to the much documented, unprecedented collapse of the Irish economy in 2008 (Gerlach 2013; Central Statistics Office 2016a). Six years of contraction followed, with output reducing year on year before bottoming out in 2013 resulting in a severe contraction in construction employment (Central Statistics Office 2016b).

With the reduction in construction employment came a decline in apprentices, particularly in the construction trades (Department of Education and Skills 2013a).

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Although the significance is often overlooked, apprentices do not just provide cheap labour in the form of semi-skilled operatives (Zimmermann 2002). Instead, apprenticeships supply foundational education for those who will potentially evolve into construction managers over time (Mohrenweiser and Backes-Gellner 2010).

Though extensively analysed as a paradigm of learning, a detailed focus of apprenticeship under the stresses of an economic downturn remains undocumented. This paper sets the context of construction apprenticeship in Ireland. An overview of the current Irish construction industry, employment and apprenticeship is therefore provided. Finally, an analysis of Europe's most pervasive training model is presented followed by conclusions for the future of Ireland's apprenticeship. Ultimately, the analysis possibly raises as many questions as it answers, however its importance to the industry warrants careful consideration and debate in this regard.

### **Research Methodology**

As Biesta and Burbules (2004) point out, educational policymakers "want knowledge that can inform their actions and activities" and that they "seek knowledge that can support and guide their decision making".

The research presented is based on documentary analysis of available publications from key stakeholders including industry, government departments and education providers as well as national statistical data. The work forms part of an ongoing PhD thesis thus does not purport to be conclusive, but more so serves to provoke a deeper investigation to a crucial component of construction labour market analysis.

## **CONSTRUCTION INDUSTRY IN IRELAND**

### **Economic growth and construction employment**

The construction industry is vital for economic growth as it delivers the building and infrastructural needs of the rest of the economy and society. In Ireland, the importance of the construction industry to the national economy cannot be overstated, due in no small part to it being a major provider of employment and "a key generator of wealth" (Forfás 2013: v). Consequently, this symbiotic relationship between the macro economy and construction industry, proved detrimental to both in the context of the recent economic downturn.

Figure 1 details the reduction in construction output and the corresponding reduction in construction employment. A direct correlation between the two is clearly evident.

Despite the fact that economic cycles are expected, the severity of the shock was unprecedented and the industry was unprepared. In particular, the resultant reduction in new apprentices was unanticipated (Department of Education and Skills 2013a). This is conceivably attributable to the fact that the training model had been operating with overwhelming success since its inception (Steedman 2010) and further, that this was the first collapse of the Irish construction industry in living memory.

### **Trends in apprenticeship registrations**

A successful apprenticeship system relies upon a steady supply of new apprentices annually. Prior to recession, new registrations were constantly in excess of 8,000 individuals annually. At the time of impact of the recession, there was circa 30,000 apprentices across 26 trades in Ireland, grouped by industrial category: construction, electrical, engineering, motor and printing.

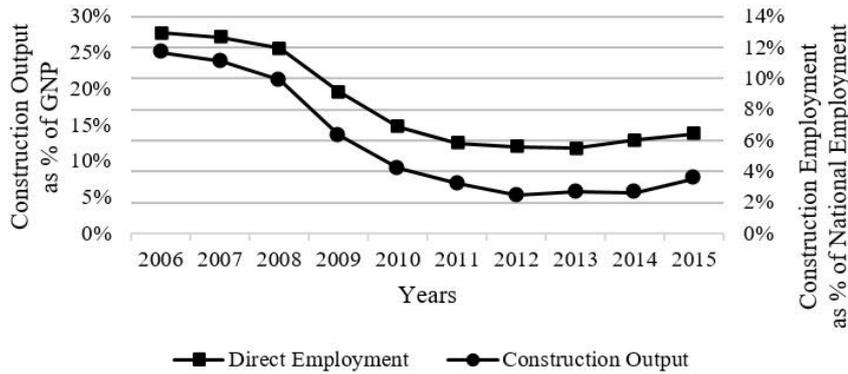


Figure 1: Change in construction employment in relation to construction output (Data: Dept. of Environment, Heritage and Local Government, Central Statistics Office)

Figure 2 shows the catastrophic effect to apprentice registrations. A decline of 82 % is seen at the lowest level (2010). When focusing solely on construction trades, the reduction is of the order of 93 % at its lowest (2012).

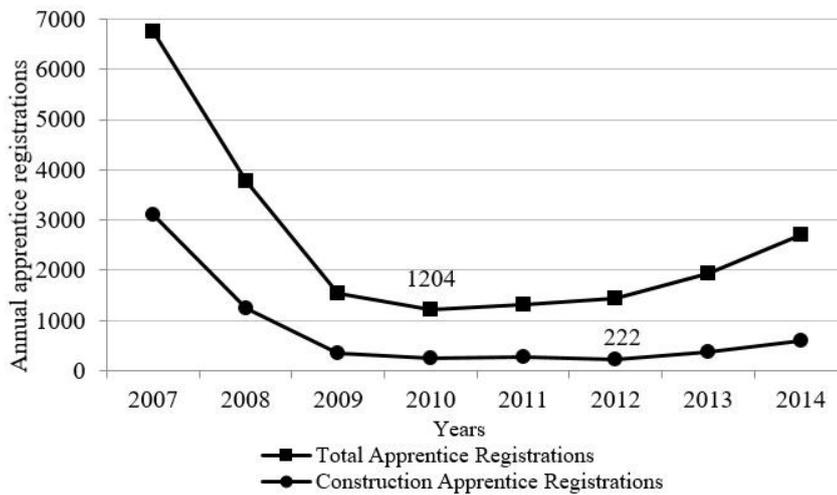


Figure 2: Change in annual registrations of new apprentices (Data: FÁS, SOLAS)

A further indicator of the severity of the collapse upon apprenticeships was the increase in the number of unemployed apprentices. The total number of unemployed apprentices increased to more than 20 times its level in only three years (Figure 3). So extreme was this change, that in 2010, there were more unemployed than employed apprentices in Ireland (SOLAS 2015a).

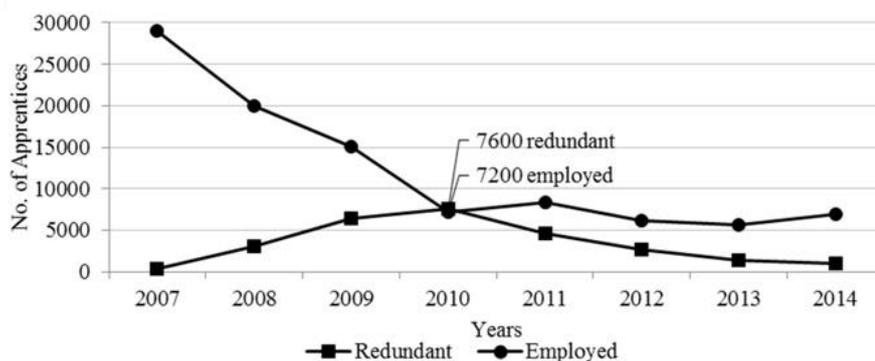


Figure 3: Change in the number of redundant apprentices (Data: FÁS, SOLAS)

Following arduous years of depression, the Irish construction industry is in a recovery phase with recording growth of 7.8% in Q4 2015 (Central Statistics Office 2016c). Recently there has been a modest increase in apprenticeship registrations (SOLAS 2015a). However, this increase is unlikely to meet medium term demand given the rate of economic growth. Now, more than ever, a lasting system of apprenticeship is required to ensure stability over the economic cycle.

## **APPRENTICESHIP IN CONTEXT**

### **Apprenticeship as a paradigm of learning**

There is no single authoritative definition for what constitutes ‘apprenticeship’. For the purposes of this research, the definition provided by the International Labour Organization is used, stating that:

apprenticeship means any system by which an employer undertakes...to employ a young person and to train him...for a trade for a period...in the course of which the apprentice is bound to work in the employer's service (Steedman 2012: 2).

It is this ideal, that an apprenticeship is a contract between an employer and employee, which is important. It raises the topical issue that “not all instances of training on a job are apprenticeships” (Richard 2012). Principally, an apprenticeship is experiential in nature, specifically, that the apprentice must learn in the workplace (Rauner *et al.*, 2012). This mode of learning implies a ‘duality’ of importance between college and workplace as learning environments, hence the term ‘dual based apprenticeship’ (Muhlemann, Wolter and Wuest 2009).

### **Apprenticeships in Ireland**

In Ireland, apprenticeships have always been ‘demand led’ meaning that the number of apprenticeships offered depends on employers offering places based on their own requirements (Steedman 2007: 5). Traditionally, apprentices trained under a ‘time served’ model, whereby apprentices were required to ‘serve’ as an apprentice for a pre-determined amount of time. This system was limited in that there was a lack of standards applied; despite successive Irish governments attempting to address the issue through legislation and the formation of national training authorities (O'Connor and Harvey 2001).

In 1991, following a major review of manpower in Ireland, the then newly established training authority FÁS, introduced a new ‘Standards Based’ Apprenticeship framework aimed at replacing the emphasis on time served with common standards (O'Connor 2003). Immediately, the new apprenticeship model thrived. To a large extent, this success was enabled by a period of economic growth, which concealed the fact that the new model was overly dependent upon employer engagement.

### **Government review of apprenticeship**

In 2013, a review of the Irish apprenticeship system was announced by the Irish Government (Department of Education and Skills 2013b). By which time the Irish economy had been in recession for nearly five years. It is therefore not unreasonable to suggest that this review was overdue.

A potentially contentious issue raised by the review relates to the purpose of apprenticeship socio-economically. In positing the need for apprenticeship, this report states that: “by 2020, while all jobs will require higher levels of skill, 50% of them will need medium level skills and 15% will require low level skills...[and]...even in a

high tech world some two-thirds of all jobs will be in the mid to low skills range. (Department of Education and Skills 2013c).

To determine that apprenticeship as a paradigm of learning is suitable only for the delivery of low to mid-level skills is not constructive. This stance does not aid apprenticeship in the difficult battle against academic snobbery when there is a need to enhance the public perception of apprenticeship (Lee 2012).

In this regard, the Irish review of apprenticeship could have taken the lead from its contemporary review in the UK. The Richard review states that “we must ensure that apprenticeships are well regarded. Apprenticeships cannot be the collateral partner amongst our learning pathways. It is inappropriate for it to be viewed as a lower-status alternative” (Richard 2012).

### **A Qualitative concern for the future of apprenticeship**

Whilst this paper presents for the most part quantitative issues regarding apprenticeship, there are concerns of a qualitative nature going forward.

The culmination of the apprenticeship review was a call for the proposal of new apprenticeships by enterprise (Department of Education and Skills 2014). Whilst this is in essence a positive move to expand the utilisation of experiential learning as a method of training, there is a fundamental concern.

The Standards Based Apprenticeship (SBA) model demanded a form of legislative homogeneity in terms of key common standards such as duration, examination, certification etc. (SOLAS 2015b).

Although the SBA is the only extant apprenticeship model in Ireland, theoretically, the expansion of apprenticeship may allow for alternative training standards and therefore a lack of conformation of the key common standards mentioned above. Thus, the future of apprenticeship is open to possible deregulation and a potential diminishment of common standards which have upheld the core value of Irish apprenticeship.

## **CONSEQUENCES FOR THE INDUSTRY**

### **Future skills shortage**

As stated, a negative implication for the construction sector, which a serious reduction in apprentice numbers brings, is one of a future skills shortage. In the UK, a report prepared by the Work Foundation describes how skills shortages exist more than a generation after recommendations were made to invest in labour market skills (Wright, Brinkley and Clayton 2010).

More recently, a survey of its members by the Chartered Institute of Building revealed that 82 % of respondents felt there is a serious skills shortage in today’s UK construction industry (Chartered Institute of Building 2013).

The issue is also evident in the Irish construction industry, less than a decade after the economic downturn began. The severity of the situation has been noted by SOLAS, who have indicated that “the availability of qualified tradespersons may become an issue as the recovery in the labour market continues” (Skills and Labour Market Research Unit 2015). Even before this becomes a long term issue, in the short term, the skills shortage in Ireland is being fed by a need for skills in other countries, which has seen Irish apprentices and tradespeople emigrate (Skills and Labour Market Research Unit 2008). Between 2005 and 2013, Irish emigration trebled from 30,000 to 90,000 annually (Central Statistics Office 2016d).

## Future management shortage

In addition to the issues associated with a skills deficit, there is another, potentially more serious implication for the construction industry brought about by a lack of apprentices, namely, the threat to future management skills.

Apprenticeships supply the industry with a chain of craftspeople that perform an essential role within the hierarchical structure of the industry (O'Connor and Harvey 2001). Historically, these individuals, through their applied skills and experiential knowledge of the industry, evolve into construction managers over time (Skills and Labour Market Research Unit 2008).

When considering the principle members of a construction project team (Figure 4), only one member follows a vocational route to management – the construction manager. Traditionally, this individual has followed a route of experiential learning, often beginning with apprenticeship (Mohrenweiser and Backes-Gellner 2010). This is vital, as it delivers a pragmatic understanding of construction which is not readily replicated by other members of the project team. Though the other team members, also play crucial roles in their own right, they have followed paths through tertiary education which were not aimed at qualifying them as site managers.

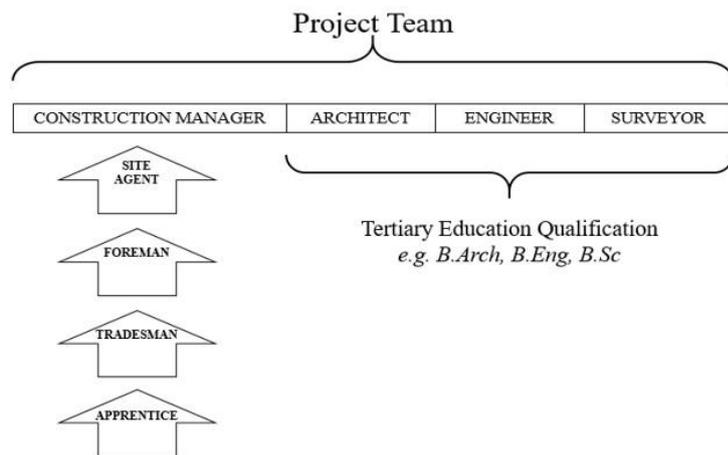


Figure 4: Vocational route to management of the construction manager

It should be noted that many of Ireland's Institutes of Technology now offer degree programmes in Construction Management. However, it remains to be documented as to whether this is an acceptable alternative to the alternative vocational route in terms of the quality of managers it produces.

## A need for change

Given the reduction in apprentice numbers, there is evidently a need for change to avoid a future skills and management shortage in the construction sector going forward. Such a shortage has already been evidenced within other parts of the construction labour market, including the quantity surveyor profession (Murphy and Walsh 2014) and is likely to occur elsewhere also.

There are many elements to consider. Firstly, numerous stakeholders are involved. Many successful European arrangements are “social partnerships between the State, employers, trades unions, and education and training providers” (Fuller and Unwin 2008). By engaging with social partners in this way, apprenticeships in theory, are aimed at “meeting the needs of the changing economy” (Richard 2012).

Herein lies a fundamental issue – the economy is constantly changing with numerous facets affecting output. Apprenticeships therefore, are no longer homogenous as can be seen from the varied programmes of training internationally and the need to equip society with the skills required by the current and future economies (CEDEFOP 2009).

It could be posited that the ideal apprenticeship structure should be flexible enough to cope with the cyclical nature of the sector. Assuming this as an essential quality, research would almost certainly lead to the German apprenticeship system as an exemplar (Gibbons-Wood and Lange 2000; Wyman and Gedge 2015).

However, the supposition that the German training model could be simply transposed to another nation is illogical. While the German model is meritorious, there are many significant differences, not least of all, that vocational training begins in second level school in Germany (Deissinger 2004) and it does not in Ireland for example. Thus it is an issue which is not easily replicable by another country without major educational reform.

In addition, recent investigations of German VET shown that they too have problems as “an increasing number of German youth are unable to access Germany’s much lauded vocational training system” (Kohlrausch 2014). This may be due to the myriad transformations of a “political, policy and institutional” nature, which the German labour market has undergone in recent years (Brady, Biegert and Vitols 2015).

One strategy introduced by the German government is the ‘transition system’, aimed at easing the shift for many young people from school to training, due to the fact that increasing numbers of youths fail to successfully make the traditional transition (Kohlrausch 2014). Yet this measure has not had the intended success of Government. Owing to the differences in qualification levels of second level, the system has made “access to vocational training...more stratified” (Kohlrausch 2012). This has led the OECD to conclude that “the transition system...suffers from undue fragmentation and an absence of transparency” and that “too few...participants make a successful transition into the regular VET system” (Hoeckel and Schwartz 2010).

Clearly then, there are issues even with the world’s most ubiquitous model of excellence.

## **IMPLEMENTATION**

The Irish apprenticeship system needs to be cognisant of all of the aforementioned information, both positive and negative. Owing to the fact that the existing standard of training is amongst the highest standard on offer (Steedman 2010), the answer would not appear to be an attempt to simulate a central European framework. However, determining a model of training is not the only issue to be addressed. Another is the method of implementation of an alternative model. In this regard, Ireland is lucky in that it has a well-established method of social partnership for apprenticeship which Government has promise to preserve going forward (Department of Education and Skills 2014).

Nevertheless, issues surrounding the use of the National Training Fund (NTF), previously the Apprenticeship Levy, remain for the most part unexplored. An investigation should be undertaken as to whether an augmented NTF could be used as a method of addressing apprenticeship engagement by employers during economic downturns. The viability of combining social welfare support with emergency

funding from the NTF should at least be probed by government as a means to bolster apprenticeship levels during periods of recession.

## CONCLUSIONS

The Irish apprenticeship model is misinterpreted as being ineffective when in reality the primary failing lies with an over reliance on employer engagement. Addressing this requires legislative change in order to build in protection against cyclical elasticity. Another significant and ongoing issue is that of the value of apprenticeship socially and culturally. This must be addressed in order for the Government's plan for the expansion of apprenticeship, as a paradigm of education, to be successful.

The examination of the current German apprenticeship system shows that vocational education is valued there. It would appear that this is the best way for apprenticeship to flourish; it must be socially accepted as a credible educational method. This would require a major cultural shift in Ireland due to a cultural lack of value in VET.

The solution would appear not to be to attempt an emulation of the German system but rather to encourage the adoption of a Germanic type appreciation of vocational education. Apprenticeship must be valued, just as it is in Germany. Furthermore, as there are many stakeholders to apprenticeship, the government cannot afford to be partisan. To do so would be irresponsible and potentially perilous in terms of future skills. The future success of apprenticeship will depend upon all parties collaborating.

Ireland's educational leaders therefore stand at an extremely important juncture in the history of apprenticeship. The status quo cannot be allowed to remain. Now is the time to tackle the social inequality of education stratification and to rethink the concept of apprenticeship. Through collaboration, there is an opportunity to design a modern model of excellence for the delivery of apprenticeship training, flexible enough to minimise the risks of future cyclical shocks, thereby improving the labour market for the betterment of society and ensuring the ability to meet future skills needs.

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# WHAT KIND OF EXPERTISE IS NEEDED FOR LOW ENERGY CONSTRUCTION?

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Three possible transition pathways to an energy efficient future - market-based, ecological modernisation, and radical transformation - are considered for the construction industry, responsible for 40% of European Union (EU) end-use emissions. Considerable obstacles to achieving low energy construction (LEC) are evident in the UK, including: a performance gap between design intention and on-site energy performance; sharp occupational interfaces where the main heat losses occur; declines in the level, breadth and quality of construction vocational education and training (VET); and the lack of a learning infrastructure on sites. Near zero energy building (nZEB) is very different from traditional forms, requiring greater 'thermal literacy' of all construction occupations, higher qualification levels, broader occupational profiles, integrated team working rather than self-employment and extended subcontracting chains, and better communication given the complex work processes involved. The required expertise is relative to the transition pathway adopted and in the UK a radical transformation of the existing structure of VET provision and of employment is needed for trainees and the workforce to acquire enhanced understanding of LEC, based on a broader concept of agency and backed up by rigorous enforcement of standards.

Keywords: low energy construction, expertise, transition pathways, labour, vocational education and training

## INTRODUCTION

As much as 80% of greenhouse gas emissions in the European Union (EU) originate from firms' production of goods, suggesting that work sites and processes and chains of production are major polluters (ILO 2011). The construction industry in Europe is especially affected by the need to confront the increasingly rapid warming of the world, not only in terms of employment and the transformation of vocational education and training (VET) systems, but also because the sector as a whole is responsible for 40% of EU end-use CO<sub>2</sub> emissions (Dupressoir 2007). What distinguishes low energy construction (LEC) is the delivery of buildings with extremely low levels of annual energy use (expressed in kWh/m<sup>2</sup> per year) in order to meet national and international carbon dioxide emission reduction goals. With core guidance given in three key EU Directives - the Energy Performance of Buildings (EPBD 2010), the Renewable Energy Sources (RES or RED 2009) and the Energy Efficiency Directive (EED 2012) - the EU Roadmap proposes an 80% CO<sub>2</sub> reduction in building emissions by 2050 to be achieved through energy-efficient building envelopes supported by renewable/low energy building services (EC 2011a).

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Technically, LEC demands a fundamentally different approach from conventional construction methods, one that recognises the building envelope as a single thermal unit with renewable technologies and as made up of elements that come together through the interaction of different occupations, including bricklaying, carpentry, tiling and floor laying, insulation, electrical engineering and plumbing.

This study explores the implications of these energy imperatives for expertise in the construction industry. It is largely focussed on the United Kingdom (UK), though similar problems and issues in meeting low energy standards are evident in other European countries and the questions addressed are universal. What kind of transition pathway is best to pursue, given the obstacles to achieving energy efficient construction, and what implications does this have for VET? What does a different, more holistic, approach to the building envelope imply in terms of the VET and qualifications required? And, above all, how is it possible, given the fragmented nature of the construction industry, to achieve the integrated labour process required for these different occupations to work together as a team? Drawing on the work of theorists of education (e.g. Georg Kerschensteiner), sociology (e.g. Richard Biernacki), and economics (e.g. Adam Smith), the study addresses the challenges to the construction industry if low energy targets are to be met and concludes by considering the relativity of construction expertise to the transition pathway pursued.

### **The transition to low energy construction**

There is increasing recognition, particularly following the Stern Review of 2006 that it is necessary to make a social transition in order to improve the environment, employment, qualifications and well-being (Steward 2015). Alternative transition pathways have different implications for employment and working conditions and for knowledge and skill development in construction, as well as for the organisation of production and the labour process (Eurofound 2011; CEDEFOP 2013; ETUI 2014; UKERC 2014). For example, one-off short training courses in, for instance, insulation skills will have vastly different consequences for young people and for the labour process compared with comprehensive VET courses for thermal literate insulators. Some transition paths lead towards eco-efficiency, others towards weak ecological modernization and still others towards strong ecological modernization, whilst others move towards more transformative paths. Paul Hampton (2015) has identified three prevalent frameworks in the wider debates on the dynamic of transition to a low carbon economy, each of which implies a different approach to the construction labour process and VET, and hence different kinds of expertise.

The first of these is market based, seeking to avoid state-led investment and promoting strategies focused on adjusting the market context through instruments such as emissions trading, carbon pricing and consumption taxes, as a viable way of easing the cost of transition or a means of creating jobs (Pearce and Markandya 1989). In terms of low energy construction, this means continuing to rely on the premise that skill shortages will be filled by market demand mechanisms, so that, in accordance with Marsden's (1999) 'production' approach, skills are seen as work-based and training dependent to a large extent on the individual employer and on-the-job learning. Such an approach implies that labour is regarded as a commodity, performing recognized activities in the work process under conditions of limited autonomy linked to a specific output, echoing what Biernacki (1995) terms 'embodied labour' (Clarke *et al.* 2013). This is much the same conception of labour as Adam Smith (1776/1947) espoused, with the worker trained and paid to fulfil particular

tasks, broken down into simple steps and overseen by managers, as similarly envisaged by Frederick Winslow Taylor (1911). In relation to construction, it is also identifiable with Ramioul *et al.*'s (2016) 'low-road' approach in their study of energy friendly house construction in Belgium, involving high levels of centralised control and specialisation, a lengthy value chain, erosion of team-based working, and poor job quality.

A second and common framework is what has been termed 'ecological modernization', which adds to the first framework policies for employment and social justice, training and retraining, learning and skills development and expresses a broadly positive view of the dominant patterns of technological change and economic development in their potential to deliver sustainability, whilst acknowledging that government policy needs proactive investment and promotion and emphasising the need to invest in green jobs and for a 'just transition' towards them (Hajer 1995; Mol *et al.* 2009). This framework accords more with Marsden's (1999) 'training' approach, which regards VET as institutionally regulated, related to a person's ability and certified qualifications, and generally collectively and industrially organised. The labour implied is no longer a commodity but has a mind of its own, though as an agent remains restricted by the institutional setting or structure. This second approach is close to Ramioul *et al.*'s (2016) 'high road', which is more employee-centred, with greater worker participation, empowered teamwork, investments in skills of the workers, and better job quality.

A third framework identified is more radical, suggesting that radical transformation of social and technological arrangements through a coalition of societal actors and stakeholders will be needed to ensure a transition to a low carbon society (Grin *et al.* 2010). According to this 'radical transition' approach, to achieve the necessary carbon reductions will require integrated and publicly-owned energy supply, natural resources and transport systems, 'socially/ environmentally useful production' and/or 'extended producer responsibility'. The approach implies that, through the development of personal capabilities and occupational capacity, labour - or in Biernacki's (1995) terminology 'labour power' - becomes a more active agent with real autonomy to challenge the institutional structures of VET and employment and to champion the reduction in carbon emissions, for instance in the UK through green representatives (Snell and Fairbrother 2010).

This sociotechnical transitions framework therefore raises the wider issue of workers as environmental actors or innovators (Eurofound 2011). The VET system required to achieve this needs to be broader, akin to that advocated by Georg Kerschensteiner, which advocates developing the civic virtues of the worker and consciousness of the impact of occupational activities both on other occupations and on society. The consequence of such a system should be to help to equip labour with the potential to challenge structures through the knowledge, skills and competences (KSC) acquired and the expertise to innovate (Winch 2006). It is no longer a system geared only to developing skills but one associated with a broader concept of agency, developing the intellectual and manual capabilities necessary to act autonomously and to plan and manage new and complex processes (Winch 2013). This third orientation indicates the need for interventions in the construction process that are not simply reactive in terms of justice or job protection, but proactively intervene to shape the nature of the green transition. It concurs with Markey *et al.*'s (2015) findings that a high degree of substantive - broad and deep - employee participation, with employees and unions

providing an important impetus for action, can most effectively reduce carbon emissions.

### **Problems with low energy construction**

Which of these different transition pathways is needed in order to develop appropriate expertise for an energy efficient construction? Many countries have embarked on LEC programmes, including developing ultra-low standards such as the Canadian R2000; the Swiss Minergie; the Code for Sustainable Homes Level 6 in the UK; and the German Passivhaus. However, though the imposition of stringent control measures through building regulations should mean that new buildings achieve higher energy efficiency than previously, research has documented a so-called ‘gap’ between the design and building performance of both low energy new buildings and retrofits, between what might be regarded as application of the design or engineering concept to the reality of the building process (Johnston, *et al.* 2010). As-built performance rests on whether the design elements are possible to construct under site conditions, along with important considerations concerning the competence, know-how and knowledge of building workers or what might be termed their ‘energy’ or ‘thermal literacy’.

Measuring energy performance, whilst not an exact science, is a relatively new experience in the UK construction sector, driven by the need to evidence the reduction of carbon dioxide emissions. Three test procedures - air permeability; coheating; and thermal imaging - can be used to assess the pre-occupancy thermal performance of the building envelope (floor, walls/doors, windows and roof). Through these techniques, it is possible to make a reasonable assessment of the building envelope’s ‘as-built’ heat loss and compare the designed heat loss with that of its performance without the additional complication of normalising for occupancy. Air permeability testing has shown that the UK maximum air leakage rate - at  $10\text{m}^3/\text{m}^2\cdot\text{h}$  at 50Pa - is about ten times that of the European Passivhaus low energy standard (Johnston and Miles-Shenton, 2009; Shattock, 2012). The need to remedy this performance gap is, therefore, crucial to meeting UK low carbon targets.

The social relations involved in the construction process and its organisation are central to understanding the difference between the energy loss envisaged and the actual building performance. They imply a focus not only on how labour is organised and employed but also on the quality of the labour involved, including the qualifications of building workers and the VET system in place. This has been recognised by the European Commission in its *Energy Efficiency Plan 2011* (EC 2011b), which specifically addresses the need for qualified workers, the lack of appropriate training for architects, engineers, auditors, craftsmen, technicians and installers, notably for those involved in refurbishment, and the requirement for ‘new skills’ and ‘environment-conscious’ VET in construction and for adapting ‘curricula to reflect the new qualification needs’ to ‘transition to energy-efficient technologies’ (p.7). To facilitate this transition, the EU has supported an audit of labour availability through the *Build-up Skills* initiative, with National Reports leading to National Roadmaps, which should integrate into the broader EU employment and qualification strategy and are focussed on social rather than purely technical obstacles, especially with regards to upskilling the existing workforce through continuing training.

These have shown that VET for LEC poses particular challenges not only because of its technical demands but also because of the complexity of process management and co-ordination, particularly the cross-occupational co-ordination required. The Build-up Skills overview report notes ‘weaknesses of national education and training

systems' and a 'shortage of cross-trade knowledge and skills (e.g. installation of few RES systems), including insufficient coordination between occupations and their 'borderline' skills and unsatisfactory interdisciplinary training opportunities within upper secondary and continuing education and training systems' (EC 2014: 64-5). The German *Build up Skills* report in particular locates the main problem in reducing emissions in: 'interfaces between trades' and 'lack of any understanding for a house/building as one integrated system' (Build Up Skills 2012: 6-7). The suggestion is that energy requirements can only be met by overcoming obstacles that lie in the VET system (achieving broad and comprehensive know-how) and the building production process (bridging trade interfaces). Yet studies across Europe indicate a lack of thermal and energy literacy and a growing need for transversal abilities within those areas critical to achieving energy efficiency (Zero Carbon Hub 2014).

The imperatives for low energy construction to meet EU 20/20/20 targets thus introduce new VET requirements presenting a major challenge to European countries, including: greater educational input to achieve thermal literacy for all workers concerned; broader qualification profiles to overcome interfaces between the activities of different occupations where the main heat losses occur; learning from feedback; and integrated team working and communication given the complex work processes involved. Sealing and insulating the building envelope is critical to achieving energy efficiency given that air leakages in, for instance, a house typically occur through the interfaces between the roof and walls and between the windows and doors and walls. These interfaces are at the same time between those employed in different occupations, between, for instance the roofer, carpenter, bricklayer and ground worker. And these occupational interfaces are not just socially but contractually divided, coming usually under separate subcontracts. The methods deployed by the builder also need to encompass the supply chain since any change in the quality of components, either because those specified are not available or from a value engineering perspective, will impact on the final energy demand. This suggests a major transformation of the current fragmented labour process, characterised in the UK at least (though perhaps to a lesser extent in some other European countries), by extensive subcontracting, the use of agency labour and the self-employed, widespread non-formal on-the-job learning, high labour mobility, exclusively white male social networks and a sharp separation between operatives and professionals.

### **Problems with developing VET for LEC in Britain (VET4LEC)**

LEC requires a highly qualified workforce, whether for retrofitting or new build, with knowledge of building physics, mathematics, engineering or material behaviour as well as more abstract competences such as reading off drawings, setting out, bridging interfaces and constructing to high precision. The low level of skills and qualifications of many employed in the industry in Britain and the lack of initial and further training are detrimental to low energy performance, just as are the increasingly high numbers of those self-employed and employed by agencies. In 20013/14 nearly half of the total construction workforce of two million came under the special Construction Industry Scheme (CIS) for self-employed workers (UCATT 2015). At the same time, the number of first year trainees and apprentices has plummeted since 2007, with those in the wood trades falling from 13,743 to 4536 by 2015, in bricklaying from about 9,000 to 2364, and in plant operation from 4,747 to just 834 (ConstructionSkills 2015).

Overall in ten years construction ‘craft’ training has collapsed, from first year trainees numbering 38,447 in 2005 to a historical low of 11,586 in 2015, only 35% of whom were undertaking work-based training and only 3,000 an apprenticeship programme. Most training provision too continues to be concentrated in the traditional trade areas, covering an ever-narrower scope of activities. About three-quarters of apprenticeships are in the four main building trades - wood, bricklaying, painting and decorating, and plastering and dry lining, though these constitute little more than half of the forecast requirement for skilled manual trades. In addition, the vast majority of construction trainees only achieve National Vocational Qualification (NVQ) Level 2, a qualification far lower than that typical for skilled construction workers in other leading European countries and too low to then progress to supervisory or managerial levels (Brockmann *et al.* 2010).

In this situation, it is not surprising that few builders in UK take responsibility for training: 73% of construction companies have been found to have no training plan, 81% have no training budget and only 19% invest in training (BIS 2013). This is understandable in the light of the high levels of self-employment and the fragmentation of firms and degree of subcontracting in the industry. It is, however, that much more serious given the employer-led nature of the VET system, where trainees depend on employer goodwill to acquire work experience, qualifications and VET (including for green construction), where lobbying by employer trade associations is critical to new qualifications being developed, and where government policy is focussed on work-based apprenticeship.

The example of new build traditional masonry well illustrates the extent to which construction qualifications in Britain incorporate or are sensitive to low energy requirements. Labour requirements for the dwelling envelope relate to solid ground floor slabs, cavity brick walls and timber roofs and Table 1 reveals the extent to which these areas are carried out by those with ‘skilled’ and ‘advanced skill’ qualifications, as well as those operations where there is no formal training available, including ‘groundworks’ (e.g. digging foundations, laying drains and, paving slabs) and concreting. For those areas with formal training, whilst ‘insulation and energy efficiency’ is referred to in NVQ Level 2 and 3 documents for bricklaying, site carpentry and plastering, this is treated as an element in a range of ‘knowledge’ issues and therefore of equal importance to other areas within ‘knowledge of building methods and construction technology’. There is no knowledge requirement to understand the envelope as a single system, no reference to air barriers, air tightness or thermal bridging, no requirement to understand the interplay between the separate envelope workers and final energy performance, and no celebration of the ‘thermal literacy’ of the construction worker so central to achieving a low carbon future. Where formal VET exists, analysis of the training content for new entrants to the industry identifies a lack of focus on low energy as a key performance objective.

The examples given in Table 1, coupled with the declining levels of training, suggest that the third transition pathway, radical transformation of social and technological arrangements, rather than the incremental improvements of the first and second pathways, is appropriate. This implies a transformation of VET away from narrow, low level task-based training towards a system more akin to that proposed by Kerschensteiner, with a wide occupational scope, encompassing also ‘civic virtues’ and a high level of technical and manual expertise (Winch 2006).

Table 1: Thermal skills required for different building elements

Envelope Element	VET role	Thermal Skills required
Ground floor slab	No formal VET. Site experience by general labourer	Horizontal insulation of the slab with vertical insulation to prevent thermal bridging at perimeter
Walls	Bricklaying NVQ levels 2 and 3	Cavity wall insulation. Insulation must be butted together and be complete at corners and breaks in the wall. Air circulation behind or through insulation significantly reduces its impact. Bricklayers need to understand the role of thermal bridging. There is no mention of air tightness or thermal bridges in NVQ levels 2 and 3.
Openings (windows and doors)	Level 2 NVQ Diploma in Fenestration Installation required for UK Government sponsored 'Green Deal'. Otherwise there is no formal VET and these are fitted by many occupations including bricklayers, carpenters, general builders, specialist window fitters.	No formal VET in window fitting. It is traditionally the role of the carpenter but with newer materials, such as PVC, aluminium and specialist glazing those carrying out the fitting vary from the general building labourer to the window supplier. This is central to air tightness programme since windows fill a hole in the wall.
Loft insulation	Insulation installer NVQ level 2 required for 'Green Deal'. Otherwise no formal VET.	No formal VET in insulation. Six separate NVQs at Level 2 were developed for the Green Deal in 'Insulation and Building Treatments'.
Plastering	Generally Plastering NVQ level 2	The wet plaster seals the envelope to act as the 'air barrier'. No mention of air tightness in the NVQ level 2.
Builders openings	Various/bricklayer/labourer. Often no formal VET.	Holes in envelope for services (water, drainage, etc.) break into the 'air barrier'

Source: CITB Qualification Details. For example: Level 2 Diploma in Bricklaying DIP 102/2, Level 2 Diploma in Plastering, etc. Revised March 2009.

### What kind of VET for LEC in Britain?

Traditionally, VET in Britain has relied on the development of narrow trade-based skills geared to particular employer needs, and focussed on producing pre-defined outputs (Clarke *et al.* 2013). Increasingly the system has become work-based, with a built-in assumption that learning depends on induction, on the generalisation of a range of practical experiences (Clarke and Winch 2004). However, the KSC required for much low energy construction work cannot be directly read from experience or site observations. Nor, given the contractual divisions between the different trades or occupations, is it possible to observe or experience the real problems associated with bridging interfaces between them. These are not manual skills but more abstract competences, requiring a model of learning revolving around the application of relevant theories and instances of theoretical propositions to practical situations, and thus depending on deductively relating general principles to particular circumstances. This in turn suggests a higher level of qualification, as proposed in the Richard Review of Apprenticeships in 2012, which recommended far-reaching changes to the way in which VET is conducted in England and a minimum Level 3 qualification. A qualification at Level 3 is necessary for effective LEC because the abilities required range beyond a narrow band of technical skills and encompass heightened technical understanding of the technologies employed, together with process knowledge of the project and the ability to communicate, co-ordinate and evaluate elements of the process with other occupations.

As apparent from Table 1, broader occupational profiles and at the same time integrated teamwork are also required, as each occupation must understand its role in the process and 'buy-in' to the project. Since the joint efforts of several occupations are needed to meet energy standards for the successful completion of the project, an understanding of the work of several occupations will be necessary. With the

envelope air tightness standard, for example, an initial target, a method statement, is required for all types of buildings, and then each occupation has to realise its role in creating an envelope that meets the design specification. For masonry build, bricklayers, plasterers, window fitters and plumbers (more generally, service entries - what are known as 'builder's openings') are involved. Another example of where cross-occupational knowledge is needed is insulation completeness plus the 'thermal bridges' that occur at all junctions and openings such as at lintels; bricklayers, floor layers, and roofers are all involved and need to co-ordinate their work. Envelope insulation needs to be continuous, the building must exclude draughts and meet an air tightness specification, and this involves all elements of the envelope and raises technical specification with detailed treatment of thermal bridges, builders' openings, sealing windows and ensuring appropriate air tightness at all junctions between floors, walls and roof to meet the target 'fabric energy efficiency'.

To ensure thermal comfort and public health, the building then requires space heating and/or cooling, domestic hot water and lighting. Provided the fabric energy efficiency has been met, reducing heating and cooling needs to the absolute minimum, the selection of heating and cooling appliances demands attention to their product efficiency, their fuel or power source and emissions. New low and zero carbon technologies that replace boilers with heat pumps, micro-combined heat and power, solar thermal (solar hot water) provide the opportunity to offset emissions through the generation of renewable power (electricity) and/or renewable heat. However, unlike boilers, heat pump performance is particularly sensitive to poor design, installation and operation and successful installation requires understanding quality engineering design and all the problems associated with the handover to the user (e.g. commissioning, controls setting and ability to explain these) (Gleeson, 2015). For most buildings integrated renewable generation will entail photovoltaics and/or solar thermal installations where renewable output is deemed as 'off-setting' and provides net zero or nearly zero emission buildings.

All built environment occupations need enhanced VET and increased occupational scope for near zero energy building (nZEB) to succeed, so that workers can carry out a wider range of operations relevant to LEC than is currently the case with, for instance, the narrowly trained English bricklayer (Brockmann *et al.* 2013). LEC workers need to understand and evaluate the principles of LEC, including the technologies employed and how these work within a low energy building, as well as the conditions for the successful execution of a LEC project and the principal factors that can cause it go wrong. Their curriculum needs to embrace the principles concerning why certain activities are carried out in the way and the sequence in which they are carried out, as well as how such principles are realised in practice, appreciation of which can be taught in relation to some observational work on site.

## CONCLUSIONS

Ultimately the concern for all should be that carbon dioxide reduction targets will be missed due to inadequacies in the VET and qualification systems and the organisation of the production process. For these obstacles to be overcome, it is essential not only to appreciate the role and value of labour but also to involve the workforce in transforming the VET system and the labour process for a low carbon future. For LEC to succeed, it is vitally important for each occupation to know what the other is doing, but the integrated teamwork needed to prevent energy loss requires a less extensive subcontracting chain and more direct employment if the different

occupations are to work more closely together and a learning infrastructure is to exist. In terms of expertise, an extensive initial and continuing VET programme is needed to enhance KSC, based on broad occupational profiles and careful attention to the application of theoretical propositions. These requirements for LEC imply a radical transformation of both the structure of the industry and the VET system, to be achieved by enhancing the role of labour as an agent of production. They also suggest that the nature of expertise is relative to the transition pathway adopted.

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# VOCATIONAL TRAINING AND KNOWLEDGE DEVELOPMENT: A DEEPER UNDERSTANDING

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Construction management research literature has identified the importance of understanding the practical realities of skills and training provision and the role of reflective practice in the development of knowledge. This paper examines vocational training of experienced site staff in the development of their knowledge through SVQ training to investigate the primary factors for successful learning in site-based construction staff with a supervisory/management role. Using semi-structured interviews the impact of vocational training on individual candidates and other site-based staff are investigated. The paper explores, through the reflections of 26 SVQ candidates (20 SVQ3 and 6 SVQ4), a deeper understanding of how site supervisors and site managers learn through the SVQ process and develop tacit knowledge through formal reflection. Reflective practice develops practical wisdom (Phronesis). The investigation explains aspects of practical wisdom and how knowledge, practice and skills are developed through vocational training. There is a clear perception by those completing the qualification that it has enabled them to perform their job better identifying numerous examples relating to problem solving, critical thinking, making decisions and leadership. It has been found that Phronesis is evident on a day-to-day basis on site activities developed through reflective practice in personal development. The reflective practice in developing knowledge also builds, within individuals, a better understanding of themselves and their capabilities through the learning achieved in the SVQ. Future work is identified around analysing the role of the assessor in facilitating Phronesis in the SVQ context.

Keywords: learning, Phronesis, tacit knowledge, vocational qualifications

## INTRODUCTION

A number of authors have explored issues around skill shortages and employer based skills development in construction (Raiden and Dainty 2006; Clarke and Herrmann 2007; Chan and Moehler 2007) and related areas of the employers role in skill development, vocational skills development and workplace informal influences on skill development. Moehler, Chan and Greenwood (2008) identified the trend towards work based learning through NVQ and suggest a movement of organisations playing a greater role in engaging with skill development. Cano Lopez, Copping and Bullock (2008) explored onsite training and assessment where learning takes place in the workplace and is assessed through observation and questioning to develop effective strategies for integration into organisational practice. These previous authors

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considered theories of learning and this paper extends this work towards the concepts of practical wisdom and knowledge, how knowledge and skills are developed through vocational training and tacit knowledge development is prompted through formal reflection. Since 2010 there have been 239 experienced site supervisors, site managers or construction managers that have successfully completed a Scottish Vocational Qualification (SVQ) with RT Resources. Vocational qualifications are much more than a “young person’s apprenticeship” or a training course. The higher level SVQ awards equate to levels 7, 9 and 11 on the Scottish Credit and Qualifications Framework ranging from level 7 for SVQ3 comparable with first year of university through to level 11 for SVQ5 equating to post-graduate study.

Praxis is a term used by researchers in educational learning and writers link the term to the work of Freire (1972). In practice the term praxis does not have everyday use, but the reality is that in many professional contexts (e.g. HEA teaching development; ICE and CIOB professional development for Chartered status) practice is a simpler, more basic derivative of what praxis actually means. It would appear that Freire is a typical starting point for researchers on the subject (Beckwith, 2015; Smith, 1999, 2011), quoting Freire (1972) indicating the problems for those facing a highly theory based education for a vocational career. Smith (1999, 2011) goes on to explain how knowledge can be categorised as theoretical (such as with pure maths), productive (as in building) and practical (social work training). This is developed further as Smith then presents the productive disciplines can be associated with Aristotle’s form of thinking called *poietike* in relation to the work of craftspeople or artisans; indicating that praxis is guided by a moral intention (Aristotle, 2004) to do the right thing with a view to furthering human well-being. In this context this is what the Greeks called *phronesis*; necessitating an understanding of people (and one-self) and has been described as practical wisdom (Smith, 1999, 2011).

Reflection on experience has been advocated as a way to facilitate experience-based learning. Mathew and Sternberg (2009) define reflection as a process of guided critical thinking that directs attention selectively to various aspects of experience, making knowledge typically acquired without conscious awareness explicit and available for examination and modification, hence developing practical wisdom.

### **Phronesis and tacit knowledge**

Experience is built over time by individuals and organisations working in and developing an understanding of the Construction Industry. Intuition is the acknowledgement of “gut-feeling” which is often rooted in experience and that much of the knowledge that is relevant to competent performance is not openly expressed or readily stated. Research on expertise in a variety of domains supports the notion that much of the knowledge associated with successful performance is tacit (Nonaka, 2005). To succeed in organisational environments professionals must enhance their capacity to learn from experience and adapt their modes of practice accordingly (Mathew and Sternberg 2009). Experience based knowledge is context-dependent and typically develops over time through an iterative learning process of perception, action, and feedback. Developing methods to enhance the acquisition of experience-based knowledge have never been more relevant to professional education and development (Mathew and Sternberg 2009).

Michael Polanyi wrote in *The Tacit Dimension*, “we can know more than we can tell” (Polanyi 1967, 4). Work by Nonaka (Nonaka and Takeuchi 1995; Nonaka 1998) stated that there are two types of knowledge, Tacit and Explicit. Explicit knowledge

is “formal and specific...it can be communicated and shared” (Nonaka 1998, 27) Zack (1999) defines explicit knowledge as knowledge which can be precisely and formally articulated, easily codified, documented, transferred and shared. Egbu (2006a) proposes that a great deal of knowledge for addressing challenges within the urban environment is tacit in nature. Anumba, Egbu and Carillo (2005) identify the opportunity for knowledge production, transmission and transfer between different professionals in the construction industry. However, tacit knowledge, which is deeply rooted in action and context, can be acquired without awareness and is typically not articulated or communicated. Tacit Knowledge is defined by Nonaka and Takeuchi (1995) as: “highly personal and hard to formalise, making it difficult to communicate and share with others”. Subjective insights, intuitions, hunches all fall into this category of knowledge. Furthermore, tacit knowledge is “deeply rooted in an individual’s action and experience, as well as the ideals, values, or emotion he or she embraces” (Nonaka and Takeuchi 1995, 8). Nonaka and Takeuchi (1995) further split tacit knowledge down into two parts, a technical dimension and a cognitive dimension. Technical dimension encompasses the knowledge gained through experience, whereas the cognitive dimension is based on the individual’s belief and how they perceive the world. Tacit knowledge is “what the knower knows which is derived from experience and embodies beliefs and values” (Marwick 2001).

Cianciolo (2006) defined tacit knowledge as the generally unspoken knowledge gained from experience (as opposed to explicit instruction), which distinguishes between expert individuals in a particular domain. Practical intelligence therefore can be viewed as developing expertise (Sternberg, 1998), and tacit knowledge its manifest indicator (Sternberg *et al.*, 2000). Tacit knowledge has been recognized as both an outcome of experience-based learning and as a basis for continuous learning (Sternberg & Horvath, 1999). Expanding the theory of the knowledge-creating company (Nonaka and Takeuchi, 1995), Nonaka and Toyama (2007) propose a view of strategy as distributed phronesis, using Aristotle's concept of phronesis, which translates roughly as “prudence,” “practical wisdom,” and “practical rationality, in which human values and ideals are inherent.

Nonaka and Toyama, (2005) believe phronesis is an illuminating description of knowledge creation. The concept of phronesis originates with Aristotle where he distinguishes between three types of knowledge: episteme, techne, and phronesis (Flyvbjerg 2001). Kinsella and Pitman, (2012) describe Phronesis is an intellectual virtue, incorporating prudence, ethics, practical wisdom or practical rationality takes into account contextual circumstances. Nokayan and Tokana (2007) identify phronesis as the high-quality tacit knowledge acquired from practical experience that enables prudent decision-making and action appropriate to each situation, guided by values and ethics.

Birmingham (2004) identifies reflection with the classical moral virtue of phronesis by merging contemporary work on reflection in teaching with philosophical work on phronesis. The article concludes with an account of the value and utility of conceptualizing reflection as phronesis. In an educational context, Kessels and Korthagen (1996, 19) explain that phronesis has to do with “the understanding of specific concrete cases and complex or ambiguous situations”. Episteme in the form of educational theory can inform phronesis, but phronesis is not the simple application of educational theory, for educational situations are much too complex, ambiguous, and unpredictable (Birmingham, 2004). The knowing and thinking that phronesis requires a context and represents Schön’s (1992) work on reflection, in which the

terms knowing-in-action, reflection-in-action were developed. The importance of learning is recognised by professionals and organisations as a part of maintaining competitive advantage (Bhargav and Koskela 2009). The benefits of vocational and work-based learning are obvious, when people learn by doing as well as by thinking, reading and writing they develop skills, competence and knowledge that may be partly evidenced through reflection, reflection-in-action as conceptualised in Figure 1.

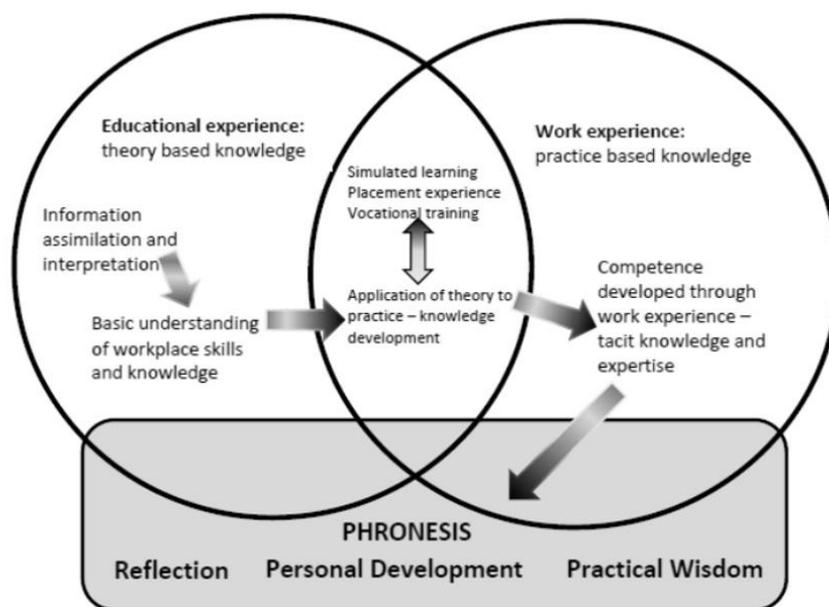


Figure 1: Developing Phronesis

## RESEARCH METHOD

This study investigates the role of vocational training and reflection in knowledge development to explore two themes: 1) how knowledge and skills are developed through vocational training and reflection; 2) how SVQ candidates turn their learning into practice and tacit knowledge and the concept of practical wisdom gained.

RT Resources have trained 239 candidates since 2009 completing their SVQ award successfully (SVQ3 Site Supervisor = 131; SVQ4 Site Manager = 92; and SVQ5 Construction Manager = 16). Semi-structured interviews were adopted to enable a deeper understanding of the candidate experience and the learning process upon the individual, their workplace and those with whom they work. The task in the semi-structured interviews was to discover as much as possible about how site based supervisors and managers learn. Semi-structured interviews, the most wide-spread research methodology in qualitative research (Dawson 2002), commenced by asking indirect questions and then explored specific issues. This methodology provides the interviewer with the freedom to probe various areas and to raise specific queries enabling the ability to probe the unknown. The purpose of the interviews was to find factors that explain the learning processes in vocational training that may help develop an understanding of how tacit knowledge is developed within site based supervisors and managers. The research team used thematic analysis (Braun, V and Clarke, V, 2006) to analyse the interview data and through codification assess meaning and frequency in context (Joffe and Yardley 2004).

## Knowledge development through vocational training

The themes arising from the sample of 26 interviews showed no difference between the 20 candidates for SVQ3 and 6 candidates for SVQ4 other than the matter that for professional development/self-improvement the choice at SVQ3 level was led by the candidate and at SVQ4 level the employer organisation tended to make the learning a requirement for developing within the role. The themes arising from the analysis have been grouped into 6 theme categories. They are presented in Table 1 alongside theory from literature as discussed in the previous sections and conceptualised in Figure 1. The themes identified during interviews fit well with components of Phronesis and reflection.

*Table 1 Themes arising from analysis*

Theory	Theme from interviews
Phronesis	Working better with people: improved team results and better leadership skills (through knowing how to communicate effectively, through listening and giving feedback with empathy to make better decisions and through being respected and asked for advice/suggestions).
Phronesis	Self-improvement for career/professional development: drivers include peer pressure, employer expectations, progress towards CSCS card and personal motivation. Perceived benefit of additional respect from peers and supervisors for completing the award.
Reflection	Lack of time: work on the SVQ limited with candidates expressing the desire to spend more time thinking about the assessments and completing them.
Phronesis	Improved knowledge and understanding: of people, processes (better planning and record keeping consistent specific examples), current and innovative technical information and construction techniques.
Reflection	Reflection or 'thought': Prompted by assessors as a formal action to examine depth of knowledge in articulating justifying decisions; answering the 'why' one solution was better over any other. Also evident as an informal learning experience through interaction with peers when explaining problem solving on site-based issues requiring candidates to draw upon previous experience/knowledge and other sources in creating 'new' solutions. Several participants commented on the difficulties in articulating their thinking within personal statements based on personal skills - most participants indicated improvements in communication as part of the benefits of completing the award including all those that indicated they had difficulty in articulating how they thought.
Phronesis	Recognition by others for achievement: gaining respect from peers and seniors with a perceived increase in being specifically asked for advice/solutions to problems and included in more complex decision making

In addition to the theme identification, interviews explored the process of reflection. Research investigating vocational training and labour market education has shifted focus from education and teaching to learning and/or competence development; with the interest in vocational training identifying workplace learning, work-based learning or work-related learning as the context (Illeris, 2003). It is within this context that the process of reflection can be identified as a part of embedding what has been learned through a self-critique of past events, learning for the future as a part of self-development. Reflection does not have to be formal with assessors to prompt the self-reflection required for personal statements and evidence for the SVQ award. Reflection can also happen during discussions and deliberations when, for example, faced with problem solving under circumstances with which a candidate is not yet familiar. One example cited by a candidate included supervising a team responsible for fitting sun-pipes for the first time where the drawings and design information were ambiguous for the purposes of fitting correctly and the supplier instructions were

helpful but not as complete as to be entirely useful for the task for someone doing this for the first time. In this situation several people discussed the problem and pooled their collective knowledge. Based on their previous experience in problem solving and understanding how others outside their problem would not engage they examined other avenues in the absence of further information from the supplier and designer. The team, by the end of the discussion had a working plan to get the job done without any further delay.

On completion of the first finished attempt they all had a discussion on how it had gone and with minor alterations had identified some changes to simplify the process of fitting the remainder of the sun pipes. This process of reflection and problem-solving has been a typical 'tried and tested' approach to dealing with innovative problems to keep project work on target for site-based staff. It inevitably requires a team approach and the team will not articulate their knowledge without specific reason, in this case, SVQ assessor asking candidate to reflect on their personal problem solving skills, personal contribution to team success and their own personal development. The candidate had to then articulate this example in their assessment evidence for the assessor writing a reflective personal statement, thereby learning more about themselves. It could be argued that in the tripartite model of knowledge transfer this example demonstrates each of the concepts of knowledge, social network structure and trust in relationships (Butler *et al.*, 2007). This task being complete, the knowledge the site supervisor and the team had gained was not written down anywhere (no practical reason to do so) and no changes to drawings or supplier instructions arose from the problem that was solved; therefore this 'knowledge' was then embedded in the memories of those involved for any future use and was only evident when asked to reflect upon recent problem solving examples for the purposes of SVQ assessment.

In every case the individuals were personally motivated to succeed and had either identified the appropriate opportunities themselves or by the company and provided with the necessary resources to support their personal development with the exception of the belief that there was a lack of time, confirming the underpinning motivational drivers for successful learning (Seward 1952).

## **DISCUSSION**

Candidates for SVQ awards vary in length of experience prior to undertaking their award and it is possible to make the assumption that length of service in any kind of supervisory/management role correlates with the level of accumulated knowledge. This issue was examined in detail (Armstrong and Mahmud, 2008) and the results of their study successfully refuted any correlation between the duration of experience and accumulated tacit knowledge and confirmed that how people learn from experience is of greater influence. Discussions with candidates prior to starting their awards to assess their readiness for the SVQ and to determine the appropriate level of study for their existing experience and ability to produce evidence confirm this finding; there are other variables that have more impact on accumulated tacit knowledge other than duration in any particular role.

Previous studies (Garrick, 1998; Boud, 2003) suggest that informal learning and interaction with peers have more impact than formal training, which is perceived by them as having marginal impact. Whilst we recognise that the analysis shows clear evidence in the themes of team-working supporting the essential role of interaction with peers that the formal training was an essential element in the learning process

when reflection revealed improvements in record keeping and planning as well as communicating and working better with others. We would argue that the intervention of assessors, for example, in the formal training towards the SVQ award process for site supervision and site management, has not been fully recognised in these studies as a catalyst for learning through reflection with the additional requirement of articulating this in either verbal responses to the assessor or written statements to demonstrate competence. Candidates within the SVQ process for site supervision and site management appreciated how their knowledge, through the award, had been broadened to help them better understand their role and working environment and the ability, with a depth of knowledge, to make more effective decisions.

The SVQ assessment process, due to the experience of assessors and the assessment framework, encourages candidates to reflect on their learning and decision making processes to ensure that candidates can articulate their knowledge. It is argued that tacit knowledge cannot be captured, translated or converted and can only be inferred from actions and statements (Tsoukas, 2002; Armstrong and Mahmud, 2008); observation of working practice is a part of the assessment of the SVQ. The SVQ award provides a means for a candidate to evidence knowledge through, for example, reflective writing in their numerous personal statements, responses to questions from assessors in interviews/viva and observation by the assessor of the candidate at work. In our experience the intervention of the assessor is an essential part of the learning process. The assessor observes the candidate at work to use observation to confirm competence and inform discussion surrounding decision-making and problem solving to prompt the candidate, where required, to reflect upon and then articulate how they know what they know to be an appropriate and successful way of doing things on site.

The research identified the key role of reflective discussions on learning achievement based on developing new knowledge required to achieve the SVQ site supervision, site management and construction management qualifications. There is formal reflection with the assessor for specific assessments to articulate justifications in support of decisions made and informal reflection with colleagues as part of problem solving. Where the assessor is involved the process could be described as a form of knowledge transfer where the more experienced assessor uses their knowledge to encourage the candidate to seek answers to questions in a range of ways to demonstrate they are competent. How candidates learn is then internalised through repetition and familiarity for certain tasks, through reading and discussion for new information and through reflection when trying to understand the importance of the new information. It is possible to distinguish these two types of learning that appear to be taking place on sites; deliberative learning when the focus is towards SVQ achievement and time set aside for that purpose (Eraut, 2000) and implicit learning where there has been no deliberate attempt to learn such as learning through problem solving (Reber, 1993). Individual learning for site supervisors and site managers in the SVQ process is contextualised and that intuition forms part of developing the expertise required of the individual, confirming the observations of Farrar and Trorey (2008) in their study of vocational learning in dry stone walling. The reflection process helps site based staff transform new information into personalised knowledge when they reflect on what this information means for their understanding of how they currently do their job and tasks and what this new knowledge can mean. It could be argued that the process of reflection is where the distinction between knowledge of the world (know-what) and knowledge in the form of skills and competence (know-how) takes place (Johnson *et al.*, 2002).

Prior to taking on a leadership role candidates could rely on others leading them to put forward ideas and solutions allowing them to avoid having to think critically or justify a decision; and in this, usually passive role prior to taking responsibility for leadership, they do not feel any ownership for a decision if things go wrong even if they had the ability to question and challenge the decision. When asked why a passive attitude was adopted prior to engaging with the SVQ it is attributed to previous negative experience (whether real or perceived) in challenging decisions of supervisors/managers - reinforcing in some people a negative learning behaviour that 'even if you know better, say nothing'. Taking on a leadership role requires greater thinking about all sorts of decisions and given the accountability for decisions the focus of SVQ candidates on pre-empting potential problems to reduce the consequences of making a poor decision. The interviews identified evidence of an attitude shift away from blaming people for failure within a working site environment towards recognition of learning from situations where things have gone wrong to avoid repeating mistakes in the future. Candidates are aware of being judged by others in the working environment all the time in doing their job by both peers and seniors, including making sound decisions consistently and reputation was cited as an important aspect of professional capability and recognition for candidates.

During the SVQ process assessors not only cover technical questions but use their experience to get candidates to think about how it felt when they weren't listened to by supervisors and to remind them that everyone is always learning, including them as supervisors. Several candidates cited that their personal listening skills and teamwork improvements related to a better understanding of why this is an important issue for leadership and team development with examples of improvements on site related directly to this factor. Assessors have the experience of the workplace to know that listening is an important skill to learn for a site supervisor and site manager so that if one of the team disagrees with a decision or the way something is to be done the supervisor could explain their decision fully. In this way other people can understand the rationale for the decision; thereby helping everyone to learn more through the decision-making process.

## **CONCLUSIONS**

This study has investigated, through 26 semi-structured interviews, how site supervisors and site managers learn through the SVQ process. The investigation explains aspects of how knowledge and skills are developed through vocational training in addition to informal methods such as problem solving and colleagues. It has been found that Phronesis is evident on a day-to-day basis on site activities developed through reflective practice in personal development. It has been found that during the SVQs individuals have stretched themselves to realise greater achievements; the reflective practice in developing knowledge builds, within individuals, a better understanding of themselves and their capabilities. There is a clear perception by those completing the qualification that it has enabled them to perform their job better identifying numerous examples relating to problem solving, critical thinking, making decisions and leadership. There is scope to investigate further the role of the assessor in the learning process. The mentorship of experienced assessors appears to be an essential part of developing tacit knowledge and reflective practice in developing practical wisdom; it is proposed that this factor may be explored in more detail in future work.

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# **ENVIRONMENTAL ASSESSMENT**



# POST OCCUPANCY EVALUATION (POE): A BREEAM EXCELLENT CASE STUDY

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Despite many challenges, building industry stakeholders of the early 21st century could be viewed by future generations as pioneers for sustainable development and construction. That is, this industrial chapter may be remembered as one in which the demand for heat and power in buildings and associated carbon emissions ceased to be on an upward trajectory. In addition to the concept of a low carbon, low energy built environment, this period may also be acknowledged as one in which the comfort, health and wellbeing of building occupants is fully included. This honourable legacy is arguably within reach due to clearly-stated national and international policies on climate change, energy consumption, safety and end-user comfort. Post-occupancy evaluation (POE) is an important mechanism for the construction industry to objectively measure building performance against policy targets. A function of POE is to capture the value of 'in-use' demand in comparison with theoretical performance. The information gathered can be collated to underline performance outcomes in building energy usage, carbon emissions, wider environmental impacts and end-user satisfaction, thus providing (1) a benchmark for building operation and (2) a route map for future developments and initiatives. This paper draws upon a case study to explore the value of POE of a BREEAM Excellent building. Opened in 2011, the five year occupancy timescale will disclose key performance data. Findings from the POE study will be drawn upon to investigate potential performance gaps that may exist between BREEAM model predictions and actual results for three key parameters: 1) energy (electricity and gas), 2) water (supply and waste) and 3) social performance (comfort, health and wellbeing). Whilst the design of low carbon, low energy buildings is commendable, recording and interpreting actual building performance is a fundamental step in the continuous improvement of sustainable construction outcomes.

Keywords: sustainability, BREEAM, post-occupancy evaluation

## INTRODUCTION

"Post-Occupancy Evaluation (POE) is a structured process of evaluating the performance of a building after it has been built and occupied" (Menezes *et al.*, 2012 p.357). For many years there has been considerable debate on the performance of buildings, both domestic and non-domestic especially when comparing design performance versus operational performance. Industry critics have long suspected that building performance in operation most notably in the area of energy consumption has consistently failed to meet predicted outcomes. In the wake of the Innovate UK publication 'Building Performance Evaluation Programme: Findings

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from non-domestic projects (2016), the reality of this ‘performance gap’ has been laid bare. Reviewing the apparent scale of the problem (Knutt, 2016), the ‘performance gap’ challenge facing UK construction is likely to occupy the minds of industry stakeholders for the foreseeable future.

Given the findings published by Innovate UK (2016), the role and future significance of POE has undoubtedly increased. Actual building performance clearly requires to be evaluated against predicted design benchmarks; only through a process of in-use evaluation can lessons be learned that can inform future design. This is the first step in continuous performance improvement towards the goal of a low carbon, low energy built environment. According to Atkins and Emmanuel (2014 p.12), the dual benefits of a robust POE protocol is; first it provides a mechanism to improve energy use and end-user comfort and secondly, understanding gained through POE experience will contribute to "the development of improved standard assessment methodologies". This necessity for POE refinement is arguably a reflection of a nascent practice.

The realization that many newly certified low carbon, low energy buildings significantly exceed their pre-occupied design estimates is sobering, raising numerous questions about design, construction and operability. The problem is undoubtedly complex. In addition to any disparity between the original building design and predicted energy consumption / performance (fabric performance) there is also the question of economics (industry profitability) and social desire (market enthusiasm) for low carbon low energy buildings. Whilst the focus of this research is POE of a BREEAM excellent facility and the building performance after a five year occupancy period, other ‘dimensions’ of the performance gap equation require to be acknowledged (Tierney and Tennant, 2015). Indeed, future discussion of POE and by extension building performance strategy will in all likelihood blur the lines between energy consumption, industry accountability and wider societal attitudes towards a low carbon low energy built environment.

The paper is presented in a standard format. Following a brief synopsis of POE, the BREEAM model is reviewed and the research case study outlined. Thereafter findings and analysis from the POE study will be drawn upon to investigate potential performance gaps that may exist between as-designed model predictions and actual results for three key parameters: 1) energy (electricity and gas), 2) water (supply and waste) and 3) social performance (comfort, health and wellbeing). The discussion explores pre-occupied certification with actual performance outcomes and discloses potential challenges in achieving meaningful and comparable evaluations. In contrast to the pessimistic overtones associated with recent findings (see Innovate UK, 2016), it is suggested that recording and understanding actual building performance is a positive and fundamental step in the continuous improvement of a sustainable construction strategy. The paper concludes with some reflections.

## **BUILDING PERFORMANCE EVALUATION**

Objectively measuring the quality of the construction process has been enshrined in the building practice(s) of many countries for centuries. For example, rule 229 of 282 in the Code of Hammurabi in ancient Mesopotamia is around 3700 years old and included the following declaration addressing issues of structural integrity; “if a builder build a house for a man and do not make its construction firm and the house which he has built shall collapse and cause the death of the owner of the house, that builder shall be put to death (taken from Prince, 1904 p.607). Whilst the ‘event’ and ‘consequence’ in this building code is extreme, the inference that builders retain

accountability for a period after handover for the services and products they offer is arguably pertinent.

As European cities developed in both size and scale in the middle ages and problems associated with access, land encroachment, fire safety and, of course, structural integrity started to emerge for civic authorities, building standards evolved accordingly. In addition to progressive and increasingly prescriptive 'Technical Standards', interest in the systematic evaluation of building performance as a discrete practice has its origins in the 1960's (BSRIA, 2011). Whilst early interpretations of building performance largely overlooked in-use energy consumption, occupant feedback and empirical evidence of operational efficiency, management systems for improved analysis and mechanisms for meaningful feedback began to develop. In 1975, the Post Occupancy Review of Buildings and their Engineering (PROBE) studies represented a significant development in building performance understanding and arguably remains an industry yardstick for subsequent performance studies of multiple building types (BSRIA, 2011).

To date, the most significant aspect of building performance evaluation is in the area of sustainability. In 1990 the UK government published 'This Common Inheritance, Britain's Environmental Strategy' (DOE), which set out for the first time UK Government policy to address environmental concerns. A key driver has been the UK Government's commitment to reduce carbon dioxide emissions by 80% by 2050 when compared with 1990 levels (Menezes *et al.*, 2012). Coincidentally, in 1990 the Building Research Establishment published its first Environmental Assessment Method (BREEAM). Since first launched, BREEAM has continued to grow in popularity and it is estimated to have been used to evaluate and certify the environmental performance of more than 540,800 buildings in over 75 countries (BREEAM, 2016). For many construction professionals, BREEAM is now a familiar design and construction environmental assessment tool (Schweber and Haroglu, 2014).

More recently, the UK Government introduced an initiative called 'soft landings'. With its origins in the PROBE studies (BSRIA, 2011) which date back to 1975, soft landings is focused on the notion of 'building aftercare' with the objective to promote designers, contractors and service engineers help new clients understand how their building(s) operate and maximize the efficiency of the building management systems in place. Although beyond the scope of this case study, Government Soft Landings (GSL) is a pillar of BIM level 2 adoption (Adams, 2016) and an important component of an embryonic and overarching building performance evaluation strategy.

## **BREEAM ACCREDITATION**

BREEAM is a credit-based environmental assessment system addressing key categories of a building specification: energy use, health and wellbeing, innovation, land use and ecology, materials, management, pollution, transport, waste and water. A building design is assessed against the maximum number of credits available in each category and rated accordingly. An overall percentage score is awarded and a BREEAM rating of 'unclassified' (<25%), 'pass' (≥25 - <40%), 'good' (≥40 - <55%), 'very good' (≥55 - <70%) or 'excellent' (≥70%) can then be applied. It should be noted that these figures are for BREEAM Bespoke 2006. A further summary classification of 'outstanding' (≥85%) is now awarded in BREEAM but was not part of the BREEAM Bespoke 2006 procedure and the requirements for 'pass' and 'good' are now ≥30 - <45% and ≥45 - <55% respectively.

For this POE case study, BREEAM Bespoke 2006 was used to evaluate energy and transport combined, materials and waste combined, health and wellbeing, land use and ecology, management, pollution and water. The overall percentage awarded in February 2008 was 71.38%. This environmental evaluation ( $\geq 70\%$ ) equated to a BREEAM rating of 'excellent'. The aim of this case study is to review the pre-occupancy predictions made for energy, water management and health and wellbeing at the 5-year post-occupancy juncture. Three key categories of the BREEAM Excellent rating from February 2008 have been selected for PO analysis in 2016: (1) energy use and associated carbon emissions; (2) water usage and the pollution aspects associated with site surface water and flood risk reduction and (3) health and wellbeing of building users. Note, the criteria for credits awarded in 2016 (five year POE) relate to evaluation guidelines set out in BREEAM Bespoke 2006.

## RESEARCH STRATEGY

The objective of this POE case study of a BREEAM Excellent facility is to add to the body of work reviewing the performance of pre-occupied certified sustainable building projects. The primary research data is taken from energy meters located onsite and accessed via a central data base. This is augmented by secondary data including a literature review of recent publications including research articles, books and magazine editorials. Anecdotal evidence from meetings with in-house Facilities Management (FM) personnel is also drawn upon to support findings and discussion.

There are two related research questions. First, do the case study findings correlate design intention with post-construction reality in terms of energy use, site water management, including flood risk reduction and occupant health and wellbeing (satisfaction)? And, second, if there is any discrepancy between the predicted and actual performance is this because (a) the prediction methodology was flawed, (b) the construction process was unsatisfactory or (c) a combination of both?

The case study is a POE of a BREEAM Bespoke 2006 'Excellent' award made in February 2008 for a university campus building located in South-West Scotland. Building use, occupancy and resources is shared by two higher education institutions. The original outline business case (OBC) for the shared campus began in 2006 with funding approved in 2007. The construction phase commenced in October 2008 with handover in May 2011. In 2012, the building received the Green Gown Award: Modernization - effectiveness and efficiency in the estate. This award recognizes enhanced sustainability without compromising core business objective of 'value for money'. BRE was commissioned to undertake a POE - operational review, this was initially scheduled to take place within 3 - 6 months of handover however due to funding delays, the timeframe slipped to 12 months.

The research is site-specific in its analysis, but anticipated that outcomes can inform industry-wide understanding of post-occupancy building performance. There are a number of limitations and assumptions. A case study is unique and may have contextual constraints that inhibit like for like comparison (Leaman *et al.*, 2010). To mitigate potential differences, the POE draws on performance criteria used at the design stage and set out in BREEAM bespoke 2006. In addition, definition and measurement of building performance may also be contested. Any deviations in performance measurement may skew final interpretations. Despite these caveats, performance measurement is an important starting point and whilst industry-wide generalizations come with a 'health warning', assimilation with recent publications

(see Innovate UK, 2016) provides a valuable, interesting and ongoing contribution to the 'performance gap' conversation.

## RESULTS, ANALYSIS AND DISCUSSION

### (1) Primary energy demand and reduction of CO<sub>2</sub> emissions (Credit E1)

The results disclose a key post occupancy adjustment. A notable outcome of the POE is the reduction of 2 credits (7 credits in 2016) for E1 (Reduction of CO<sub>2</sub> emissions). For this case study, the original award of 9 credits in 2008 implied an 18% improvement over and above the building regulations (2006) requirement of a minimum 23% improvement on the notional Building Emission Rate (BER) value (119 kg CO<sub>2</sub>/m<sup>2</sup>) for naturally ventilated office buildings. In other words, a 41% (18% + 23%) improvement on 119 kg CO<sub>2</sub>/m<sup>2</sup>, this equates to 70 kg CO<sub>2</sub>/m<sup>2</sup>. The case study gross floor area is 18000 m<sup>2</sup>, which equates to an as-designed annual CO<sub>2</sub> emissions rate for the facility equal to 1260000 kg CO<sub>2</sub>. The framework for comparative credit awards to be made in 2016 based upon actual energy usage data from the metering records for the facility is shown in Table 1.

Table 1: Case study year-5 credit assessment for Energy

BREEAM reference	Credits available in BREEAM Bespoke 2006	Credits awarded in BREEAM Bespoke 2006	POE survey credits awarded 2016 (change)
E1 Reduction of CO <sub>2</sub> emissions	15	9	7 (-2)
E2 Sub-metering of substantial energy uses	1	1	1 (0)
E3 Sub-metering of areas / tenancy	1	0	0 (0)
E4 External lighting	1	1	1 (0)
E21 Energy efficient fume cupboards	1	1	1 (0)
E (Eco) 4 Provision of energy efficient white goods - fridges / freezers	1	1	1 (0)

To facilitate predicted versus actual energy performance, annual energy consumption for 2011-12 reveals that 1903 MWh (gas), 1924 MWh (electricity) and 1959 MWh (biofuel) were used. The total actual Building Emissions Rate (BER) for 2011-12 was 68kg CO<sub>2</sub>/m<sup>2</sup> (<70 kg CO<sub>2</sub>/m<sup>2</sup>). In 2012, the two biofuel boilers were replaced by gas boilers. This was a decision based primarily on economics although it was noted that the burners proved to be less reliable than previously expected. Given the excessive price of biodiesel in comparison with fossil fuel (gas) coupled with poor reliability, it became financially problematical to justify the operation of an alternative low carbon energy source. Subsequent meter readings for 2014-15 were 2979 MWh (gas) and 1910 MWh (electricity), which means that the total actual Building Emissions Rate (BER) for 2014-15 increased to 77kg CO<sub>2</sub>/m<sup>2</sup> (>70 kg CO<sub>2</sub>/m<sup>2</sup>).

From the figures, the predicted BER in June 2007 can be seen to have been very accurate and, if anything, slightly cautious on energy consumption when gas, electricity and biofuel were all used in 2011-12. The nine credits awarded in BREEAM category E1 are therefore valid at that point in time. The removal of the biofuel from the heating and hot water strategy meant that the actual BER in 2014-15 increased to 77kgCO<sub>2</sub>/m<sup>2</sup> from the predicted 70kg CO<sub>2</sub>/m<sup>2</sup>, this means that the nine credits awarded would be seven retrospectively. The loss of two credits in the E1 category has the effect of reducing the overall BREEAM rating from 71.38% to

69.96%. The overall BREEAM rating would be compounded further with the replacement of the biofuel boilers, resulting in the loss of a further three credits in the Pollution section (P11 category). The loss of three P11 credits means that the overall BREEAM rating for the POE 2016 reduces from 71.38% to 67.15% and therefore downgrading the facility from BREEAM 'Excellent' to BREEAM 'Very Good'.

Despite the apparent re-classification, it is important to note that the inferred carbon emissions target of 70kgCO<sub>2</sub>/m<sup>2</sup> per year is a specific targeted improvement on the 'notional' building emissions rate (BER) of 119kgCO<sub>2</sub>/m<sup>2</sup> for a naturally ventilated office building as per case study documentation dated June 2007. Given the case study building is only partially naturally ventilated, the BER for mixed mode ventilation (natural and mechanical) is likely to be higher than the documented 119kgCO<sub>2</sub>/m<sup>2</sup>.

### **Important prescriptive aspects of BREEAM Bespoke 2006**

This section of the POE explores BREEAM credits awarded largely on the basis of a building specification checklist. In contrast to the potential variance in performance frequently associated with energy demand and CO<sub>2</sub> emissions, there are key aspects of building design and construction where the POE is relatively constant. Key aspects selected for discussion are; (2) Water and Pollution categories: minimising flood risk (P7), renewable and low emission energy technology (P11), potable water consumption (W1); and, (3) Health and Wellbeing category: day lighting and window views to outside (HW1 and HW2), artificial lighting (HW3 - HW7), internal air pollution (HW9) and ventilation rates (HW11).

#### **(2) Water (building water usage, surface water run-off and flood risk)**

Three credits were awarded for the design approach to surface water run-off and flood risk in the campus environment (P7). The importance of this aspect of a sustainable built environment has become very well known to many communities in the UK in recent years. The strategy for this building design was to take all the rainfall from the estate surfaces including car parks and other hard landscaping to a sustainable urban drainage system (SUDS) pond, which has an attenuation capacity of approximately 4000 cubic metres. The POE survey has noted that the SUDS pond has worked effectively as a flood risk reduction feature both at the site and by mitigating any additional pressure to the local sewer pipe work on heavy rainfall days.

The BREEAM category that aims to minimise the consumption of potable water (W1) in buildings awards up to three credits for compliance. In this case study, two credits were awarded for specifying dual flush WCs to reduce flush volumes from 6 litres (full flush) to four litres (partial flush) and, secondly, for specifying waterless urinals. Aspects of W1 that were not specified in the case study included electronic sensor, spray or aerating taps or timed push taps. Interestingly, the last of these (timed push taps) are installed in many locations throughout the building. The framework for comparative awards to be made for water management and pollution risks in the year-5 POE in 2016 is shown in Table 2.

Table 2: Case study year-5 credit assessment for Water and Pollution

BREEAM reference	Credits available in BREEAM Bespoke 2006	Credits awarded in BREEAM Bespoke 2006	POE credits awarded 2016 (change)
W1 Water consumption	3	2	2 (0)
W2 Water meter	1	1	1 (0)
W3 Major leak detection	1	1	1 (0)
W4 Sanitary supply shut off	1	1	1 (0)
W5 Water recycling	1	0	0 (0)
W6 Irrigation systems	1	1	1 (0)
P7 Flood risk / water run off	3	3	3 (0)
P8 Minimising water course pollution	1	1	1 (0)
P11 Renewable and Low Emission Energy	3	3	0 (-3)

### (3) Health and wellbeing of building users (occupant comfort, safety and satisfaction)

The Health and Wellbeing section of BREEAM Bespoke 2006 applied more categories than any other in this case study (18 in total) and clearly signals that the comfort and health of building occupants is a significant consideration for a BREEAM sustainable building design (and construction) audit. BREEAM reference HW1, HW2-7, HW9 and HW11 have been highlighted here for their general importance to building occupant well-being and because of specific interesting observations made during the POE case study.

HW1 awards one credit where at least 80% of the occupied building floor area has adequate daylight provision (glazing area being the key influence), aiming at an average daylight factor (DF) of 2%, measured as the ratio of internal to external illuminance, expressed as a percentage. The DF of 2% is not an onerous minimum requirement and most commentaries emphasise the potential gain in health and wellbeing. In this POE of a BREEAM Excellent building, the credit was not awarded. The initial evaluation included an observational survey of the staff offices and found it necessary for the artificial lighting to be on for most days during the observational period.

This category of the POE focuses upon the award of credits for the expected health and wellbeing of building occupants. The year-5 case study addresses these matters by determining the credits achieved in an observational verification survey in 2016 (see Table 3). A summary point of this survey finding is as follows: the atrium and south façade offices and classrooms are very well served by natural daylight but the north façade and courtyard orientated offices are not. The primary reason for this is the importance placed upon the super-insulated wall fabric, which inevitably reduces the glazing surface areas.

HW2 awards one credit for the provision of a view to the outside for all occupants. This was not used in all parts of the building assessment, but the credit was awarded where applicable and was verified in the POE observational survey work. HW3-7 are

all associated with credits to be awarded for visual comfort in the building and all of these were awarded: glare control from internal or external blinds (HW3), high frequency fluorescent lighting to avoid a flickering perception that can be evident with low frequency fluorescent light fittings (HW4), appropriate illuminance (lux) levels for all parts of the building (inside and outside) (HW5), the provision of separate lighting zones to allow variation control in the building (HW6) and switching arrangements that allow easy light settings control (HW7).

Table 3: Case study year-5 credit assessment for Health and Wellbeing

BREEAM reference	Credits available in BREEAM Bespoke 2006	Credits awarded in BREEAM Bespoke 2006	POE credits awarded 2016 (change)
HW1 Daylighting	1	0	0 (0)
HW2 View out	1	1	1 (0)
HW3 Glare control	1	1	1 (0)
HW4 High frequency lighting	1	1	1 (0)
HW5 Internal and external lighting levels	1	1	1 (0)
HW6 Lighting zones	1	1	1 (0)
HW7 Lighting controls	1	1	1 (0)
HW8 Potential for natural ventilation	1	0	0 (0)
HW9 Internal air pollution	1	0	1 (+1)
HW11 Ventilation rates	1	0	1 (+1)
HW14 Thermal comfort	1	1	1 (0)
HW15 Thermal zoning	1	0	0 (0)
HW16 Microbial contamination	1	1	1 (0)
HW17 Acoustic performance (ambient noise levels)	1	0	0 (0)
HW17 Acoustic performance (room reverberation time)	1	1	1 (0)
HW19 Safer parking	1	1	1 (0)
HW25 Laboratory fume cupboards	2	2	2 (0)
HW26 Containment Level 2 & 3 laboratory areas	3	2	2 (0)

The risk of internal air pollution is assessed in HW9 and refers to the location of fresh air intakes in the ventilation system and specifically that they must be away from sources of external air pollution such as car parks and roads. In the BREEAM analysis carried out in 2007, this credit is not awarded, but this position is certainly worth reviewing given the car park and roadways around the campus building are substantially more than the required 20m distance from openable windows and ventilation system intakes. Also worth reviewing is the credit considered in HW11 for providing minimum building ventilation rates. In spite of being a mandatory building control requirement, the credit was not awarded in 2007. The reason being, that HW11 is directly linked to HW8, which requires all external façade windows to be openable. The case study building has some external windows that do not open and perhaps, therefore, suffers an unfair 'double jeopardy' penalty. Two extra HW credits

would take the overall BREEAM rating from 67.15% to 69.38%, which is very close to the 2007 BREEAM 'Excellent' rating.

### **POE: Benchmarking performance**

The POE results for this case study are essentially positive and therefore contrast recent findings in the Innovate UK report (2016). However, reservations remain regarding the operational ease of PO measurements of building performance and their frequency. Many of the POE credits awarded adhere to a checklist of design and built requirements as opposed to 'actual' building performance. Indeed, the calculation of BER was one of the few areas where actual building performance in terms of energy consumption was measured against as-designed calculations. Reviewing this case study, it is very important to highlight the definite need to connect initial design aspirations with a range of post-occupancy building performance analyses.

Drawing on both Menezes *et al.*, (2012) and Atkins and Emmanuel (2014) there is a requirement for environmental performance modelling to be objectively verified for accuracy and for POE to be interpreted as a process, not just an event. There are arguably two rational approaches to building performance measurement; a prescriptive based approach or alternatively a performance based approach. The prescriptive based approach, not dissimilar to the assessment discipline adopted by BREEAM would set out clear guidelines which if satisfied would support the award / rating of an environmental performance. Alternatively, a performance based approach could be adopted where resultant performance standards are established but crucially no recommended route to achieving these standards is specified. A performance based approach would also ratify the idea of staged 'environmental' building classification. At design / handover (year zero) a 'predicted' award would be made, at handover plus one year (year zero + 1) a 'provisional' award would be made based on a 12 month POE and at three years (year zero + 3) a 'full' award would be presented. Throughout the design, build, operate process, the environmental classification may alter dependent upon actual, post-occupancy performance outcomes.

Adoption of a performance based and staged approach (predicted / provisional / full award) for the environmental classification of buildings would also endorse the notion of mandatory post occupancy evaluation. Although not a new concept (Heffernan *et al.*, 2012), in the UK objective post occupancy evaluation of actual energy efficiency remains a largely unorthodox practice. Given Government targets for CO<sub>2</sub> reductions, the measurement and evaluation of actual energy consumption needs to become a cornerstone of a viable and sustainable low carbon, low energy construction strategy.

## **CONCLUSIONS**

POE in building design, construction and operation is fundamental. Without objective review, analysis and comparison between predicted and actual performance future opportunities for improvement in building design, construction and operability may be missed. Repeated industry inability to capture and reflect on 'live' data sets may inadvertently facilitate ongoing sub-standard performance.

This case study makes two notable contributions to the performance gap debate. First, currency, the positive case study PO findings are in contrast to the negative tone reflected in the recent Innovate UK report (Innovate UK, 2016). Second, the analysis and discussion highlight common tensions between finance, efficiency and low carbon design solutions. Given the many challenges associated with POE and achieving

meaningful comparison it is suggested that a prescriptive model of assessment is overly cumbersome. Future debate should not only focus on the performance gap per se; the validity, protocol and ease for environmental modelling should also be explored. In addition, case study findings and analysis support the idea that POE needs to become a mandatory element for every new construction project (domestic and non-domestic) if UK carbon emissions reduction targets set by the Energy Performance of Buildings Directive (EPBD) (OJEU, 2010) are to be realised.

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# PERSPECTIVES AND PRACTICES OF COLLABORATIVE ENERGY DESIGN TECHNOLOGIES FOR CLOSING THE BUILDING ENERGY PERFORMANCE GAP

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Both researchers and practitioners have increasingly observed the significant deviation of buildings' actual energy consumption from their design predictions, which is known as the "performance gap". The organizational and procedural fragmentation of multi-disciplinary stakeholders has been realized to be a major cause of the performance gap. Nevertheless, little of previous research addressed the performance gap from the perspective of improving design stakeholders' collaboration. The widespread adoption of information technologies has generated a paradigm shift of stakeholders' collaborative design. The aim of this paper is to figure out technical characteristics of information technologies that help to improve stakeholder collaboration, so as to close the performance gap. The research takes the basis of information processing theory, and was carried out through the combination of a critical literature review, semi-structured interviews of ten industry representatives, and case studies of six state-of-the-art energy design tools. A comparative analysis was then conducted between academia research, industry perspectives, and technical practices. The findings of this paper suggest that there are mismatches between current practices and perspectives. Improvement strategies were finally proposed to contribute to the understanding and development of collaborative energy design technologies.

Keywords: building energy performance gap, collaborative design, BIM, information and communication technology

## INTRODUCTION

According to IPCC, building construction, operation and maintenance together account for 40% of the energy sources used, which has led to energy-related carbon emissions of 36% in industrialized countries (Metz and Davidson, 2007). However, noncompliance with building energy regulation and discrepancy between predicted and measured building energy performance has been widely reported (Pan and Garmston, 2012, Frank *et al.*, 2015). Such discrepancy is often referred to as 'building energy performance gap', or 'credibility gap', and has attracted urgent and significant attention of government, industry and academia. Some researchers found that for some officially certified (e.g. LEED) low energy buildings, the measured performances are not in agreement with the credits they obtained (Newsham *et al.*, 2009, Agdas *et al.*, 2015). Building energy design is a dynamic, iterative information processing activity in order to cope with various uncertainties. In many cases, the

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performance gap mainly result from inappropriate handling with building design information due to the lack of collaboration between multi-disciplinary stakeholders. Nevertheless, little of previous research addresses the performance gap from the perspective of stakeholder collaboration. This paper aims at investigating current perspectives and practices of collaborative building energy design technologies through strategic literature review, semi-structured interviews, and case studies. Two research questions are primarily investigated in the research:

- What technical features can improve stakeholder collaboration, so as to close the performance gap resulted from the inability to process design information?
- What are the knowledge gaps (academic research vs. industry perspectives), implementation gaps (industry perspectives vs. technical practices), and technology gaps (academic research vs. technical practices) in the development of collaborative design tools?

## RESEARCH BACKGROUND

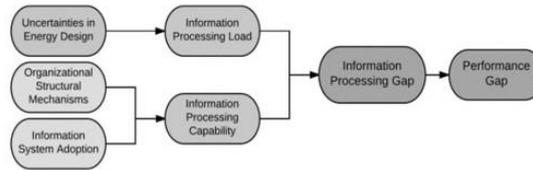
Researchers and industry experts have realized that the performance gap results from various causes throughout multiple stages of a building project. De Wilde (2014) classified the root causes into three main categories: causes that pertain to the design stage, causes rooted in the construction stage (including handover), and causes that relate to the operational stage. Menezes *et al.*, (2012) proposed another categorization that groups the casual factors into both prediction and actual parts. Previous empirical studies have revealed many situations in which the integrity of design information is harmed when information is transferred among project stakeholders, including omission, errors, and fuzziness (Opitz *et al.*, 1997, Bordass *et al.*, 2001, Stevenson and Rijal, 2010, Coleman *et al.*, 2012, Dong *et al.*, 2014). It provides another perspective of investigating the performance gap, i.e. the lack of information integrity in building energy design. Due to the lack of information integrity, designers cannot correctly estimate actual operation conditions, while design intentions are not fully comprehended by contractors and operators, so that the performance gap appears.

Building design stage is an information-intensive process in which most key decisions are made. The information processing theory identifies three important concepts: information processing needs resulted from internal and external uncertainties, information processing capability, and the fitness between the two to obtain optimal performance (Galbraith, 1973). The information processing capability refers to the ability to gather, synthesize, and disseminate information properly to cope with uncertainties, and is primarily supported by proper organization structure and implementation of information system (Tushman and Nadler, 1978). Achieving a fit between the information processing needs and the information processing capability to attain optimal organizational performance has been a primary focus of organization designers (Daft and Lengel, 1986). Project teams in construction project have long been viewed as information processing organizations. The performance gap issue can thus be regarded as the consequence of the mismatch between project team's ability to cope with design information and its information processing loads, i.e. information processing gap (see Figure 1). The implementation of collaborative technologies is therefore essential to achieve better information integrity in building energy design, so as to close the performance gap.

Current information management and interoperability solutions support a small amount of integration, either through the supply chain or along the design path. These approaches are typically vendor-specific and tie together a small number of design

tools, which are unlikely to facilitate a fully integrated team involved in a construction project (Owen *et al.*, 2010). Previous research has discussed a lot on the socio-technical feasibility of integrated, project-level collaboration platforms that enables teamwork of various stakeholders.

Figure 1: Information processing gap and the performance gap

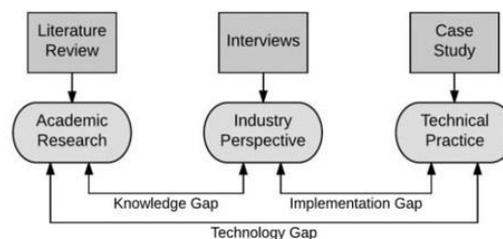


In the development of low energy building projects, performance-based evaluation and associated coordination is particularly required in the design process. Nevertheless, traditional energy design tools focus mainly on the mathematical simulation of sustainability-related aspects such as thermal, lighting, and airflow, and there is usually an overlook of technical collaborative features.

## METHODOLOGY

The research data were collected in three correlated phases. A strategic literature review of current document-based collaborative technologies and their application in building energy design was conducted in a meta-analysis approach. The transition and composition of research focuses were figured out in the review. Ten semi-structured interviews were conducted with representatives from five key stakeholder groups in Hong Kong building industry, i.e. developer (two), architect (three), engineer (two), contractor (two), and facility manager (one). The interviews aim to identify the awareness, expectations, and requirements of collaborative technologies across multi-disciplinary professionals. Six state-of-the-art collaborative tools for building energy design were analysed using an integrated evaluation framework. The aim of the case studies is to test functionalities, usability, and limitations of technologies that are currently available to building energy designers. The findings of the three phases are then analysed comparatively, based on which the knowledge gap, the implementation gap, as well as the technology gap, are identified (see Figure 2).

Figure 2: Research methods



## RESULTS AND ANALYSIS

### Literature review findings

The literature review was carried out through the examination of journal articles related to collaborative building energy design technologies, and the articles were generated in a searching and screening process from the Scopus, ScienceDirect, and ISI Web of Science. Searching keywords were identified and the criteria of searching control and screening were established, in order to keep the scope of the review manageable and to provide sound results. The searching was limited to topic only,

including title, abstract, and keywords. Only technical solutions for collaboration in the design stage were considered, and the functionality of the tools was limited to whole building energy/sustainability design. The searching results indicate growing research outputs of collaborative tools to support building energy and sustainability design, which are in multiple levels of maturity and usability.

Table 1: Literature searching keywords and screening results (total=106)

Searching keywords (OR is logically prior to AND)	Theoretical framework	Technical prototype	Practical tool	Review and analysis
Inter-disciplin* OR multi-disciplin* OR integrat* OR collaborati* AND framework OR technology OR tool OR platform AND building AND "sustainab* design" OR "energy design"	48	21	15	22

Figure 3: Transition of research focuses in the reviewed articles (total=99)

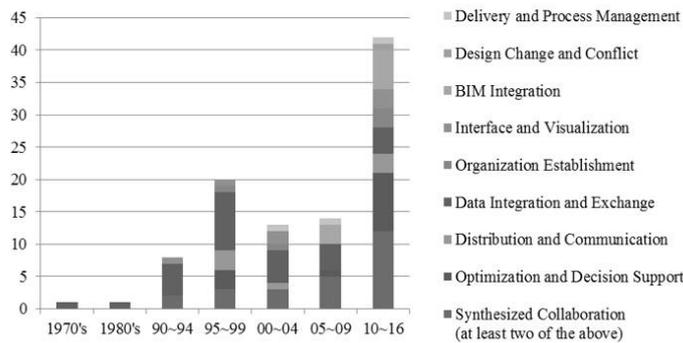


Figure 3 portrays a general picture of various research emphases over the past a few decades. A rising number of synthesized tools have appeared to facilitate design teams on all dimensions. Data integration is a perennial topic since 1970's, and it addresses the foundation of design information exchange. Visualization method and user interface design deeply affect the usability of the tool, and the booming virtual reality technology also provides promising space for further development. Another important feature to support collaborative design is the ability to help designers make right decisions, and many tools adopt optimization methods, e.g. genetic algorithm. Researchers also advocated the necessity that design tools support organization establishment and process management. Building information modelling (BIM) is a globally accepted platform for general multi-disciplinary collaboration and data integration. In the domain of energy and sustainability design, the integration of design tools with BIM platform has gained more and more attentions since 2005. Some other issues were also indicated in the reviewed articles, including tracking design change, conflict management, and establishing communication channels for distributed team members. In the review, some basic technical and implementation-related issues were identified, which are primarily related to:

**Simulation:** A fundamental functional requirement of collaborative energy design tool is the simulation of building system performance. In the context of low energy building, energy simulation provides basic evaluation of different design strategies. The majority of the reviewed tools denote their ability in this domain by integrating thermal simulation cores, e.g. EnergyPlus. More integrated software has been developed as other sustainability-related aspects become necessary.

**Data:** Data integration and exchange method is the basis of building project modelling. The ability of collaborative tools to organize project data relies heavily on the development of design platform. In the era of two-dimensional computer-aided design (CAD), while most design platforms were object-oriented program, the models

they provided were merely graphical objects or "entities". Researchers in the 1990's focused mainly on the project database technologies and the representational schema of complex data types and relationships. Both relational database and object-oriented database were adopted. BIM technology brought about a paradigm shift in the data modelling of buildings. Object-oriented IFC format was widely considered, and its interoperability with various analysis tools was also discussed. Database technology was also adopted along with IFC to serve different functional layers. The gbXML schema, which was specially designed for data exchange between analytic tools, was also widely considered by researchers in the design of collaborative environment.

*Visualization and UI:* Kim and Degelman (1998) argued that user interface system for computer-aided building design (CABD) system is not a simple layer between user and simulation model, but rather a general interface strategy to control simulation models and relevant database. User interface design affects the usability of design tools by formatting the way designers interact with data, design patterns, as well as multidisciplinary collaborators. A primitive interface model is a binary system consisting of a building browser and a decision workbench. The building model browser usually evolves on condition that the data basis of representing model asset has updated. Different from design sketching tools, visualizing model for building analysis requires more 3D visualization of building data. The COMINE project in the 1990's realized the visualization and exchange of 3D models from CAD by establishing an integrated data model (IDM) based on the ISO-STEP initiative. Researchers in the BIM era rely either on interoperating and post-processing existing BIM models, or integrating specified model browser for building analysis, e.g. FZKViewer for xml file visualization. Some studies also took a further step by using virtual reality technologies for better end-user participation in the design process, such as the CAVE system.

*Stakeholder and workflow:* The collaborative nature of tools is mostly instantiated by to what extent various stakeholders are involved. Traditional tools were designed merely for separated design professional, and therefore no collaboration was considered. More synthesized frameworks for various designers were developed, in consideration of the possible delays, confusion, and harms to the final design when multidisciplinary communication is missing. Jansson *et al.*, (2014) proposed a form of platform that is client-driven in order to handle the distinctiveness of building projects through an iterative design procedure between architect, engineer, and clients. Nevertheless, the reviewed tools seldom consider contractors and suppliers. Stakeholder engagement is also influenced by what collaborative technologies are adopted. For instance, virtual reality integrated design system is proposed in order to include occupants early in the design evaluation process (Christiansson *et al.*, 2011, Niu *et al.*, 2016). Computer-aided collaborative design tools also emphasis on parallel design generation and evaluation feedback via the simulation tools. One example is the integration of certificate submission process (e.g. LEED), and thus stakeholders in institutional groups are included.

*Decision support:* The greatest opportunity for low energy building design strategies resides in the early stages of design when most important decisions are made. In complex building projects, many decisions are made based on information obtained from a variety of sources that are well beyond the engineering disciplines. Collaborative tools facilitate decision-making mainly by fully support multidisciplinary information sharing. Another advantage is the ability to retrieve

through the solution spaces and to optimize design for comparison and selection under multiple criteria.

### **Interviews of industry perspectives**

Building design process in Hong Kong is mostly an architect-centred process, surrounded by multidisciplinary consultants and engineers. Environmental consultants take charge of low energy/sustainability design, assisted by architect and system engineer. Regular project meeting is the major chance for collaboration and problem solving. Communication among industry professionals usually takes place through face-to-face meetings, emails, phone calls, and messages. As for data exchange, 2D drawings are mostly used in the project meeting, and paper-based documents are used for energy analysis. BIM serves basically for conflict detection, quantity take-off, and briefing to clients. Environmental consultants use building analysis tools in isolation from the tools of other professionals. The general interview results indicate the lack of technical knowhow and fragmented nature of the AEC industry (Singh *et al.*, 2011).

Various energy certification schemes (e.g. LEED in USA, Green Star in China, and BEAM+ in Hong Kong) have become affirmatively chosen items for building developers due to strong political support (e.g. property tax reduction and GFA concession for BEAM+ buildings in Hong Kong). As those schemes focus mainly on design, there is a strong industry need for integrating the certification submission process into the main design workflow. Moreover, building energy design is an iterative process among clients' needs, engineers' knowledge, architects' design, and certification requirements. Thus decision-making support is required, especially the capability of making sensitivity analysis. User access control is also implemented, merely for security purpose, and there is a desperate lack of knowledge exchange interface. In a word, there are insufficient communication channels between the information demand (consultant) and supply (supplier) in most cases.

### **Case study of technical practices**

Hamedani and Smith (2015) concluded a set of four major selection criteria for building energy performance tools as design decision-making tool, including 1) input data required for simulation, 2) usability, graphical visualization, and interface, 3) interoperability of building modelling, and 4) accuracy and ability to simulate detailed and complex building forms and components. Based on the literature review analysis and interview results presented above, an evaluation framework was developed which categorizes the features and technical requirements for collaborative energy design tools. Eight major aspects were selected for evaluation purpose, and the evaluation criteria were selected on a developing basis. Six state-of-the-art integrated energy design tools were investigated (see Figure 4), i.e. DesignBuilder, Autodesk Insight 360, Sefaira Architecture and Systems, IES Virtual Environment (VE), TAS, and GEnergy. DesignBuilder and IES VE are more commonly used in Hong Kong building consulting industry.

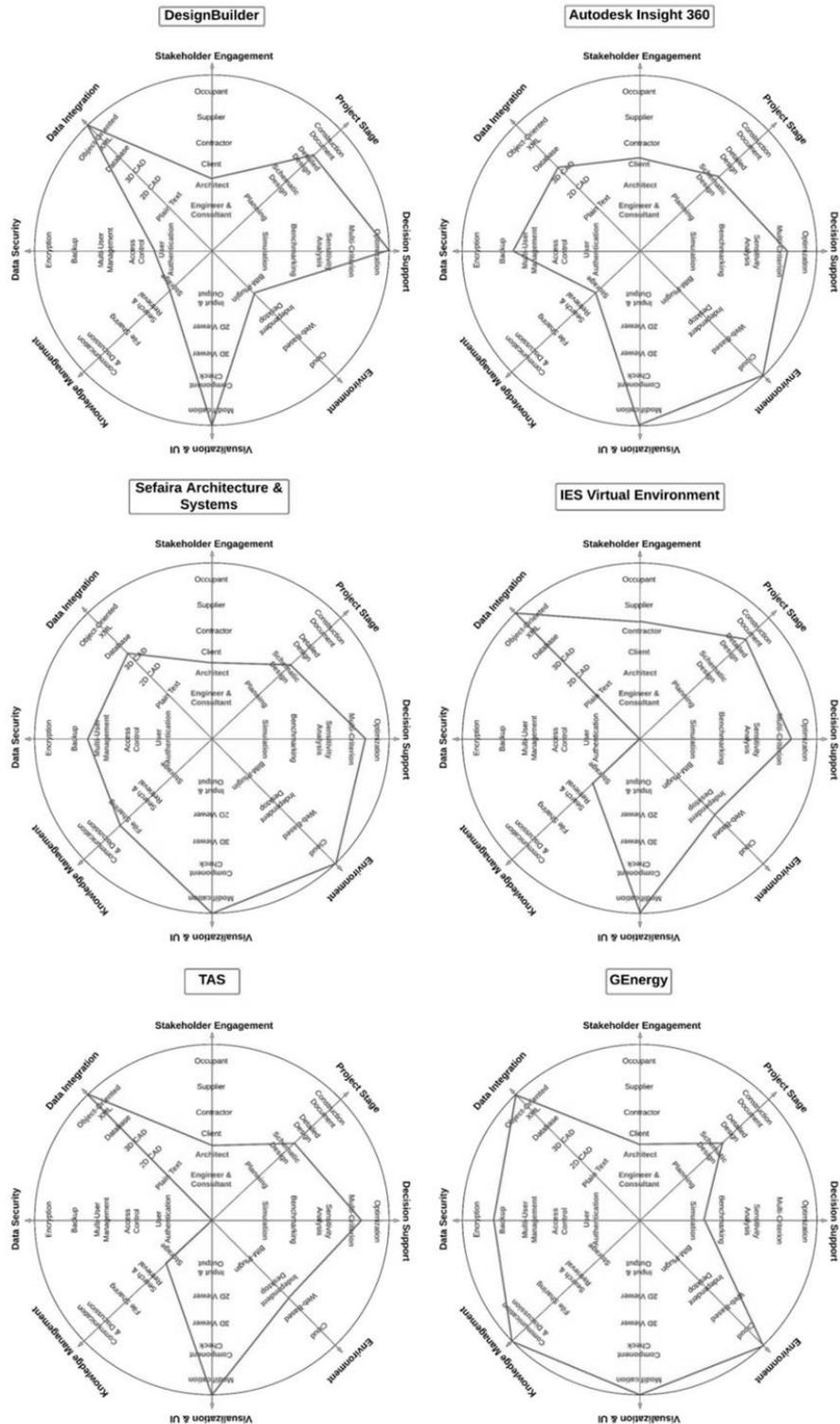
### **Comparative analysis**

#### *Knowledge gaps*

The interview findings echo most of the literature review results that the accuracy of building simulation, easy-operable data format, and user-friendly interface are mostly expected by building designers. Nevertheless, major knowledge gaps also exist. Due to the lack of integrated delivery methods, contractors (especially sub-contractors) and

facility managers are seldom involved in design, and thus there are few technical needs for later-stage stakeholder involvement and data integration.

Figure 4: Comparative case study of state-of-the-art collaborative energy design tools



Furthermore, design decisions are usually made centrally by the clients, whose main purpose is LEED or BEAM+ certification. Thus advanced decision support is poorly required. In the iteration of design process, there is a significant lack of holistic thinking and methods, but mostly fragmented modifications (e.g. simply alter the

shading length or change the lighting to LED panel). Knowledge management also takes a very simple form, e.g. a shared ftp server for the storage and exchange of project documents. In a word, the adoption of technical solutions is constrained by traditional business procedure and the subordinate position of energy efficiency.

#### *Implementation gaps*

The development of technical practices keeps a close pace with industry needs. However, two major differences can be identified:

1. *Desktop vs. Web/Cloud:* The working environments of collaborative tools determine platforms' basic capabilities of supporting collaborative work. On the one hand, most interviewees agree that independent desktop tools are developed mainly for professional engineers, while architects and clients only get involved when less expertise is required; on the other hand, more international projects require remote collaboration through the web. The rapid-developing web service and cloud technology enable designers to get access to project data anywhere, and thus multi-user work becomes possible. Cloud technology frees the user from heavy computing burdens, and communication channels are also established through the integration of social media. Nevertheless, independent desktop applications take the advantage of providing more complex analysing services for decision support, and they usually outperform their web-based counterparts in supporting more data types. Considering data security, desktop-based tools seldom consider this issue, while most web-based tools have established a user management system to support teamwork among stakeholders.
2. *Independent vs. BIM/SketchUp Plugin:* The nature of BIM as a data centre gives rise to a symbiotic relationship between BIM and a variety of functional modules. Compared with independent tools, those plugged into BIM make the full use of its visualization interface and data resources, and thus workflows from architects' design to engineers' analysis can be more fluent. SketchUp is also a wide-adopted visualization interface, which provides designers with easy manipulation and modification of model, especially for complex building forms. Nevertheless, although independent tools perform not as good in solving graphical issues, they can be much more stable because missing and malposition problems occur frequently in the plugins' conversion process from BIM center.

#### *Technology gaps*

The comparison of research and practice implies that researchers focus mainly on digital foundation, while technical solution suppliers focus more on usability. Commercial tools are usually well wrapped with user interface that fully visualize building geometries, design options, and analysis results. Another difference is that researchers usually concentrate on specific aspects such as data transfer and optimization, while commercial tools are more integrated in the face of multiple user needs. Some decision support functions are constrained in commercial tools due to their functional complexity, e.g. the number of thermal zone for optimization, and the number of variables for uncertainty analysis. Academic research also discusses more on the compatibility of technology with organization structure and design procedures. On the contrary, most commercial tools work in isolation from project management tools, and thus the interoperability between technologies is necessary.

*Strategies for improvement*

1. *Knowledge gap*: Innovative collaboration technologies and integrated workflows supplement each other as building energy design tasks become more and more complicated. Nevertheless, current building energy design practice operates in the “comfort zone” in which low information processing capability is required. The main reason is that the industry claims a facile standard for energy consumption compared with traditional aspects such as safety and quality. Low information processing load implies poor attention to various uncertainties, and thus design analysis cannot fully anticipate actual circumstances. More attention, as well as a higher standard, is thus necessary to orientate the shift in building industry.
2. *Implementation gap*: Technical solution suppliers should not only be the followers of industry needs, but also layout the shift in the mode of design collaboration. Integrated measurements (e.g. cloud-based environment and BIM integration) provide chances for designers to establish communication channels at a lower cost. In the meanwhile, innovative technologies (e.g. optimization and multi-criteria decision support) fully exploit design information to better inform stakeholders.
3. *Technology gap*: The application and commercialization of research outputs should be better encouraged. Some academic tools have the potential to facilitate industry practice, especially in decision support, remain under-developed due to the lack of user interface. A close collaboration is therefore required between academia and technical solution vendors.

**CONCLUSIONS**

This paper contributes to the understanding of the building energy performance gap by emphasizing stakeholder collaboration and associated technologies on the basis of information processing theory. Current research progress, industry perspectives, as well as technical practices of collaborative technologies were investigated through a series of research methods, and were analysed comparatively. The results indicate that there are mismatches, i.e. knowledge gaps, implementation gaps, and technology gaps that undermine the development of collaborative technologies. Three improvement strategies were proposed in accordance with the three gaps, and collaborative technical features of digital solutions were also identified systematically based on both perspectives and practices. Future research will focus on other issues such as the initial set-up of collaborative tools, and the learning and training of collaborative technologies.

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# GOVERNANCE UNITS AS INTERSTITIAL ORGANIZATIONS: THE ROLE OF GOVERNANCE ORGANIZATIONS IN THE DEVELOPMENT AND ESTABLISHMENT OF BUILDING ENVIRONMENTAL ASSESSMENT METHODS (BEAM)

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Green Building has been touted as the future of building construction. However, its emergence, due to the fluidity of the green building concept, is sometimes fraught with power struggles in the debate over which standards and practices to be adopted. With the emergence of Building Environmental Assessment Methods, much hope has been put on their associated third-party certification organizations to help forge a common ground for green building. These organizations are boundary spanning, traversing multiple professional jurisdictions, organizational fields, and involving various state and non-state actors. Despite wielding much influence in the development, establishment and promotion of BEAMs, the authority, and legitimacy of governance organizations are being questioned as to whose interest they serve, and whether they promote realistic green building practices. We argue that while the success of these governance organizations will be their ability to act as neutral ‘brokers’ of green building practices, they may end up capitulating the interest of powerful actors. Drawing on the theory fields proposed by Fligstein and McAdam (2012) and the concept of interstitial emergence, we explore the role of governance organizations for BEAMS in the building industry. The case is made that there is a need to examine the activities of governance organizations in the development of BEAMs, and why conceptualizing them as interstitial/boundary-spanning organizations could offer new insights and research directions in the burgeoning researching on BEAMs.

Keywords: Building Environmental Assessment Methods (BEAMs), field theory, green building, interstitial emergence

## INTRODUCTION

Climate change has moved from the realm of science into policy. Since the establishment of the Intergovernmental Panel on Climate Change (IPCC), the subsequent negotiation of the first International environmental treaty (UNFCCC) during the Earth Summit in 1992 (Yergin, 2011) and the recent Conference of the Parties (COP21, 2015) in France, governments all over the world are now taking environmental issues seriously. This, amongst other things, is due to the growing concern about the depletion of the quality of the environment. The rise of

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Environmental Assessment Methods (BEAMs) or various other forms of environmental assessment schemes in the 1990s was, thus, an attempt by the industry to introduce measures for reducing the impact of building construction activities; or, at the very least, give shine to the fact that the industry was taking the issue seriously.

The establishment of these schemes have been championed by various stakeholder groups in the building industry. For example, Feige, *et al.*, (2011) describe the emergence of the 'Network for Sustainable Construction Switzerland', which is an organization designed to influence business and enhance their participation in sustainable construction in that country. A similar case is reported by Theaker and Cole (2001) in their study of how the private sector and public sector stakeholders came together to commission a consulting team to develop Green Building Design and Construction Guidelines for the City of Santa Monica, USA. In Hong Kong, the partnership between the Buildings Department and private sector consultants to develop the Comprehensive Environmental Performance Assessment Scheme (CEPAS), and the mobilization of various stakeholders by the Hong Kong Real Estate Developers Association to develop the Hong Kong BEAM can be viewed in the same light as those described by Feige, *et al.*, (2011) and Theaker and Cole (2001). These efforts by industry actors have led the establishment of various organizations to promote the adoption and implementation of BEAMs. The establishment of the HK-BEAM Society to promote the HK-BEAM, the US-Green Building Council to develop and implement the US-LEED and the Green Building Initiative (GBI) that owns and operate the Green Globes are examples of these organizations. These organizations, thus, represent efforts by stakeholders to engage with each other in providing a platform for consensus building around environmental issues related to buildings.

Despite the proliferation of assessment schemes championed by various stakeholder group in the building industry, most research work have focused largely on the technical aspect of these schemes, their strategic adoption by industry professionals, and their role in promoting sustainability in the building industry (e.g. Crawley and Aho, 1999; Cole, 2005; Cole, 2006). An area which has received little attention in the academic literature is how these schemes have been developed, and how they are institutionalized to promote their adoption in the building industry. Although some researchers have explored how assessment schemes have changed and influenced construction professionals and construction practices in the industry (e.g. Schweber, 2013; Schweber and Haroglu, 2014), this does little to further our understanding of the role of industry actors (stakeholders, professional organizations, industry consultants) in establishing assessment schemes, and how their actions contribute to the failure, or success, of implementing assessment schemes.

This paper draws on the concept of interstitial emergence (Morrill, 2006) and the theory of strategic action fields proposed by Fligstein and McAdam (2012) to provide a theoretical conceptualization of organizations that own and operate assessment schemes. We take as our point of departure the assumption that these organizations are boundary spanning, traversing multiple professional jurisdictions, organizational fields, and involving various state and non-state actors. Their actions are thus influenced by the interests and logics of operations of stakeholders. The paper begins with a brief account of the concept of green building and the development of building environmental assessment schemes. The focus here is on the workings of governance organizations and their role in the development of schemes. We then provide a theoretical explanation of how competing interests from the myriad of actors in the

industry influence the actions of governance organizations in the establishment and development of BEAMs. This section provides a theoretical portrait of how the power struggle that shrouds the development of these schemes explains how some groups can succeed in controlling the activities of governance organizations, and thus influencing the content of BEAMs. The paper concludes by making a case for the need to examine the activities of governance organizations in the development of BEAMs, and why conceptualizing them as interstitial/boundary-spanning organizations could offer insights in their role as developers of BEAMs and as facilitators of green building.

### **Emergence of Assessment Schemes for Green Building**

Following the publication of the Brundtland Commission's report 'Our Common Future' (WCED, 1987), and the subsequent emergence of the concept of sustainability, various reports have been produced to explore the impact of construction activities on the natural environment. These reports and various other studies have highlighted the extent to which activities in the industry contribute significantly to environmental problems ranging from excessive consumption of global resources to the pollution of the environment (see Ding, 2008, Cheng and Venkataraman, 2013). Although most of the issues highlighted in these reports have existed since the era of the industrial revolution (Shrivastava and Hart, 1994), it is the emergence of sustainable development in the 1990s and the subsequent revelation of the building industry's contribution to the problem of climate change that has triggered concerns about what the building industry is doing to alleviate the negative impact of its activities on the environment. With increasing expectation on the industry for greater environmental responsibility (Cole, 1999), the industry had to develop approaches and practices that address these environmental concerns and adhere to the emerging principles of sustainability. The concept "Green Building" emerged in the 1990s as various industry actors - specialists, practitioners, researchers, and myriad professions, organizations, institutions, and communities - started to look for ways to decrease the impact of the building industry's operations on the environment (Cole, 1998).

Yet, the adoption of green building principles is sometimes fraught with a number of challenges. Green building practices are sometimes at odds with conventional building construction, and extant building codes and standards. The integration of these new practices in already existing project delivery processes and the need for new skills also hampers the transition to green building (Cole, 1998). Considering the vast range of environmental criteria that are relevant to buildings, the development of schemes provides a means for designers and builders to identify specific environmental criteria based on the demand of clients and to provide a guideline for design and construction. These schemes have evolved out of the need for a holistic comprehensive procedure to identify and ascertain the environmental impact of building construction (Ball, 2002; Ding, 2008). Their development, therefore, serves to provide a way of structuring environmental information, and offer a means for industry actors to objectively assess the environmental performance of buildings, and to measure the building industry's progress towards sustainability (Ding, 2008). By laying down the fundamental direction for industry actors to adopt green building practices, their use is aimed at enhancing the overall environmental awareness in the industry.

While the major challenge in the development of any particular BEAM is the codification of the numerous environmental criteria relevant to building, deciding on

which practice is green and which one is not is not a trivial task. The emergence of terms such as “sustainable building”, “High-performance building”, “smart building”, “environmentally friendly building”, which have all become synonymous with the concept of green building (Henn *et al.*, 2013) shows that industry actors may have varied interpretation of what green building should accomplish or the goal of green building. With such variability in the concept, codifying green building practices is bound to be fraught with struggles over how to frame the concept in assessment schemes.

Thus, during the development of BEAMs, there is the tendency for some actors to adopt strategies aimed at promoting certain practices that will advance their interest. Industry professionals, for example, will want to appropriate new knowledge and practices for their own benefits (Bresnen, 2013). Furthermore, some actors may want to influence the content of assessment schemes in order to advance their own interests. The success of varying interest groups to decide on the content of assessment schemes may, therefore, raise questions about the authority and credibility of developers and owners of these schemes. In the UK, for example, increasing rejection of assessment criteria in BEAMs as authentic measures for green building has been reported (See Schweber, 2013; 2014). Professional actors have criticized particular credits or categories for not adequately capturing the green building concept. The major challenge in the development of schemes is, thus, the operationalization of the green building concept to resonate with the industry’s myriad actors (*ibid.*).

### **The development of BEAMs in the building industry**

The first assessment scheme, the Building Research Establishment Environmental Assessment Method (BREEAM), was established by the UK Building Research Establishment in 1990. Since its establishment, numerous assessment schemes have been developed for the construction sector. The most prominent amongst these being the US Leadership in Energy and Environmental Design (LEED), which was established in 1998 by the US Green Building Council. Since the establishment of these two schemes, there has been a rapid growth in the number of Building Environmental Assessment Schemes around the world.

BEAMs employ a set of environmental criteria against which green building performances are checked and evaluated. Most schemes are constantly updated and extended to meet changing market demands and environmental expectations. The UK-BREEAM, for example, has been constantly updated since its emergence to include assessment of such buildings as existing offices, supermarkets, new homes and light industrial buildings. In Hong Kong, the HK-BEAM has undergone several transformations since the introduction of the first scheme in 1996. The first scheme covered new and existing air-conditioned office buildings and was released in 1996. Later in 1998, the Hong Kong Housing Authority joined the HK-BEAM Steering Committee and supported the introduction of HK-BEAM assessments for high-rise residential developments. This led to the development of a new version of the assessment scheme in 1998. A third version of the assessment scheme was released in 2003 to cover both existing and new buildings (HK-BEAM Society, 2014).

Moreover, for each new version that is released, the scope of the assessment scheme is usually broadened to address new and current sustainability issues (Cole, 2006). For example, in response to the December 2009 Copenhagen Conference on climate change, when climate change and global warming became an international issue and several world leaders called for radical action to be taken, HK-BEAM Society

decided to introduce a new version of the assessment scheme - HKBEAM-Plus Version 1.1 ((BEAM Society, 2010). This version was introduced in April 2010 to meet the higher expectation from the public. In response to the conference outputs, this version of the scheme placed more emphasis on the importance of greenhouse gas emission reductions. Further, it incorporated a number of mandatory features that aligned with prevailing industry standards and regulations.

The major challenge in developing and updating these schemes is, however, how to categorize and rate the various environmental issues relevant to buildings, and which industry experts, or actors, should be involved their development. In most cases, various technical committees, advisory groups, industry experts, and consultants are engaged in developing new and updated versions. These actors decide on how to operationalize the green building concept to meet specific environmental objectives. Indicators are used to structure these environmental objectives. These Indicators define the terms by which the performance of a particular development project and progress toward environmental objectives would be measured. Indicators in assessment schemes are structured to allow ease of measurement of environmental performance, and they are intended to provide designers and developers and other users with a common way to set targets for project performance. Recommended practices and weightages are assigned to various indicators to provide guidance for industry professionals.

While the decision as to which indicators to prioritize, or weightage to use, is usually decided by actors in charge of updating and developing BEAMs (see Theaker, and Cole, 2001), these actors may represent various interest groups who may advance practices that serve specific interests and/or promote practices influenced by their own unique ideologies. The content of assessment schemes can, therefore, be skewed in favour of some actors who may not truly represent the interest of all actors in the building industry. There is always the likelihood of powerful actors, who might not necessarily be experts, to want to influence the content of scheme by engaging in various actions aimed at advancing their interests.

### **The Role of Governance organizations in the development of schemes**

Organizations that own and operate BEAMs, for example, the UK Building Research Establishment's BRE Global which owns the BREEAM, the US Green Building Council (USGBC) which owns the US-LEED scheme, and the Hong Kong BEAM Society which owns the HK-BEAM, are responsible for the maintenance and continuous improvement of these schemes. These organizations also organize educational programmes, provide professional accreditation, third-party certification of projects and promotion of their use. The credibility of these organizations is critical in terms of the credibility of the scheme (Cole and Jose Valdebenito, 2013). Since they are viewed as neutral "brokers" of green building practices, their presence, to some extent, influences the uptake of the assessment scheme. Aside from developing and maintaining the assessment scheme, they engage in a number of activities such as marketing and advertising the adoption of the scheme. These activities influence the awareness of the assessment scheme, either domestically or internationally. As the assessment scheme is affiliated with these organizations, the legitimacy of these organizations determines the human and financial resources available to maintain and implement the scheme.

While majority of these organizations are private sector bodies, increasing adoption of assessment schemes as policy instruments (Schweber, 2014), and the involvement of

some state agencies in the development of schemes (for example, the case of Hong Kong Housing Authority as stated above), presents a situation whereby both states and industry actors are heavily involved in the creation and amendment of assessment schemes. This has led to a growth in what some have labelled as "mixed" regimes of a hybrid nature (e.g. Clapp, 1998), where both private sector actors and public sector actors equally influence the creating and implantation of BEAMs. Thus, aside from managing the interests of the multitude of stakeholder groups in the private sector in the framing and development of assessment, these organizations also need to manage the influence of public sector actors.

What this means is that developers of assessment schemes have to constantly engage with various actors and mobilize support for the practices they are trying to propagate. They have to engage with different actors from time to time and forge alliances (Jaradat, *et al.*, 2013) with both private and public sector actors to promote assessment schemes.

### **The theory of Strategic action fields**

This paper adopts Fligstein and McAdam's (2012) conceptualization of fields to make the argument of the role of governance organizations in the development of assessment schemes. Through this lens, the building industry can be viewed as a social space where various industry actors take each other's actions into consideration in their daily activities, and through this process bring a new field into existence. Within this social space are various fields, with each field comprising aggregates of organizations/professionals/actors providing similar services, their constituencies, and their relevant professional bodies (DiMaggio and Powell 1983). These fields exist together with numerous other fields and are nested within each other in a broader institutional context. Industry actors operate in various fields, interacting with each other on the basis of shared (but not consensual) understanding about what is at stake in the industry (in this case green building). Actors also engage with each other with a shared understanding of the rules governing legitimate actions in the field vis-à-vis green building.

Fields are composed of two distinct antagonistic groups of actors, namely incumbents and challenges. Incumbents are those actors who, at any point in time, wield greater influence within the field and whose interest and views are usually reflected in how the field is organized. The purpose and dominant ideas of the field are shaped in their interest. The rules in the field also tend to favour them and shared meanings tend to legitimize and support their position in the field. The challengers are those actors with less influence in the field and they occupy a lesser position. While they recognize the dominant influence of incumbents on the shared meanings of the field, and may usually conform to the prevailing order of the field, they can propose new shared meanings that will enhance their own positions. The theory recognizes the presence and influence of state actors who usually have formal authority to intervene in, set rules for, and legitimize the position of, non-state fields. These state actors form their own unique fields.

In addition to incumbents and challengers, SAF theory also proposes the presence of governance units in fields. These units are established in the field to oversee compliance with the rules in the field, and assist with the overall functioning of the field. They "are internal to the field and distinct from external state structures that hold jurisdiction over all, or some aspect of, the field" (Fligstein and McAdam, 2011 pp. 8). Examples of these governance units are industry trade associations and

certification boards or organizations; and in the case of this study, Green Building Councils, and various BEAM certification organizations established to oversee the adoption and implementation of assessment methods. Governance units usually bear the imprints of the most powerful actors in the field and the logics that are used to justify that dominance. The governance units are therefore there to reinforce the dominant logic and protect the interest of incumbent actors.

For example, in Hong Kong, HK-BEAM is the dominant assessment scheme. The scheme has its own governance unit, i.e. HK-BEAM Society, which owns and operates the scheme. This governance unit oversees the adoption of green building practices. HK-BEAM Society is embedded in a complex web of fields made up of myriad actors who have interests in green building: financiers, suppliers, customers, industry associations, and state regulators. Actors in each of these fields will, from time to time, behave strategically to change existing logics in with regards to green building. They will do so by introducing new logics and practices. During episodes of change triggered by changes in government policies, international laws or other external shocks, actors in various fields may act strategically by promoting practices which advance their interest in the industry. If new versions of schemes are to be developed during these episodes of change, actors may behave strategically to incorporate these practices in assessment schemes, and thus make these practices standard industry guidelines. In such nested fields, consisting of actors with varied interest, the argument that governance organizations can behave as, neutral 'brokers' of BEAMs is questionable.

### **Governance at the interstices of multiple organizational fields**

The theoretical concept of interstitial emergence as proposed by Morrill (2006) is adopted to explain how a field for green building certification has emerged in the building industry and the actions of governance units in charge of certification schemes; i.e. BEAMs. The concept posits that firms, organizations, and industry professional are simultaneously members of multiple overlapping organizational fields. In this sense, the emergence of an issue of common interest to actors belonging to these nested fields leads to the emergence of interstices between fields (Rao *et al.*, 2000). What this means is that actors, instead of addressing the issue at stake in their own field by introducing a new logic and practices in their field, will act by creating a peripheral field at the overlap of their various fields. These interstitial spaces are populated by groups of actors with a common interest in the issue at stake, and will develop frames to codify practices. Thus, if we take the emergence green buildings as an issue that is of importance to various actors in the industry, it can be argued that, as actors with common interest in addressing environmental concerns have engaged with each other to develop schemes, various fields for green building certification has emerged in the building industry replete with new practices, norms, and values. Since actors may still be part of their individual fields in which they have been historically institutionalized, there is the challenge of managing conflicting logics between the newly emerging field and the actors own field.

Organizations established in these interstitial spaces to manage schemes and provide certification for green buildings, therefore, has the responsibility of managing the emerging new practices and norms. Situated at the boundary of multiple organizational fields - the state, industry and various organizational fields, Bátora (2013) notes that these organizations are inundated with different and sometimes conflicting organizational logics, principles, and ideologies, and has to manage and

synthesize different and sometimes conflicting logics of operation. Moreover, since logics and practices emerging in the interstitial space may conflict with those of actors in their respective fields, these organizations need to develop and deploy various strategies in order to successfully promote the adoption of practices. They should ensure that schemes used to promote practices resonate with the normative and cultural-cognitive aspects of actors (See Schweber, 2014; Rao *et al.*, 2000).

## **DISCUSSION AND CONCLUSIONS**

Following from the above argument, research on BEAMs should consider the organizational and institutional context in which there are developed and used. Assessment schemes should be seen as documents, whose development subsists in an environment of power struggles, behind which there could be various regulating, controlling and/or commercial interests. We have noted that the development of BEAMs involve the participation of various working groups and technical committees who decide on the content of these schemes. These working groups or committees include various actors, experts, and professionals operating in different professional jurisdictions or fields. Various groups of actors, thus, influence the formation and codification of practices in assessment schemes. Through their background and organizational affiliations, these actors may have varying views on what is 'good' green building practice. Due to the varying interest of these actors, and the fluidity of the green building concept, the development, and establishment of assessment schemes in the industry can be fraught with powerful struggles over the meaning of 'green building' and which practices qualify as realistic and pragmatic green building practice. Thus, the field in which a particular assessment schemes has emerged to can be seen as an arena where many organizations - companies, trade associations, governmental and professional organizations - participate and act to advance their interest; all in a complex interplay of struggle over what is green and what is not.

From this argument, there are various interesting research questions that could be asked about the institutional context of assessment scheme: How established organizations, for example, the Hong Kong BEAM Society, the UK Building Research Establishment (BRE) and the US-Green Building Council (US-GBC), work in formulating and publishing green building standards for the whole industry. How can these organizations assure actors of the authenticity of practices, and encourage actors to adopt these schemes? How are the practices codified in schemes and the process of arriving at these practices justified? Who takes part in the development of schemes and how do they decide on which actors to involve? And finally, how do these organizations maintain authority and ensure continuous adoption of schemes. Exploring these questions will offer insights into the actions of governance organization that undermines their reported credibility and authority in the building industry. This will further contribute to the burgeoning research aimed at addressing legitimacy concerns of assessment schemes in the building industry.

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# **BUILDING ENVIRONMENTAL ASSESSMENT SCHEME FOR RESIDENTIAL BUILDING IN BRUNEI**

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Building's construction activities, operation and demolition are increasingly recognised as a major source of environmental impact. One strategy for reducing such impacts is most widely known by the term Building Environmental Assessment (BEA). The research is an attempt to develop a new BEA scheme for residential buildings in Brunei which focussing on identifying BEA indicators that best suit for Brunei environment, social and economy. Studies show that Brunei residential sector needs urgent attention to transform its current consumption rate in more sustainable way. Recent launch of Brunei Green Building Council, mandatory energy efficiency guidelines and declaration of ambitious energy intensity reduction target, a new BEA scheme will help contribute sustainability target in residential sector. However the issues of developing a new BEA schemes using existing methods may face constraints in their effectiveness. In this regard, a consensus-forming technique - Delphi method – helps improve greater communication and gain consensus from experts in the construction industry through series of questionnaires. As a result, the final framework is produced comprises of 7 key categories and 37 applicable criteria that achieved high degree of consensus and importance.

Keywords: Brunei, building environmental assessment, Delphi Method, residential buildings

## **INTRODUCTION**

One of the prominent sectors that contributed to high carbon dioxide (CO<sub>2</sub>) emission is construction industry. The World Business Council for Sustainable Development (WBCSD) proved that buildings are the largest energy consumers in the world economy, accounting for over one-third of final energy use and approximately 30% of global CO<sub>2</sub> emissions (WBCSD, 2014). One strategy for reducing such impacts is by implementing Building Environmental Assessment (BEA) also known as Green Building Assessment. Green buildings can be defined as “healthy facilities designed and built in a resource-efficient manner, using ecologically based principle” (Kibert 2012, 6).

However the issues of developing a new BEA schemes using existing methods may face constraints in their effectiveness. Studies suggest that adapting existing BEA schemes directly may suffer several constraints such as regional incompatibility (indicators and weightings), transparency and complexity (Cole, 1998; Chew and Das, 2008; Retzlaff, 2009). Nonetheless existing BEA can provide a general system as a

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foundation and an interface between different schemes (Gu *et al.*, 2006). As there is no BEA scheme for residential buildings in Brunei yet, the aim of this paper is not only to explore the required categories and criteria that best suit for Brunei socio-economic and environmental needs, but also to develop a BEA scheme for residential buildings in Brunei.

## BRUNEI CONTEXTS

Brunei Darussalam is a small country located on the north-western coast of Borneo Island, facing the South China Sea, and with a land area of about 5765 square kilometres and an estimated population of around 410,000 and 68,208 households. In 2012, the Ministry of Development has launched a Green Building roadmap that will eventually lead to a National Green Building Certification Scheme (IBP Inc., 2015). The Ministry is urged to develop a scheme that is environmentally responsible and resource efficient in all stages of its development. The implementation is still in early stages and the Ministry is currently reviewing current maintenance practices and collecting data for the benchmarking of existing buildings (APEC, 2013). This initiative is in line with Brunei's aspiration working towards an ambitious goal of a 45 percent energy intensity reduction by 2035 on four major sectors including building sector (Prime Minister Office, 2014).

In particular, residential buildings should be paid critical attention to achieve this because residential buildings in Brunei consumed the highest energy and water consumption compared to other sectors: 48% of the electricity generated goes to residential, while commercial, government, the oil and gas industrial sector consumed 25%, 17% and 10% respectively (APEC, 2013). In 2011, domestic water consumption has reached 62,487 thousand cubic metre and commercial consumption is merely 4,294 thousand cubic metre. High CO<sub>2</sub> emission is another matter to manage as Brunei is ranked fourth CO<sub>2</sub> emissions from the consumption of energy in the world (APEC, 2013). Hence, the residential sector needs an urgent transformation that potentially make the contribution towards sustainability target.

## RESEARCH DESIGN AND METHOD

This paper employs an exploratory mixed method approaches due to broad concept of sustainable development which covers a multi-dimensional aspects i.e. environmental, social and economic aspects. The main research strategy is conducting Delphi survey questionnaire involving construction experts. It is crucial to acquire stakeholders' involvement to help improve its effectiveness and relevance. Hence, Delphi method is adopted to improve communication and obtain the reliable consensus of opinion of experts through series of intensive questionnaires. Figure 1 shows the theoretical model showing the sequence of BEA scheme development.

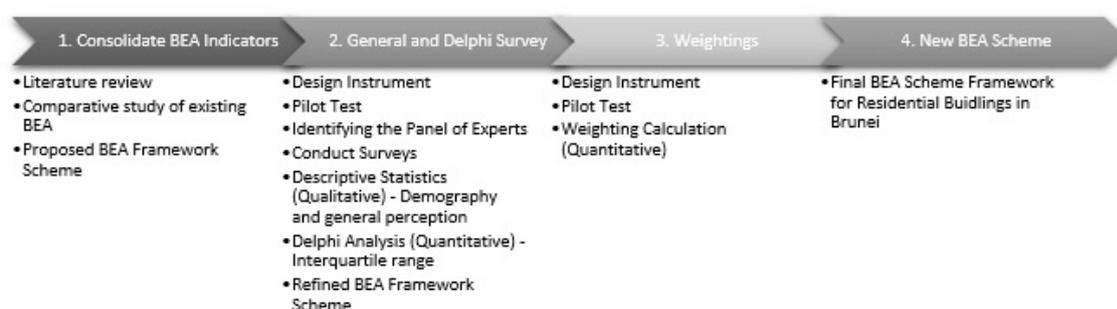


Figure 1: Theoretical model for Brunei BEA scheme development

The different BEA assessments including BREEAM (BRE Environmental Assessment Method), GMS (Green Mark Scheme) and GBI (Green Building Index) are reviewed and their indicators are compared to set common indicators, typically as a starting point for developing a new assessment scheme (Cole *et al.*, 2005). The proposed assessment will then be used to develop research instrument (pilot study and survey). Through series of questionnaires, the instrument will eventually produce a refined BEA framework for Brunei in Figure 2.

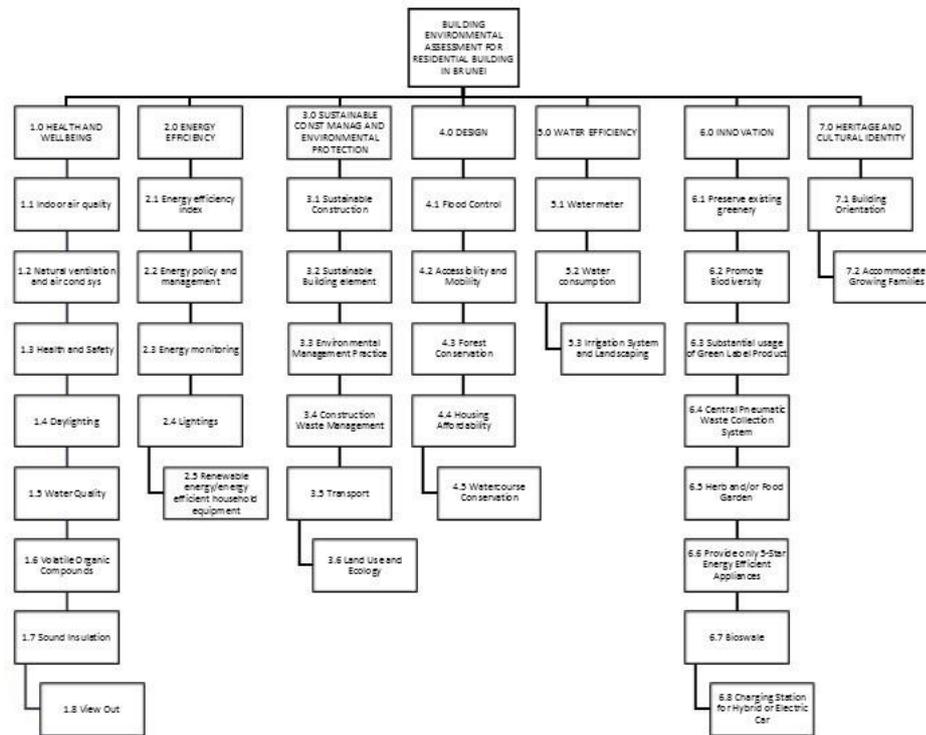


Figure 2: Framework of new BEA Scheme for Residential Building in Brunei

### Delphi Survey

The Delphi method was developed by Dalkey and Helmer for the US Defence Industry at the RAND Corporation in the 1950s. Its objective is to obtain the most reliable consensus of opinion of a group of panels through series of intensive questionnaires interspersed with controlled opinion feedback (Dalkey and Helmer, 1963). It is a systematic, iterative procedure for “structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem” (Linstone and Turoff, 2002, 3) and it is desirable as it does not require the experts to meet physically, which could be impractical for international experts (Okoli and Pawlowski, 2004).

Many researchers found its ranking is the most appropriate for multi-dimensional aspects that requires greater communication in the development and customisation of BEA scheme. Delphi study in this research covers three rounds of questionnaire: (1) the discovery of issues, (2) determining the most important issues, and (3) ranking the issues.

### Panel Selection and Size

The three rounds of questionnaire are sent out to panellist comprise of architects, engineers, managers, contractor, surveyors and academics from both government and

private sectors. Ludwig (1997) found that the majority of Delphi studies have used between 15-20 respondents, and avoid large numbers of respondents which may lead to difficulty in the summarising process. However the panel should be sufficiently large to allow the patterns of responses to be clearly seen (Okoli and Pawlowski, 2004) and provide increase in the reliability of group responses (Fusfeld and Foster, 1971). Essentially, the main objective should be to select panellists with the capability, knowledge, professional qualifications and relevant experience in the field under investigation. Therefore, this research adopts expert sampling to ensure the proposed outcome is reliable. The target sample consists of key stakeholders includes:

- Academic specialises in the area of construction, environment and sustainability
- Decision-maker, policy-maker or practitioner in the field of building construction
- Accredited professional in one of the leading sustainable assessment systems
- Practical experience and sufficient knowledge in construction, environment and sustainability
- Experts with level of influence and the main driver in the construction industry
- Willingness to participate

### **Data Collection**

*Round 1:* this round intended to gather as many input as possible to seek increase in accuracy and representative statistics of opinions by careful selection of sample. General or introductory questions are asked before the actual Delphi questionnaire section started. The questions make sure that, the participants are aware the typical category and criteria in BEA schemes. Participants are asked to rate the initial set of indicators using 5-point Likert scale and are encouraged to provide additional indicators that they believe are important and vice-versa, and to comment on their rationale for omitting or adding and rating additional indicators. The data are analysed and identify area of agreement or disagreement by calculating their central tendency including inter-quartile range (IQR): the indicators with IQR less than or equal to 1.0 – based on 5-point Likert scale – are deemed high consensus and hence, were omitted in round 2 (Faherty, 1979; Raskin, 1994; Rayens and Hahn, 2000; Heiko, 2012). The additional indicators are brought forward in Round 2 for rating.

*Round 2:* this questionnaire round is developed based on the information collected from round 1. Respondents are asked to rate all additional indicators identified in the round 1 and repeat the analysis to identify degree of agreement or disagreement.

*Round 3:* the Delphi respondents finalise their decision on each item. To assist in their consideration, participants are provided summary of analysis or final outcome of the study in the previous round and are asked to revise their judgments or to specify the reasons for remaining outside the consensus, if any.

### **RESULTS AND DATA ANALYSIS**

In the Round 1, a total of 207 were invited to participate and 102 (49%) responded, 89 are good for use and 69 respondents are willing to participate in the consecutive rounds while both Round 2 and 3 received 28 responses (41%). It is important to provide demographics characteristics so that it can be judged the relevance and reliability of the respondents (Schmidt, 1997). The size of the response is indicated in both percentage (%) and raw numeric terms. Table 1 shows that the participants are dominated mainly by engineer which contribute 57% which is 51 out of 89 participants. However, good number of participations 15, 9 and 8 are also obtained

from quantity surveyors, architects and academics respectively. A total of 7 senior officers, directors, managers and company owners are amongst the respondents. The respondents' working experience in construction industry is a defining index of their knowledge about construction project in general as well as in residential project in particular. More than 67% respondents have over 6 years' experience in construction industry, while 33% have at least 5 years or less. Their views with experience obtained through the survey can be regarded as important and reliable data.

Delphi study results were analysed using descriptive statistics, including the mean ranking and the interquartile range. As a result, additional criteria and new major categories have been developed to produce final BEA framework for Brunei in Figure 2 which illustrates the framework comprising of 7 key categories and 37 applicable criteria that cover aspects of sustainability including environment, economic and social. Results in Table 2 show that overall IQR average of 0.31 and overall mean ranking scores 4.01 which indicate high degree of consensus in all the categories and criteria.

Table 1: Demography of participants

Expert Sample									
Designation*	Eng	QS	Arc	Aca	SO	FM	EO		
No	51	13	8	7	6	3	1		
%	57	15	9	8	7	3	1		
Working Experience									
Years	2-5	6-10	11-15	16-20	21-25	>25			
No	29	31	12	9	4	4			
%	33	35	13	10	5	4			
Qualifications									
Type**	O lev	Diploma	HND	Degree	Masters	PG	PHD	RIBA	MICE
No	1	1	24	24	27	2	3	5	1
%	1	1	27	27	31	2	4	6	1
Note:	* Eng – Engineers Arch – Architects QS – Quantity Surveyor, Project Manager Acad – Academics SO – Senior Officers, Managers, Owners FM – Facility Manager EO – Environmental Officers				** HND – Higher National Diploma PG – Post Graduate PHD – Doctorate Philosophy RIBA – Member of Royal institute of British Architect MICE – Member of Institution of Civil Engineer				

### Health and wellbeing

Health and wellbeing ranked as the most important categories by the panellist with mean ranking of 4.41 and IQR of 0.23. Indoor air quality and, natural ventilation and air-conditioning system are considered more important due to extreme heat and humidity in Brunei's equatorial climate and thus, contributing clean air, thermal comfort and well-being of the occupants. Moreover, the additional criteria – health and safety – is deemed to be an important issue due to increase in awareness and its enforcement in the Brunei construction industry.

### Energy efficiency

The result shows how the panellists recognise the importance of efficient use of energy in common areas, limiting energy usage. Positive attitudes towards implementing energy efficient building increase readiness to monitor energy consumption by installing energy monitoring system in residential buildings. In this regard, energy policy and management play an important role to identify feasible policy, energy targets and its annual review.

## **Sustainable construction management and environment protection**

They are six criteria listed in this category with score higher than 3.86 mean ranking. Two key criteria in this category - sustainable construction and sustainable building element -received as top indicators. The former adopting sustainable design and use of sustainable and recycled materials (off-site or on-site). While the later recognise and encourage the use of construction materials with a low environmental impact over the full life cycle of the building. Furthermore environmental management practice also regarded as important as this encourage adoption of environmental friendly practice in construction such as performance incentive, educate building user, quality control, provision of composting and recycling facilities and etc.

### **Design**

Design category comprises of five criteria where flood control dominated the mean ranking due to issue of flood occurring in some parts of the districts in Brunei. Despite its seasonal phenomena, persistent heavy rainfall can cause inconvenience to residents and substantial expenditure to government as floods may lead to landslides and damage to properties and infrastructure. Promoting accessibility and mobility for the aged and the disabled are recognised as important and should set mandatory minimum standards for easing and guiding building use. Other criteria achieved almost similar level of importance.

### **Water efficiency**

All criteria are rated high level of important with mean ranking above 4.0 where water meter ranked as top priority. This is to ensure water consumption can be monitored and managed and therefore encourage reductions in water consumption.

Water consumption gained significant attention as this encourage the building user to minimise the consumption of potable water in sanitary applications. Provision of suitable systems that utilise rainwater or recycled water for landscape irrigation are also regarded equally important.

### **Innovation**

This category comprises of eight criteria where two of which are deemed very important while the other six criteria achieved similar level of important. However, the list of criteria is non-exhaustive as any other innovation related to BEA can also be included. This category encourages the designer to use of other green features which are innovative and have positive environmental impact. The most important criteria is preserve existing greenery and this enhances the quality of living environment, reduce surface runoff to drainage system and minimise impacts on fresh water and ground water systems during building use. While promote biodiversity ranked second in this category. It maintains the ecology of local areas, minimise disruption to natural habitat and promote the biodiversity of the site, attracting birds and the like.

### **Heritage and cultural identity**

Similar with innovation, this category regarded as low to moderate important however both categories achieve high degree of consensus. Residential buildings in Brunei are greatly influenced by cultural considerations. The orientation of buildings should consider the direction of Qibla and ensure separate spaces for male and female to perform their religious obligations.

The orientation should also consider the location of external doors to provide privacy to the occupants for instance, external doors should not give direct access to domestic quarter. Accommodate growing families is also included in this new category. This emphasises the importance of the relationship between family members.

*Table 2: Mean ranking and IQR*

CATEGORIES	MEAN RANKING	IQR
1.0 Health and wellbeing	4.411	0.227
2.0 Energy efficiency	4.411	0.240
3.0 Sustainable construction management and environmental protection	4.289	0.233
4.0 Design	4.239	0.236
5.0 Water efficiency	4.178	0.226
6.0 Innovation	3.780	0.264
7.0 Heritage and cultural identity	3.276	0.305
1.0 HEALTH AND WELLBEING	MEAN RANKING	IQR
1.1 Indoor air quality	4.483	0.223
1.2 Natural ventilation	4.427	0.226
1.3 Health and Safety	4.414	0.453
1.4 Daylighting	4.303	0.232
1.5 Water Quality	4.103	0.244
1.6 Volatile Organic Compounds	3.920	0.510
1.7 Sound Insulation	3.910	0.511
1.8 View Out	3.773	0.530
2.0 ENERGY EFFICIENCY	MEAN RANKING	IQR
2.1 Energy efficiency index	4.157	0.241
2.2 Energy policy and management	4.125	0.246
2.3 Energy monitoring	4.067	0.242
2.4 Lightings	3.932	0.318
2.5 Renewable energy/energy efficient household equipment	3.932	0.473
3.0 SUSTAINABLE CONSTRUCTION MANAGEMENT AND ENVIRONMENT PROTECTION	MEAN RANKING	IQR
3.1 Sustainable construction	4.393	0.228
3.2 Sustainable building element	4.393	0.235
3.3 Environmental management practice	4.281	0.234
3.4 Construction Waste management	4.000	0.250
3.5 Transport	3.865	0.259
3.6 Land Use and Ecology	3.862	0.518
4.0 DESIGN	MEAN RANKING	IQR
4.1 Flood Control	4.172	0.240
4.2 Accessibility and Mobility	4.069	0.246
4.3 Forest Conservation	3.893	0.514
4.4 Housing Affordability	3.724	0.537
4.5 Watercourse Conservation	3.690	0.542
5.0 WATER EFFICIENCY	MEAN RANKING	IQR
5.1 Water meter	4.466	0.246
5.2 Water consumption	4.169	0.224
5.3 Irrigation System and Landscaping	4.000	0.500
6.0 INNOVATION	MEAN RANKING	IQR
6.1 Preserve existing greenery	4.258	0.235
6.2 Promote Biodiversity	4.079	0.245
6.3 Substantial usage of Green Label Product	3.865	0.259
6.4 Central Pneumatic Waste Collection System	3.764	0.266
6.5 Herb and/or Food Garden	3.685	0.271
6.6 Provide only 5-Star Energy Efficient Appliances	3.685	0.271
6.7 Bioswale	3.596	0.278
6.8 Charging Station for Hybrid or Electric Car	3.443	0.290
7.0 HERITAGE AND CULTURAL IDENTITY	MEAN RANKING	IQR
7.1 Building Orientation	3.621	0.276
7.3 Accommodate Growing Families	3.483	0.287

Family members are expected to make serious and sustained efforts to live together and plan their role in society. Therefore, extended families were common in traditional Muslim societies where respect and care for elder people is essential within the family border.

## **DISCUSSION**

The results show that total number of indicators (excluding innovation category) for BREEAM, GMS and GBI are 34, 21, 37 respectively while Brunei BEA has 29 indicators which is good for a new scheme. Large number of indicators are best avoided to avoid issues of regional incompatibility, complexity and transparency as mentioned earlier. Undoubtedly the findings indicate that existing BEA schemes for residential building shared many similarities in terms of indicators, however the number of indicators and the level of importance - based on weighting or credit allocation - reveal important differences.

For instance, category for 'Health and Wellbeing' ranked as the most important category in this paper whereas BREEAM ranked it 3rd out of 9, GMS ranked it 5th out of 5 and GBI ranked it 3rd out of 6 categories. It is justifiable to recognise Health and wellbeing as the most important in Brunei. Vulnerability assessments show that the country has medium to high climate change exposure, mainly due to higher temperatures leading to potential heat-related stress and haze pollution arising from forest fires (Ministry of Development Brunei, 2015).

The issues related to 'Health and Wellbeing' are main concern to the Brunei government as part of its mandate is to ensure the highest quality of life. This made Brunei one of the most advanced standards of living in Asia and hence, 'Health and Wellbeing' is among the best in the developing world and it has already achieved almost all of the targets outlined in the Millennium Development Goals (Prime Minister Office, 2014). Moreover, study on world green building trends suggests that 'Health and Wellbeing' is the top social reasons for improved health and productivity (McGraw Hill Construction, 2013).

'Cultural Identity and Heritage' category regarded as unique addition in this assessment scheme. BREEAM, GMS and GBI do not take this category into consideration in their scheme despite Malaysia shared similar cultural importance. Residential buildings in Brunei are greatly influenced by cultural considerations. Privacy from outsiders and between male and female are important aspects when designing a residential buildings. His Majesty constantly emphasise that any development should not compromise the religious and cultural traditions that Bruneians hold dear (Suzana, 2009; Salleh, 2009; Duraman and Tharumarajah, 2010).

This is in line with His Majesty intention for Bruneian to embrace Malay Islamic Monarchy (MIB) philosophy that proclaimed in 1st January 1984 – the very moment Brunei Darussalam assumed its independent and sovereign status. MIB is an integration of three elements: Malay language, culture and Malay customs, the teaching of Islamic laws and values and the monarchy system which must be esteemed and practiced by all. Design should also consider future family expansion to nurture culture of living together. Report shows that many Bruneians prefer and continue to have extended family system resulting in demand for bigger house (Ministry of Development, 2013).

Additional indicators such as flood control, health and safety, forest conservation, accessibility and mobility, housing affordability and water quality gained substantial attention as depicted in Table 2.

These indicators – excluding flood control – are excluded by the BREEAM, GMS and GBI schemes which may jeopardise the effectiveness of a new scheme and contradict the fundamental of BEA development. 'Energy Efficiency' remains the top priority in

BREEAM, GMS and GBI including for Brunei BEA. McGraw Hill Construction (2013) asserts that energy savings are by far the most critical environmental reason to build green. It scores same level of importance with Health and wellbeing with only slight different in degree of consensus.

In 2015, Brunei has published the guideline on energy efficiency and conservation for non-residential buildings and made it mandatory for government building. This initiative made significant awareness amongst participants in this industry and recognised its importance. Moreover, evidence shows Brunei is ranked fourth CO<sub>2</sub> emissions from the consumption of energy in the world which dominated by residential sectors.

## CONCLUSIONS AND THE WAY FORWARD

This research has presented the process of identifying the important categories and criteria to be incorporated into the Brunei BEA framework. Although they are similarities with BREEAM, GMS and GBI, many new indicators incorporated to suit with Brunei context. The findings revealed that all categories and criteria achieved high degree of consensus and importance. Further work includes another questionnaire aims to quantify the weighting of every indicator as mean to evaluate level of building performance and certification. Validation of the new framework will be sought through interviews from experts who have been involved in BEA policy, design and implementation. This includes expert from members of Green Building Council Brunei, a team of Green Building Initiatives in Ministry of Development Brunei and experts from Housing Department.

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# **HEALTH, SAFETY AND WELLBEING**



# SHINY HAPPY PEOPLE? UK CONSTRUCTION INDUSTRY HEALTH: PRIORITIES, PRACTICE AND PUBLIC RELATIONS

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The UK construction industry is arguably in poor health, rates of occupational illness are statistically significantly higher than for workers in any other industry. Despite growing awareness that the 'slow burn' of occupational health requires alternative management approaches than those made to secure safety, health remains neglected. Recently, the scope of health management on large sites has actually increased; public health now included within the organisational health management remit, as promoted by the UK Government's Public Health Responsibility Deal. Yet concerns have been raised that prioritisation of public health management will distract from the more challenging problems of occupational health in practice. A critical discourse analysis of UK 'construction industry health' has been carried out, using the industry's own representations of its health; the organisational websites of the top ten UK contractors by yearly work won. Findings show that whilst safety remains the dominant partner in the H&S amalgam, 'public' has overtaken 'occupational' within the discourse of 'construction industry health'; the latter restricted to legal compliance presented as corporate citizenship, the former championed as evidence of benevolent organisational values. Yet public health concerns are limited to those of individual responsibility, whilst more complex issues around the social determinants of health as associated with work, are missing from the discourse, separating organisations from the impacts of their work on their workers. Instead health has become associated with events, prizes and awards, which are subsequently commodified to provide grist to the Corporate Social Responsibility mill.

Keywords: Corporate Social Responsibility, occupational health, public health.

## INTRODUCTION

Despite their seemingly unbreakable amalgam, health and safety are theoretically and practically very different things. The immediacy and impact of an accident has led to a prioritisation of safety in both practice and research, whilst health has been more neglected (Skan 2015) due to its 'slow-burn', and indeed the fact that it can be much more problematic to manage in practice. In recent years this inequality has become more apparent, and to redress the balance occupational health has been gaining priority within the UK construction industry, as demonstrated by its high profile on the London 2012 Olympic Park construction project (Tyers and Hicks 2012).

However, occupational health in UK construction has also been impacted by a recent paradigm shift in public health management. The UK government launched its Public

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Health Responsibility Deal (PHRD) in spring 2011, aiming to improve public health through ‘... a more collaborative approach to tackling the challenges caused by our lifestyle choices.’ (Department of Health (DoH) 2015), and in late 2013, they launched a specific Pledge (H10) for Construction and Civil Engineering Industries. Aspects of this H10 Pledge, and its potential impact on the UK construction industry health management agenda, have already been explored elsewhere (Sherratt 2015a; Sherratt 2015b), through analyses that also revealed the growing influence of Corporate Social Responsibility (CSR) on construction health. The emergence of CSR activity within the construction industry has previously led to suggestions that organisations have become more focused on the packaging and presentation of construction site health management, rather than the fundamental methods and processes of its implementation (Rawlinson and Farrell 2010).

Although empirical findings have suggested moderation of theoretical challenges, there is still the potential for construction industry ‘health’ to be cause for concern; the difficult and complex management of occupational health obfuscated by much more simplistic and photogenic ‘public health initiatives’, the management of health on sites delivered in the way most suitable for its subsequent commodification and publication as CSR. This paper seeks to present the next steps in this ongoing project and empirically explores a specific discourse of health within the UK construction industry; the way large UK construction organisations position health within their organisational identities, the subsequent relationships between public and occupational health, and the role of CSR within this context. This will provide a better understanding of contemporary ‘construction industry health’, and therefore a clearer context for research, and the development of improvements in practice.

## CONTEXT

### **The health of the UK construction industry**

The UK’s Health and Safety Executive (HSE 2015a) have reported that annually around 69,000 construction workers suffer from an illness they believe was caused or made worse by their work, a rate of illness statistically significantly higher than for workers in any other industry. Specific health issues can also be associated with construction work, for example incidents of work-related musculoskeletal disorders and lung problems are again statistically significantly higher than in other industries. Whilst the HSE (2015a:9) also note that the current burden of occupational cancers are highest within workers from the construction sector, they emphasise that these cases are from past exposures to asbestos and silica. Yet this fails to acknowledge that the industry is now regularly working with newly-developed materials, such as Nano-technologies, where associated health risks for lung disorders and even cancers could potentially be significant, but as yet remain unknown (Jones et al 2015).

In terms of its practical management on sites, occupational health should be subjected to the same approach as safety; through robust management systems and the risk assessment process as required by the Management of Health and Safety at Work Regulations 1999. Industry is also supported by various initiatives, most prominently Constructing Better Health (2015a), which provides guidance, training and links to accredited occupational health providers who work within the industry.

However, research suggests that occupational health within construction can be misunderstood and its management rendered relatively ineffective. For example, Thompson and Ellis (2011) found that health is often managed alongside safety as one

coherent unit, rather than as separate aspects which require different approaches in their mitigation and minimisation. This has the potential to limit effectiveness should controls be applied from the perspectives of immediacy, as necessary for safety, rather than the long-term view required for health, as manifested on the 2012 Olympic Park; whilst researchers found that the level of personal protective equipment (PPE) on site was good, ‘...access to equipment or procedures designed specifically to control [occupational health] risks (e.g. checks on noise levels ... well-maintained dust extraction equipment and use of anti-vibration handles) was less common’ (Tyers and Hicks 2012:8). Whilst PPE is the most immediate, readily available and cheapest response to the identification of health risks within a construction process, it should only be considered the last resort from both a risk assessment and a long-term health management perspective (HSE 2015b).

Although efforts are certainly being made to improve the health of the UK construction industry, and recent statistics do show improvements, health management is arguably still in its infancy when considered alongside the myriad of systems, controls, work processes and practices that are now in place to manage safety on sites.

### **Public health in the construction context**

The construction industry is perhaps more closely aligned with public health than some others; it needs 'healthy' workers for production - to walk and climb, to lift and move, to balance and level, to force and fit. There remains a heavy reliance on manual labour and skills within traditional work processes, and therefore health becomes an inherent and necessary characteristic of the construction worker, the big, strong ‘beefy builder’ stereotype. Yet, the UK construction industry loses on average 1.2 million working days through work-related ill health each year (HSE 2015c), to the detriment of productivity and output and, much more importantly, to the detriment of the workers themselves.

Economically public health can be seen as a corporate concern, employers interested in mitigating economic losses suffered as a result of illness, and the idea to manage public health alongside occupational health is often seen as an eminently practical and sensible approach (Healey and Walker 2009). Yet public health is also grounded in what are termed wider health inequalities, themselves described as ‘wicked problems’ (Dhesi 2014:30), where the complex interplay of factors such as status, social class, power, earnings, education and living standards all contribute to poorer or better health (Marmot 2004). It has been suggested that many of the high risk health behaviours that foster chronic disease, such as smoking, drinking, eating to obesity and drug taking, are connected with the workplace (Healey and Walker 2009:47), a relationship which contributes to the ‘social determinants of health’ (Wilkinson and Marmot 2003), the reasons why people smoke, drink or take drugs. (Dhesi 2014), and therefore one area in which occupational and public health can become closely intertwined. Indeed, one of the policy objectives put forward by Marmot et al (2010:9) in 'Fair Society Healthy Lives' for the UK Government was to ‘create fair employment and good work for all’.

However, the ways in which work influences these social determinants of health can themselves be complex. Research carried out by Papadopoulos et al (2010) exploring the ‘changing work environment’ found that increased work intensity, long working hours, weekend work, increased percentage of employment under subcontractors and job insecurity and temporary contracts all negatively impact on worker health. Indeed, higher levels of alcohol consumption, smoking, drug use and obesity are found among

temporary workers than permanent employees (Papadopoulos et al 2010). But for the UK construction industry, this is not a 'changing work environment' – this simply is our work environment; fundamentally our work is structured to the inevitable detriment of worker health. Hours on UK construction sites can be excessively long, the process of competitive tendering for winning work creates an unstable work environment reliant on subcontracting, long supply chains, and a transient and fragmented workforce, all managed through bonus and payment schemes that encourage intensive work practices to support the constant demand for progress.

But these are issues and concerns that cannot be resolved with the simple application of PPE; they relate to much more fundamental aspects of the way the construction industry 'works', and as a result are much more difficult to change. It is perhaps therefore unsurprising that health within the occupational context is often limited to the superficial; indeed 'work-site wellness' programmes rarely include changes or improvements to fundamental working conditions, and efforts are instead directed to what can be more easily controlled; behavioural factors and individual 'lifestyle' issues used to deflect '... attention away from serious examining the effects of corporate cultures or the work environment' (Conrad 2005:546). And in the UK, the PHRD itself arguably supports and even facilitates such deflection. It provides a clear distraction from the more complex problems of occupational health ingrained in construction industry operations by shifting attention from the workplace to the worker, from the underlying occupationally-triggered social determinants of health to the more simplistic 'public health' concerns of their consequences, all the while allowing the relationship between the two to remain obscured.

### **Grist to the mill? Health and Corporate Social Responsibility**

The growing emphasis on CSR within construction organisations also has the potential to enhance the superficiality of health management in practice, as the need to provide 'content' and other evidence of the manifestation of CSR in practice, through organisational reports, media presence and other PR, becomes more pressing. CSR has become a cornerstone of construction industry identity and marketing, with health (and somewhat inevitably safety) drawn under this wider 'Responsibility' umbrella and given a thick coat of PR gloss to become part of a demonstrable corporate citizenship (Rawlinson and Farrell 2010).

Yet whilst the inclusion of health within the CSR remit may seem harmonious, CSR can be defined as '... a business approach for addressing the social ... impact of company activities' (Frynas 2009) and so arguably does concern workforce health, it must also be kept in mind that it is fundamentally a tool for marketing and work winning. Indeed, the suggested drivers behind the growth of CSR, including moral obligations, have long been challenged by those with a much more pragmatic view of the ultimate organisation goal - to make profit and pay shareholders (Henderson 2001) - a perspective from which work winning is much more of a concern than addressing the nuanced complexities of workforce health.

Indeed, it is arguable that the growth of CSR has furthered misdirection in health management within the UK construction industry. CSR has created a temptation to focus on the superficial consequences of poor worker public health instead of any underlying social determinants relating to industry work structure and organisation, to address something with ready metrics and photogenic output that can be easily measured and commodified, and to focus on the management of public health issues

rather than the more complicated, fundamental and mundane occupational health risks that can be so readily identified within construction work practices.

## **METHODOLOGY**

In order to begin to explore the way large UK construction organisations position health within their organisational identities, the relationships between public and occupational health, and the role of CSR within this context, a critical discourse analysis (Fairclough and Wodak, 1997) was carried out. This is a methodological approach which explores the discourses that make up our social worlds from acknowledged and explicitly critical perspectives. It seeks to unpack the way we position and create shared understandings of phenomena, examining the processes and functions of the discourses (Gergen, 2009) within their situated contexts, which here have the potential to reveal the complexities around construction industry 'health'.

The sample for this study was partly one of convenience, comprising Building's top ten largest UK contractors in terms of 'yearly work won including civils September 2014 – 31 August 2015', yet also purposive; their size and success suggestive of proactive organisational health (and safety) practices. The sample contractors were explored through their public faces - their organisational websites. The use of web sites as documentary sources can prove useful (Rawlinson and Farrell 2010), as they can be considered 'public documents of private origin' developed through the collective authorship of the organisation itself, and are therefore authentic, credible and representative data (Scott, 1990).

A systematic approach to the websites was made, to ensure capture of all relevant pages, through direct links and a search for the keyword 'health'. It must of course be acknowledged that this is presented data (Webb *et al.* 1966) designed to portray a positive image, yet this is of course highly relevant here. It is precisely the way health is positioned by these organisational identities and through organisational policies that is sought, as this necessarily contributes to the development of discourses that will have 'social consequences ... such as influencing the social beliefs and actions of the recipients' (Van Dijk 2008:5). This 'version' of industry health will therefore affect, and indeed be affected by, the manoeuvring between public and occupational health, the potential for the attention paid to the former to be detrimental to the latter, and also better illuminate the complex role CSR plays within this relationship. Although naturally limited in generalisability by the underlying research philosophy, this approach is still able to explore and illuminate health for this stratum of the UK construction industry.

## **FINDINGS AND DISCUSSION**

The positioning of health (and its seemingly inevitable partner, safety - subsequently noted as 'H&S' where they occurred in this format) from the organisations' homepages could be traced through two distinct paths. The first travelled via 'sustainability', 'responsibility', or, more explicitly, 'corporate responsibility', to a page in which H&S was a link alongside those leading to environment, governance and community. The second positioned H&S within some form of corporate identity; 'about us', 'who we are', and 'how we do it', the H&S link here sitting alongside those leading to values, culture, strategy and history. These two different approaches were split equally between the ten organisations, five adopting a 'sustainability' approach, and five an 'identity' approach. Interestingly this reflects one of the wider debates around CSR; is it something the company does, or something the company is? From this perspective,

health, occupational or public, becomes either a practice or a 'value', and therefore its management and consideration can become very different things. However, further analysis did not reveal any coherence within the subsequent discourses of health as located beyond these two pathways, rather several nuanced facets became identifiable within the wider discourse of health that emerged from within the data as a whole.

### **An unbreakable amalgam**

The fact that 'H&S' naturally became the shorthand within the analytical process was reflective of the fact that safety is still very much the dominant partner within the H&S amalgam. Health was often negated for the maximisation of safety; where H&S formed the link or page title, the content often developed through explication of safety leadership, ways of working safely, safe behaviour, safety incidents and Accident Frequency Rates (AFRs). There was also a 'muddling' of health with safety within the discourse, and its subsequent management in practice. For example, one page stated that 'poor health in the workplace can present significant safety risks', suggesting that health was actually a predetermining factor of safe practice, rather than an occupational consideration in its own right. Another stated that 'employees with safety critical roles for example those at high risk of hearing damage, vibrations etc. are given regular health screenings'. Again, occupational health issues are aligned with safe working and management in practice, and, worryingly, screening after the event is positioned as an acceptable approach carried out for safety reasons alone, rather than any proactive prevention. Where such 'muddling' occurred, health was often the losing party, safety dominating both the organisational discourse and any recourse to practice.

### **Healthy work and healthy lifestyles**

Where health was found alone, it was positioned in one of two ways; either as focused occupational health practice or a broader area of 'concern', which could themselves be aligned with how the two types of health - occupational and public - emerged within the data. Despite its relevance to construction work, and the industry's poor record in this area, occupational health was actually very limited in its recognition. Although there was acknowledgement of 'ill health caused by work', this was not a dominant positioning of health within the wider discourse, and its contribution was limited to associations with management, and most specifically the risk assessment process. For example, one organisation stated that 'all our businesses will conduct health checks and health risk assessments to ensure there is no long-term harm to health from working in our business.' However, this positioning of risk assessments and health surveillance as pro-active efforts, rather than the minimum legal standards they actually are (HSE 2015d), is a highly misleading construct within the wider discourse of health, although one that is commonly employed (Sherratt 2015a). Seeking to create an enhanced positive image around a legally required activity is itself suggestive of PR 'spin' and the need to position organisational efforts as 'above and beyond' minimum standards in the desire to demonstrate corporate citizenship. Within this wider context, it could therefore be considered unsurprising that this dataset did not reveal more details of occupational health management in practice, such mundanity unable to make a strong contribution to what is essentially marketing literature. But this argument can itself be challenged by the fact that this was certainly not the case for health's long term partner, safety. The discourse of safety management within the dataset constantly sought to go beyond mere legal requirements; the development of safety programmes, zero targets, site management

practices and training were all championed as evidence of organisational commitment to safety. Yet occupational health did not receive this same consideration, either proportionally in terms of content, or in the level of detail accorded to its management in practice, and instead was simply reduced to the lowest common denominator of management; that of the minimum legal framework with which all must comply.

Overall, the analysis demonstrated that for large construction organisations whilst some consideration of occupational health is made, it is still not accorded either the attention or consideration paid to safety, and remains a much lesser partner in this relationship. However, the same cannot necessarily be said of public health. The more common manifestation of health identifiable within the data, was as an area of 'concern', frequently linked with wellbeing, as something 'supported' by the organisation but without any corresponding level of detail or operational specificity. This approach, an example being the organisational intention of 'promoting health and wellbeing for everyone who works with us', avoids any description of occupational activity, and instead contributes to the development of a discourse focused more on public health. Although in some instances, both occupational and public health were explicitly considered within a simple, broad reference to 'health', public health issues were themselves much more dominant within the wider health discourse (as extracted from safety or even 'H&S') found within the data. This was evidenced through explicit reference to the PHRD, companies stating their commitment to the Pledge, through the presentation of detailed health and wellbeing programmes seeking to educate and encourage lifestyle changes, or simply through core 'value' statements that 'we support health and wellbeing'. Although safety remains prioritised, public health has arguably superseded occupational health as the dominant 'health' of the UK construction industry.

The role the organisations gave themselves within this discourse was that of a provider of pastoral care, a supporter for the benefit of their workforce. Yet who this workforce actually is remains much more obscure. As noted above, reference was made to 'everyone who works with us', but in just one case the supply chain was specifically highlighted as a partner in the organisational public health improvement strategies. More frequently, the organisations 'workforce' remained obfuscated; 'all our people' providing a lack of specificity in the practical implementation of the health and wellbeing programmes. Indeed the difference in programme goals also adds to the intangibility of the discourse, imagery of offices and computers used to illustrate the need for 'active lifestyles', something perhaps less relevant for those working on site than those based in the head office. This lack of detail in terms of programme implementation is perhaps reflective of the inherent problems in maintaining a transient and fragmented workforce, which also includes large numbers of the self-employed, but, more cynically, also enables organisations to make commitments to education, training and health screening that seem more generous than perhaps they are in practice. Whilst one organisation's aim is for '75% of our employees [to be] using the programme by 2020', this will in fact be far less than the number of workers that will actually contribute to their construction outputs.

Further concerns can be raised around the public health 'problem issues' found within the data which included diabetes, high blood pressure and stress, whilst those seeking promotion included active lifestyles, smoking cessation and healthy eating. Programmes often include the offer of on-site wellness screening and health-screening clinics, with the overall aim of 'building a healthier workforce'. Yet many of these issues relate to individual choice and 'lifestyle', areas where notions of positive liberty

and personal freedoms become highly significant (and have already been theoretically explored elsewhere, see Sherratt 2015a), but they are also areas where the organisation is able to distance themselves from their manifestation within the workforce. These are individual issues, not organisational, problems of public not occupational health, and as such the organisation can confidently take on a benevolent position, helping the workforce make the 'right decisions' about their health and lifestyles, whilst the possibility that they may actually have a more significant role to play in the emergence of these health issues as a whole remains unremarked. The dominance of public over occupational within the wider discourse of health further contributes to this misdirection; if organisations are 'committed to promoting healthier lifestyles and helping our people to manage their health', surely they are also doing all they can for occupational health in their workplaces already? Furthermore, this version of public health steadfastly ignores the social determinants of health; the relationships between wider work practices and health decisions. The discourse of public health found within the data does, as Conrad (2005) suggested, focus on individual 'lifestyle' issues, and as such is able to deflect attention or enquiry away from any detrimental work practices.

### **Image is everything**

An interesting aspect of the data collection process was the location of much of the 'health' data beyond H&S webpages. Only three of the ten organisations shared their H&S Policies via their websites, far more chose instead to champion their H&S activities within press releases or news articles; health (and safety) packaged and photographed to create PR content. For example, one organisation had 'agreed to purchase fresh fruit from a local stall holder to provide fruit for our operatives' as part of their healthy eating drive, another had run 'local awareness campaigns around areas such as mental health and well-being, healthy eating and drug and alcohol abuse' which had resulted in a Better Health at Work Award. Indeed, the number of awards that can be won in this area of organisational management is really quite impressive, and although safety still dominates, health remains much more prominent in its public than occupational form.

Again, this is perhaps unsurprising given the dataset explored here, however it does lend support to the argument that such ventures are indeed only attempts to continue to feed this hungry PR machine. The provision of a few bowls of fruit to provide positive content is indeed far more visually stimulating than the provision of face fit dust masks; for one thing the latter inconveniently obscure the smiles of the workforce modelling them. Yet, more seriously, it can be suggested that this 'packaging of health' as revealed by the data has influenced the emphasis on public health over occupational, and shaped the wider discourse of health within construction. The commodification of worker health into PR packages and awards, and by association the organisations ability to position themselves as benevolent champions of the workforce (although which one remains somewhat unclear), also enables industry clients to align themselves with this shiny, happy world. Yet the development of this commercial attractiveness, as dictated by our CSR aware society is arguably a misdirection; of investment, efforts and practices to feed the superficial and photogenic, to the neglect of occupational health within the UK construction industry.

## **CONCLUSIONS**

Although focused on a very specific dataset, this research has been able to illuminate several key aspects of construction industry health. With regard to priorities, health

remains very much in second place to safety, and public health has surpassed occupational health as the dominant discourse within the public faces of the organisations. Although this could be considered unsurprising, due to the mundanity of occupational health management in practice, that safety is so heavily championed, even to the level of site management programmes and activities, suggests that this argument is not necessarily valid. The role of construction health within CSR remains prominent, the positioning of health within press releases and news stories and its association with awards and events, also suggests that efforts around health are indeed aligned to the photogenic and commodifiable, to feed the insatiable PR machine.

But construction workers should be shiny happy people! Arguably construction should be one of the UK's healthiest industries; workers are outside in the fresh air, they are mobile, they are able to use their muscles on a daily basis, to stretch and flex and tense, but they are hampered by their poor occupational health. The social determinants of health that go beyond superficialities of diet and smoking are also critical; the way the industry is organised, the way work and our workforce is structured will hamper the public health of construction much more significantly than a lack of fruit. Further research is therefore proposed to empirically explore occupational and public health management in practice; to establish the extent of the (im)balance as it exists on sites, as well as better illuminate the relationships between the social determinants of health and construction industry operations. From this broad evidence base it is hoped that effective changes to work practices can be proposed and implemented to improve occupational health, alongside changes to work structuring and organisation to positively impact public health, which can together help create the shiny happy construction workforce of the future.

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# USING PARTICIPATORY VIDEO TO UNDERSTAND SUBCONTRACTED CONSTRUCTION WORKERS' SAFETY RULE VIOLATIONS

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Traditional approaches to managing occupational health and safety (OHS) adopt a top-down approach in which rules prescribing safe work procedures are written and enforced. However, these rules are sometimes broken. Violations are actions taken by workers that they know to be contrary to rules or procedures. Violations are a causal mechanism in some accidents and understanding why violations occur is important. Rather than actions taken by deviant workers, research suggests it is appropriate to understand violations as system problems. In some cases, rules are broken because the rules themselves are not practical given situational constraints, or because working to rule would impact the ability to meet production targets. In some instances managers are complicit in rule-breaking, quietly ignoring routine violations in the interests of getting the work done. A participatory video process was used with a group of subcontracted insulation installation workers in the Australian construction industry. In making videos about their work, the insulation installers reflexively critiqued their everyday work practices, shared information and identified and explained gaps between procedures and situated practices. Interviews conducted with workers revealed how the installers sometimes committed rule-based mistakes, unintentionally breaking rules because they were not aware of them, or did not understand or remember the content of complex written procedures. Other routine violations were necessitated by not having the correct equipment. The interviews also revealed how the (sub-contracted) insulation installers are routinely expected to violate standard operating procedures by general contractors, placing them at significant risk of coming into contact with live electricity or falling from roofs. The participatory video process provided a feed-back opportunity to understand rule violations and learn from situated practices, as well as a feed-forward opportunity to engage workers in the design of better rules. The interview data suggests the reflexive learning afforded by the participatory video approach also equipped the insulation installers with the knowledge and confidence to refuse to work in unsafe ways.

Keywords: rule violations, safety management, procedures, rule-based mistakes

## INTRODUCTION

Safety rules and procedures are a fundamental component of an organisational safety management system. It is through the establishment of rules and procedures that managers' expectations for safe working are believed to be translated into the way work is actually done. Rules and procedures specify how a work process, task or activity should be undertaken, and are seen to be essential in the direction,

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standardisation and monitoring of work (Hale and Borys 2013). However, rules are not always followed.

Lawton (1998: 78) defines safety-related rule violations as “deliberate departures from rules that describe the safe or approved methods of performing a particular task or job.” Safety-related rule violations contribute to accidents and safety issues in many industries, including building (Mason 1997, Baiche *et al.*, 2006). Given their prevalence and potential for serious consequences, it is important that the causes of violations be understood. Alper and Karsh (2009) suggest that violations have not been more carefully studied because they are assumed to be actions taken by deviant workers. In reality, the causes of violations are complex and include individual, as well as environmental and system problems (von der Heyde *et al.*, 2015).

Not all violations take the same form or share the same causes. Lawton (1998) differentiates between acts committed with the intention to cause harm, for example acts of sabotage or terrorism, and those not intended to cause harm. Reason (2013) further classifies violations into: (i) routine violations, committed to cut corners, avoid unnecessary effort or bypass unworkable procedures, (ii) thrill-seeking/optimising violations, committed to make tasks more exciting or rewarding, (iii) necessary violations, committed just so that a job can be completed, and (iv) exceptional violations, committed during extreme one-off events when a system is operating outside normal parameters. Alper and Karsh (2009) also suggest that violations can be committed unintentionally. However, this contradicts Lawton's definition, which includes an element of behavioural intent. In this paper we refer to instances of unintentional rule-breaking as rule-based mistakes, rather than violations.

The study of rule violations has revealed a broad range of contributing factors (English and Branaghan 2012). For example, Alper and Karsh (2009) report that individual motivation, work system/organizational factors and aspects of the external environment interact to produce rule violations. Nordlöf *et al.*, (2015) report that workers' risk taking behaviour can be traced back to various social and technical risk factors. Nielsen *et al.*, (2015) provide evidence that workers with high male role norms are more likely to violate safety rules and less likely to report violations, causing particular concerns for male-dominated industries like building.

## METHODS

We followed a group of insulation installers working in the Australian building industry in a participatory video process. This process afforded an ideal opportunity to understand situated work practices “from the inside-out” (Dekker 2003). In doing so we were able to explore the occurrence and causes of safety-related rule violations and identify the circumstances and motivations that lead workers to break safety rules.

Participatory video is a “group-based activity that develops participants' abilities by involving them in using video equipment creatively to record themselves and the world around them and to produce their own videos” (Shaw and Robertson, 1997, p1). Unlike observational cinema, participatory video is reflexive and in our case, the workers were both subjects and film-makers.

Workers were engaged in making films about the safety aspects of their work. On completion the worker-made films would be shared with other workers as safety training resources. The participatory video process was facilitated by an external consultant, who engaged workers in brainstorming content, developing a story board and filming their work. During the making of the film a member of the research team

observed the film-making and undertook video-recorded interviews exploring work practices and the occurrence and reasons for violations or rule-based mistakes. The workers themselves viewed video footage reflexively and were able to analyse, interpret and reconstruct their experiences from their own perspectives. The organisation's health and safety manager was also interviewed in order to explore her understanding of safety-related rule violations and reasons why they occur. The video and interview data were analysed independently and discussed by three of the authors until agreement was reached about emergent concepts and the evidence supporting these.

## **RESULTS**

### **Unintentional rule breaking**

The videos and interviews revealed several instances of unintentional rule breaking among the insulation installation workers. Some safety-related rules were routinely broken because workers' simply did not know that the rule existed. For example, during the making of the film, workers were engaged in discussion about the need to maintain 600mm clearance when using a nail gun to fix insulation adjacent to an electricity conduit. Several workers indicated they had no knowledge of this rule. One commented "Yeah the 600mm thing. I've heard it when we did an audit recently...but with the conduit and stuff like that, I haven't really steered 600mm clear of that." Another commented: "I actually didn't know about shooting all the pins 600mm either side of the conduit. That's one thing that I did not know personally....Yeah like I said I thought it would have been something that someone would have told me in my whole learning process of being here but obviously it doesn't seem to be happening. So that was probably the biggest eye opener that I didn't really know about."

The 600mm clearance requirement was documented in the standard operating procedure (SOP) for fixing insulation materials, however workers described how they did not read safety documentation in detail. One said "A lot of the times you just skim over it and you sign the back half the time. As bad as that may sound everyone does it....How often is someone going to actually sit down and read every little detail? I know we should and everyone should but when it comes down to it, no-one really hardly ever does."

LePlat (1998) identifies the accessibility and legibility of safety rules as being critical determinants of their implementation. In particular, it is important that workers are able to find and comprehend rules. The mode of presentation is likely to be a key factor in accessibility and legibility. In the case of the insulation workers, presenting rules in written form was observed to be problematic. The workers identified low levels of literacy as a reason why they did not want to read procedures. One commented: "There's just so much information and it's just not practical to sit there for three, four hours because I'm not very good with the English language so for me to read a document like that would take me half a day and they're not going to let you sit there and do that...you're also going to embarrass yourself in a room with 20 other people...so there's pressures to sign them off."

However, in the above quote, the worker also reveals how commercial pressures experienced by sub-contractors 'to get the job done' also interfere with the implementation and effectiveness of safety rules. This reflects what Iszatt-White (2007) describes as a 'gambit of compliance,' in which a box is ticked to say that

workers have read the SOP but no-one actually checks whether rules are properly understood and followed. In effect, building companies are ‘turning a blind eye’ in the interests of getting the work done.

### **Physical/site constraints**

Other safety-related rule violations made by the insulation workers were made necessary by their physical work environment and/or the equipment provided to them. For example, the workers were filming the task of insulation installation in ceiling spaces in domestic buildings when it became apparent that it was practically impossible to follow the SOP for the task.

The work involved accessing ceiling manholes at a height of between 2.4 and 2.7 metres from the floor. The company’s SOP for the use of ladders and working at height requires that a straight ladder be placed at a 1:4 ratio and extend 900mm beyond the “step off” point. A script for the film was developed and distributed for comment. The health and safety manager commented that “no-one had an issue with [the script] theoretically.” However, on the day of the filming, the worker who was to undertake the task was furious, arguing that the script did not reflect the way the task is routinely undertaken. The health and safety manager describes how “shooting it [the film] and viewing it through the camera’s eye, we had to stop... the camera doesn’t lie.” She explained “to place a straight ladder at the 1:4 ratio just doesn’t work, you can’t get a body in there as well because it blocks off the access and you have to contort yourself to actually get in [to the ceiling space].” The requirement that the ladder extend 900mm beyond the “step off” point was physically impossible to achieve due to conduits, cables, beams and other obstructions. The small size of the manholes did not allow adequate entry for the ladder, the worker and the pack of insulation to be installed. The health and safety manager described how workers passing insulation packs into the ceiling space using a straight ladder had to contort their bodies to manoeuvre themselves into the ceiling space then move the ladder to get the packs in. She also explained that, if the workers used an “A-frame” ladder, “which they do because they can’t use a straight ladder,” they are forced to work unsafely because they have to step off the top rung of the A-frame. This practice is also in breach of the SOP for the use of ladders and working at height.

Iszatt-White (2007) identifies how formal safety documents are developed at a general level of abstraction, often by people who may not understand the applicability of rules or procedures to local conditions. In the case described, assumptions were made about the way work was being done and procedural violations had become accepted practice for the task. Dekker (2003) explains why it is important to continually monitor gaps between procedures and practices in order to properly understand informal systems of getting the work done. Where these are not safe, the fundamental issues of work design and equipment can be addressed. In this case, the participatory video revealed the need to reconsider equipment provided to workers and the company has since identified alternative access equipment that can be used to safely perform this task.

### **Supply chain pressures**

The workers also described being asked and expected to violate SOPs by the builders (principal contractors) who engage their services. In some instances this led them to take potentially life-threatening risks. There is a serious risk of electrocution in the installation of insulation in buildings at which the electricity supply has already been turned on. For example, in 2010, an Australian national home insulation scheme was

halted because four workers' died as a result of electrocution while installing insulation in homes (Maiden 2010).

As part of the participatory video activity, the insulation workers made a film showing the practice of isolating and "locking out" the electricity supply before commencing installation work in buildings at which the electricity supply was live. The construction sites at which the installers work are typically under the control of a builder (principal contractor). The installers described how they often receive no information from builders about the location of cables in walls and ceilings or about whether any cables are live. One reflected: "if we're shooting into concrete with live wire, then you would think someone would say something, or show you a plan." The workers also discussed the resistance they face from builders who do not want to isolate the electricity supply, even temporarily, so that the installation workers can work safely. The health and safety manager described how the insulation firm had been threatened with termination of contract when a builder learned about the company's electrical isolation procedure. She describes how "a situation had developed out on site where it had become a gentleman's agreement between the trades and ourselves 'okay you need power so we won't isolate because of the inconvenience that it would cause out on job sites'. Rather than challenge the status quo, that situation had become expected."

This example shows how managers at the insulation firm were trying to look after their workers by implementing an electrical isolation procedure. However, there is an expectation among the builders who engage the insulation firm that safety-related rules will be bent or broken in order to get the job done. This is reflective of power relations between companies in which economic and reward pressures become successively greater towards the bottom of the supply chain. The problem is exacerbated because sub-contracted workers often work in small firms, are not represented by trade unions and experience job insecurity and precarious employment (Quinlan, 2011). Shooting nail guns into walls that possibly contain live electricity cabling is akin to playing "Russian roulette" but the workers' and health and safety manager's comments indicate that this risk is tacitly accepted (even expected) by builders. However, if an accident were to occur, blame would likely be quickly shifted to the worker who broke the rules (see also, LePlat 1998).

### **Empowerment of workers**

Our final example also illustrates a general builders' expectation that the insulation installation workers deviate from SOPs to get the job done. However, this example suggests that the participatory video process changed one installer's understanding of safety and acceptance of taking risks. He describes how he refused to violate safe working procedures when he was asked by a builder to access a roof space from the outside of a residential building without an appropriate scaffold or access system. The worker described how correct procedure would be to access the roof space from an internal manhole inside the building. The builder did not want him to enter the nearly completed house and insisted the insulation worker access the space from the roof, which would have posed a serious risk of falling from height. The worker describes how he refused to work in this way, saying: "They wanted me to go in through the ceiling tiles to do some installation, and I just went....given what we've done [referring to his involvement in the participatory video process]... I know that's not the right way to do it, so I refused to do it. I said, 'Nah, I can't do it guys. Unless you can provide me with a handrail on the side of the house there, I am not going to do it.'

[They said] ‘Oh but every other installer does it that way...!’ [I said] ‘Well get one of the every other installers to do it mate, because I’m not doing it. It’s not the safest way to do it, it’s not the easiest way to do it...let’s be fair dinkum about it... ’ ”

In this case the worker made an individual decision to refuse work rather than working in a way that put him at risk of falling from height. However, he also conceded that many other insulation installers would have complied with the builder’s request and unsafely accessed the roof space to complete the insulation work. Nordlöf *et al.*, (2015) describe how an individual’s belief that taking safety risks is an inherent or necessary part of their job influences their safety-related behaviour. In the example described above, the worker attributed his unwillingness to work unsafely to the participatory video process, which he believed had instilled in him an increased awareness of the importance of “going home safely” at the end of each working day.

## DISCUSSION

### Causal factors in rule-breaking

Violation is a pejorative word that suggests deviance and wrong-doing (Alper and Karsh 2009). However, understanding the occurrence and causes of safety-related rule violations is important because violations can lead to accidents. It is also important to identify when safety rules and procedures are not well suited to particular work tasks, situations or contexts. In these instances the rules themselves may need to be improved (Pilbeam *et al.*, 2016).

Our research shows how participatory video can be an effective way to understand situated practices from the perspectives of workers themselves. Participatory video is not just a data collection approach but it is, in part, also an intervention. The aim is not simply to produce video materials but to use the process of video production to generate critical thinking and "empower people with the confidence, skills and information they need to tackle their own issues" (Shaw and Robertson, 1997, 26).

In the case of the way the workers were using ladders to access ceiling spaces, the gap between the way work was documented in the SOPs, and the way it was routinely performed became apparent to the health and safety manager when making a film depicting this task (see, also Hollnagel, 2015). Workers had long experienced this gap between work as imagined and work as done, but the participatory video made it clear to workers that their knowledge is important and that it could be effectively communicated in the video. The participatory video opened up a valuable opportunity to learn from observing workers’ situated work practices and re-thinking the equipment needed for the job.

Our research shows how safety rule violations in the building industry are mundane, everyday occurrences. The violations that became apparent during the participatory video process were not deliberate acts of sabotage. Instead they are routinely undertaken (sometimes expected) and conveniently hidden from view. This is problematic because, when rule violations become routine and overlooked by managers, it becomes very unclear which rules can be broken and which must be complied with (Weichbrodt 2015). Ultimately this can produce what Snook (2002) calls “practical drift” whereby locally-situated work practices become progressively decoupled from written procedures to the point that procedures are routinely ignored.

### **Rule-based mistakes**

The research revealed that workers break safety rules for many reasons. In some cases, rules were broken because workers were not aware of the rules. This may be partly due to the way in which information is typically communicated to workers in written or verbal instructions. The workers expressed a preference for receiving information about safety-related rules in visual (i.e. video) form. One commented: “It’s a lot easier to show someone what we’re trying to say. We could just sit here and verbally speak about it but if you put your verbal words into a video, people are going to sit back and go ‘now I know what he’s actually trying to say.’”

The difference between knowing what (or what not) to do and knowing how to do it was reiterated by another worker who commented: “I just think it’s a lot easier to visually show that you’re not to shoot a pin into this area, as to 500 words or something to describe the same thing.”

The idea that safety needs to be understood as a locally situated practice, that is not necessarily easy to describe in writing or in words reflects LePlat’s statement that “safety cannot be captured only by what is said of it” (LePlat 1998).

### **Production pressures**

Our research also revealed how sub-contracted workers are sometimes put under pressure by builders (principal contractors) to work unsafely and in breach of safety-related rules established by their own company. Pressures to complete work and managers’ unwillingness to permit subcontracted workers to spend a lot of time learning about safety-related rules have been identified as factors contributing to rule violations in the petroleum industry (Dahl 2013). Guo *et al.*, (2016) also note that pressures to maintain production in construction projects reduces levels of compliance with safety-related rules.

The insulation installation workers we followed in our research are positioned at the lowest level in the building industry’s hierarchical supply chain. Our results reveal that, even when they know about the safety-related rules that apply to their work, the insulation workers are expected to break these rules by the builders who engage them.

The participatory video process was identified by one of the workers as being instrumental in his refusal to work unsafely when requested to do so by a builder. Other workers described how they used video materials to show builders (principal contractors) why they needed to follow the SOPs when performing high risk tasks. In this, the participatory video appears to have engendered greater understanding of the importance of safety, and a sense of solidarity among the insulation installers.

### **The role and interpretation of rules**

LePlat (1998) observes that safety-related rules “have value only in as much as they are instruments for improving safety.” As safety management systems have become more prevalent, safety has been criticised as being overly “proceduralised” (see, for example, Bieder and Bourrier 2013).

It is generally acknowledged that procedures cannot cover all eventualities and, thus, workers use their judgement and experience to continuously transform rules into practice. Informal ways of working are important but are not always well understood or acknowledged. Ozmec *et al.*, (2015) describe how, in small business construction firms, work practices are constantly negotiated as workers draw on personal experience and emotions and constantly juggle safety issues with other considerations

relating to workflow, customer satisfaction and good work relations with supervisors and co-workers.

Dekker (2003) describes how safety is not always achieved through the rote following of rules. Rather, safety results from people being skilful at judging how to apply rules to particular contexts or situations. In some instances adaptation may be good for safety. However, this presents a “double bind” because although rules may need to be adapted in some situations, some adaptations can also fail with serious consequences (Dekker, 2003).

The role played by foremen in helping workers to translate safety-related rules into locally-situated practices has been noted (see, for example, Zohar and Luria, 2003). Previous research in the construction industry also reveals that supervisors identify formal procedures and safety-related administration as being a hindrance to effective safety leadership. They suggest that over-reliance on rules and enforcement of compliance is disempowering for workers and damages good supervisor-worker relationships that are important for safety (Conchie *et al.*, 2013). The insulation workers also identified the role played by foremen as being important in shaping how (and if) safety-related rules are followed. One commented: “Oh each job’s quite different really. Each foreman’s different, each builder’s different so it just depends on what you’re doing and how you’re doing it and how you have to do it. It all depends on different jobs or whatever.” Thus, given their pivotal role, the skill and experience of people in supervisory roles is critical to ensuring that informal ways of working are appropriate, that is, that the adaptations do not fail (see Dekker 2003).

Our research also highlights the potential for participatory video to help to identify and understand gaps between written or spoken procedures and locally situated work practices. In some instances, these gaps can be very instructive and suggest ways in which work processes or equipment need to be redesigned to enable safer ways of working. The gaps can also reveal problems inherent in the way that power relations in the construction supply chain can undermine organisational safety efforts, particularly in small firms engaged in sub-contract arrangements. In these circumstances pressures to “get the job done” are acutely felt and can result in a normalisation and acceptance of rule-breaking. Without understanding the underlying reasons for gaps between procedures and practice, it is impossible to deal appropriately with safety-related rule violations or mistakes. It is very unlikely that reminding workers to “follow the rules” would have been an effective remedial strategy in any of the situations of safety-related rule violations or rule-based mistakes we discovered.

## CONCLUSIONS

Our research followed a participatory video approach to explore the occurrence and reasons for safety-related rule violations and rule-based mistakes in the Australian building industry. We followed a group of insulation installers working in the Australian building industry, who were engaged in making a film about their work practices. We observed the workers and interviewed them about how they worked and why. Several examples of safety-related rule violations and mistakes became apparent in the research. Reasons for these varied. Some were unintentional mistakes arising because workers did not know about safety-related rules. Other violations arose because of unsuitable equipment or because procedures were unworkable in certain situations. However, some safety-related rule violations were also tacitly accepted (even expected) by the builders who engaged the sub-contracted workers to

install insulation. These examples reveal significant issues related to supply chain commercial arrangements in the construction industry, and pressures placed upon workers to get the job done - even when this compromises their safety. Local conditions, time pressures and conflicting goals all shape the extent to which safety-related rules are practically followed. Understanding the causes of safety-related rule violations and mistakes is an important precursor to designing better rules and/or addressing some of the contextual impediments to their effectiveness. In this, participatory video is an effective and powerful way to engage workers in reflexively critiquing, explaining and reconstructing their experiences from their own perspective.

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# INTRODUCING SITE SENSE: COMPARING SITUATED KNOWLEDGE IN CONSTRUCTION TO COALMINING

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The acknowledgment of the use of tacit knowledge as a safety praxis in the mining industry has been in existence for over half a century. This is referred to as pit sense. On the contrary, the use of tacit knowledge for site safety is only gathering steam in the construction industry. Research on common sense in construction suggests that the conflicts with official practices and policies, and resistance from individuals in managerial roles, hold back advancements in employing tacit knowledge. Common sense in construction and pit sense in coalmining substantial similarities including their heavy dependence on self-preservation and the use of a bottom-up approach i.e. both focusing on the discretion of the workers. We introduce the concept of 'site sense' as an approach to site safety which is based on tacit knowledge and reflects situatedness of knowledge. Non-participant observations and semi-structured interviews were used to collect data on the practices of workers of micro construction firms in relation to site safety. The research findings indicate that unlike site sense, pit sense has evolved from first being regarded as a mere informal practice to then being acknowledged by managers as a way of workers taking responsibility and accountability for their own safety. Site sense and pit sense are both recognised as safety practices that are not formally taught but acquired through continuous practice. They are both situational knowledge gained through informal techniques and close interactions among team members. In both schools of thought, it is widely known that experienced workers are proud to possess and demonstrate pit sense and site sense respectively whereas newcomers do not yet possess this tacit and situated knowledge.

Keywords: coalmining, common sense, local knowledge, pit sense, site sense

## INTRODUCTION

Both construction and coal mining industries are known to consist of numerous risks and hazards that can lead to fatal incidents (Health and Safety Executive (HSE), 2015). As a result, both industries have resorted to several methods to ensure workplace safety. Both industries fall under the purview of the Health and Safety at Work Act 1974. Explicit and tacit knowledge are implemented as safety management approaches in construction (see Aboagye-Nimo *et al.*, 2015; Bartholomew, 2008) and coal mining (see Morantz, 2013; Kamoche and Maguire, 2011). While explicit safety knowledge is well documented and accepted as a reliable form of knowledge in both areas, tacit safety knowledge is not as prevalent. This may be as a result of the discretionary and interpretivist component attached to tacit knowledge (Polanyi, 1966).

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In the UK mining industry, strides have been made for over half a century to recognise workers' tacit knowledge as a valid form of safety knowledge (Kamoche and Maguire, 2011; British Broadcasting Corporation (BBC), 1961). This is known as '*pit sense*' (ibid). However, the tacit knowledge found in construction safety practice referred to as '*common sense*' (see Dingsdag *et al.*, 2006; Oswald *et al.*, 2015) has failed to receive a similar level of success. We propose that common sense safety in construction is a valuable practice-based approach to safety management which draws on workers' experience and tacit knowledge. In order to locate this common sense approach within the construction site and express the situatedness of such tacit knowledge, we call it '*site sense*'. Thus, the aim of this paper is to introduce '*site sense*' as an approach to site safety drawing on a comparison with pit sense. A critical review of literature on pit sense and site safety is presented next to set the foundation for the study.

### **Pit sense**

The catch phrase "pit sense" has been in the public domain since the 1960s. Emotive ballads were sung about pit sense on ground-breaking BBC radio shows: '*[pit sense] is your only defence... your life may depend on it*' (BBC, 1961). The concept is also echoed in the historical collection of mining stories by Kiveton Park and Wales History Society (2010). Pit sense is a craft-based understanding that pit workers consider important for functioning below ground (Kamoche and Maguire 2011, 726). It is known to be instinctive knowledge that requires all of one's senses and awareness (Sommerville and Abrahamsson, 2003). However due to the tacit nature of pit sense, it may go unidentified and thus undervalued. Sommerville and Abrahamsson (2003, 26) offer the following definition for pit sense:

Well pit sense is, most blokes have it. They might, they take it for granted, especially if they've been in the pits for a long time. But they have got it. A lot of, all the blokes have got pit sense. They know that the roof's bad, they know by hearing it, they know by smell, they know by the sense of just being there and being uncomfortable, the heaviness of the air, that you're in a place where you shouldn't be, lack of oxygen or gas. You'll feel the hairs move up on your legs, y'know, with black damp or something there.

Although this definition firmly establishes that pit sense exists, it falls short of clearly identifying what it is. This comes as no surprise as scholars in the field of tacit knowledge (e.g. Nonaka and von Krogh, 2009; Tsoukas 2005) all stress how difficult it is to define tacit knowledge. In one of the definitions of tacit knowledge, a miner has been quoted as follows: '*just something that you picked up*'; '*you get it as you're working down the mine... a lot comes with experience*' (Kamoche and Maguire 2011, 732). Pit sense is used by workers as a '*flexible buffer*' for dealing with the uncertainties inherent in coalmining (Kamoche and Maguire 2011; 726). In essence, these uncertainties are risks (ibid). Thus, pit sense is or includes workers' ability to readily adapt to situations in the face of risks and dangers. In high-risk work environments (like coal mines and construction sites), the word dangerous is open to interpretation (Turner and Tennant, 2009); there are varying levels of perceived risks (Gray, 2002). Workers in such environments thus evaluate levels of risks and uncertainties, hence distinguishing between what they assume can be controlled and what is uncontrollable (Baarts, 2009). Without experience in the pits, it will be almost impossible for outsiders to acquire the tacit safety knowledge known as pit sense (Sommerville and Abrahamsson, 2003). In addition to work experience, greater cohesiveness is generated amongst mining teams that work together for long periods of time (Trist and Bamforth, 1951). In the 'Longwall Study', Trist and Bamforth

(1951) identified the importance of leadership and supervision in internal groups and responsible autonomy. By working close together for long periods of time, miners are able to learn from one another and gradually form their own safety culture and generate very unambiguous norm of safety (Kamoche and Maguire, 2011).

Although pit sense is being presented as a quasi-formalised safety approach in the mining industry, many miners hold a different view. Workers believe that pit sense (or what is left of it) may be a watered-down version following the bureaucratisation of their safety practices (Kamoche and Maguire, 2011). They describe the period where management would not challenge pit sense as the 'golden age' (ibid). Although the legitimacy of pit sense was challenged following the introduction of extensive bureaucracy in the mining industry, there is evidence of an emergent blend of formalised procedures and a tacit knowledge (i.e. pit sense) in ensuring workplace safety (ibid, 726). The current practice of coalminers' pit sense is essentially a combination of formalised practices (and explicit knowledge) and tacit knowledge. Next we introduce site sense.

### **Site safety, Common sense and site sense**

Construction sites are among the most injury-prone workplaces worldwide. Safety issues on site include serious injuries, lost work time, hospitalisation and mortality (Kines *et al.*, 2010, 399). Construction projects differ from one another and many sites present a unique and ever changing working environment. Workers must continually assess and manage risk and safety on site. Together with formal policy and processes, reactive measures are therefore always incorporated in managing unforeseen risks.

Recent research has identified common sense safety on construction sites as 'the practical knowledge and judgement developed by workers after gaining years of experience on site' (see Aboagye-Nimo *et al.*, 2013; Oswald *et al.*, 2015). Practical knowledge and judgement on site requires complex interaction of both explicit and tacit knowledge gained through training, experience, guidance by leaders, experiential learning in new situations, and from experts and experienced workers who have preceded the workers (Gherardi and Nicolini 2002, 192). Without this type of knowledge, people (especially those without experience in the construction industry) may stand right next to extremely dangerous hazards and not notice them (Baart 2009, 953). While there are clear documentation and records of explicit knowledge in the construction industry (e.g. HSE rules and regulations, and company policies), tacit knowledge is rarely represented.

Common sense safety gained some recognition when a special report highlighted its importance and relevance to site safety (see Lord Young of Graffham, 2010) in response to the increasing burden of excessive bureaucracy and red tape measures (Cook, 2015). Arguably, bureaucracy and red tape prevent experienced and knowledgeable workers from using their tacit and situated knowledge they have gained from years of site practice (Vassie *et al.*, 2000). However, it is extremely important that health and safety matters are detached from bureaucratic matters to ensure focusing effort on measures that are implemented primarily for the improvement of workplace safety (HSE, 2003, 13). Therefore, measures that help prevent injuries and harm to individuals on site must not be restricted by bureaucratic measures. Unfortunately, using measures that fall outside the scope of official work policy (even if they help improve safety) can lead to workers losing their jobs and subsequently being placed on a 'blacklist' (Taylor, 2013).

We propose that 'site sense' offers a balanced approach to managing safety on construction sites; an approach that acknowledges the need for strategy, policy and processes and more importantly one that allows for workers to employ tacit knowledge to continually assess and negotiate the changing work environment. Using site sense in opposition to excessive bureaucratic safety measures helps improve overall safety and also frees '*businesses from unnecessary burdens and the fear of having to pay out unjustified damages claims and legal fees.*' (Lord Young of Graffham, 2010: 9). Matters concerning 'health and safety' are gradually losing their importance in society as a result of red tape requirements as they have overridden common sense and personal responsibility (Löfstedt, 2011).

While investigating the evolution of workplace safety, Cooper (2003) highlights two areas that traditionally have been considered for improvement. These are as follows (ibid, 3):

Are employees provided with the maximum protection possible?

Are employees trained to recognise potentially hazardous situations and take the most appropriate actions?

The first point is out of the control of the employees themselves and may require explicit measures such as rules and regulations, statutory means and safety equipment. The second point requires workers to take some responsibility with regard to their actions and reactions. Thus, an individual possesses the relevant knowledge and skills to help avoid accidents (Cooper 2003, 3).

In order for individuals to possess the relevant knowledge and skills to help avoid accidents on site, they must have experience (Aboagye-Nimo *et al.*, 2015). This type of knowledge cannot be learnt offsite or in a classroom setting and it is best learnt through actual work practice (Sillito, 2002). It is important that this knowledge is given a terminology that reflects the situation and environment where it is implemented i.e. construction sites. The name common sense does not reflect the situatedness of the knowledge and also creates contradiction with the everyday use of the phrase. In light of the above, we introduce the term '*site sense*' as a best fit for the site knowledge often referred to as common sense. Site sense reflects the tacitness and situatedness of construction workers' safety knowledge accurately. The definition we thus offer for site sense is as follows:

*Site sense is the tacit and situated knowledge workers exercise on construction sites. It is often taken for granted due to its ineffable nature as a result of knowledge internalisation based on many years of practice and experience.*

## RESEARCH METHODS

Rich qualitative data was collected from experienced workers in the construction industry. This was achieved using non-participant observations and semi-structured interviews. Geographically the participants were located in the East Midlands and the South East regions of the UK (the 'South East' in this study excludes the Greater London area). This approach to data collection allows researchers to gain an in-depth understanding of workers' practices and perceptions and facilitates comparison with the findings from studies on pit sense (e.g. Kamoche and Maguire, 2011; Leger and Mothibeli, 1988; Trist *et al.*, 1963). The views and perceptions of construction workers were collected from visits to five construction firms in the East Midlands and two firms in the South East. All respondents worked in small teams on site (micro construction firms). Similarly, miners have been observed to work in small teams of

up to seven in some cases (Trist and Bamforth, 1951) bearing resemblance to subcontractors on typical construction projects, and so the data from construction sites provides feasible comparisons with the studies of mining workers.

The micro firms studied included different trades, ranging from general builders, steelworkers and ground workers. This variation offered important insights into how site sense manifests for different professions on site. All respondents included in this study had several years of work experience on construction sites. Table 1 presents the research participant profile.

*Table 1: Profile of the research participants*

Region of operation	Type of work	Participants	Years of experience
East Midlands	Refurbishments	John	17
East Midlands	Bricklayers	Steve	28
East Midlands	New builds	Derek	21
East Midlands	Steelworks and groundworks	Tony	11
East Midlands	New builds	Tom, Andy	14, 38
South East	Temporary structures	Phil	20
South East	General builders	Bruce	21

To preserve the anonymity of the participants, pseudonyms have been adopted in place of their actual names. All the semi-structured interviews were digitally recorded and transcribed verbatim. Extensive field notes were recorded during the non-participant observation events. QSR Nvivo 10 was used to facilitate data management and thematic analysis.

## **COMMON SENSE ON SITE VS PIT SENSE = SITE SENSE**

Several themes emerged in the data analysis. The key themes included the definition of common sense, teaching and learning on site, workers' personal responsibility with regard to safety, and how site sense may be accepted as a valid safety approach.

### **Defining common sense**

While discussing how site safety is created and maintained, participants made several references to the importance of common sense. This led to the question: '*what is common sense?*'

Common sense is safety, isn't it?

This was Andy's definition of common sense. Although he was confident of his understanding i.e. the importance of common sense, he was not able to give a clear definition due to the tacit nature of the knowledge. He literally equates common sense to site safety. As shown in the literature review, both pit sense and common sense are difficult to define. On a conceptual level we can see that they refer to the knowledge they gain at work i.e. in the pits or on sites respectively.

### **Teaching and learning common sense**

After participants had established the importance of common sense in site safety, they were asked how common sense was taught or learnt. Phil stated:

I don't think you can teach common sense

Although Phil mentions that common sense cannot be taught to individuals, he further states: "*You just have to keep pointing it out to people*". Phil thus unconsciously

implies that common sense can be taught. The practice of having to keep pointing things out to people until they '*get it*' is in essence a teaching and learning process. '*Getting it*' is part of the internalisation of tacit knowledge (Nonaka and von Krogh, 2009), thus a teaching and learning process. As a good teaching approach, experienced workers must thus be encouraged to '*keep pointing out*' mistakes and keep highlighting safety practices to new workers until they internalise the knowledge being taught. Although informal in nature, this is known to be a very effective method.

According to the participants, workers on construction sites learn a lot from mistakes. The workers attributed the subsequent awareness of the mistake or hazard to common sense. As shown below, workers are aware of how experience has taught them (as they have also learnt) about risks and hazards.

When you've seen someone else misbehave or how you've worked based on how far out you've worked it's just experience... you've got to be on site and you've got to be doing the job and pit up; the right ways as well as the wrong ways. (Derek)

Phil adds that "*Common sense [improves] with time... If it hurt once, you won't do it again*". This shows that subconsciously, he knows that common sense is learnt but he may not be recognising or assigning the learnt outcome to the actual learning process (considering his previous quote), in this case learning from mistakes through experiential learning. Other examples of mistakes that people learn from when on construction sites included people temporarily losing their hearing from using 'wackers' without ear defenders. From the uncomfortable experience and fear of losing one's hearing, workers do not repeat such erroneous practices.

In the case of pit sense, experiential learning and learning from mistakes is also common place. In Kamoche and Maguire (2011, 737), a pit deputy is quoted as follows: "*you get an 18-month-old youngster that will walk up to the fire and touch the fire and [they] won't do it again*". Thus in the pits, new workers learn about risks and hazards in a similar manner to construction sites. This shows that workers believe that when people carry out such mistakes or observe them, they end up committing the details of the given incident into memory and hence learn from it (Gherardi and Nicolini, 2002).

### **Site sense and its use**

The experienced workers that participated in this study had all expressed their use of common sense to create and improve site safety. None of the participants implied the everyday use of the term common sense but a much specific knowledge. They referred to it as the knowledge they had learnt through years of practice on site. Our earlier proposal of the definition of site sense thus better captures the uniqueness of the tacit knowledge often referred to as common sense.

Due to the nature of the small sized groups, there was a great deal of closeness amongst workers. All workers mentioned that it allows them to know what others know (in terms of competence) and allowing them to trust one another better. This is reflected in how new members are trained or taught. Experienced workers mentor the newcomers by allowing them to work closely with them for long periods of time. Gerhardi and Nicolini (2002) explain that tacit knowledge is best taught and learnt when experienced workers demonstrate the act and subsequently allow the newcomers to practice the given technique. Likewise, pit sense is not acquired through formal training but is disseminated in situ, experientially, informally, through close social

interaction and use of language, and based on the very unambiguous norm of safety (Kamoche and Maguire 2011, 726-727).

### **Prerequisites for site safety: Legality and practicality**

By law, all workers in construction have to possess Construction Skills Certification Scheme (CSCS) cards before being allowed to work on site. The CSCS card is an indication that the bearer has received training and skill including safety training and hence is competent enough to work on site. All workers (including the newer ones) on the visited sites possessed CSCS cards. However, experienced workers believed this scheme was not a helpful approach. They believed the newcomers had the CSCS cards but lacked site sense. John, Tom and Tony all disagreed with the scheme because they were of the opinion that the workers came on site with preconceived notions of what safety was meant to be and this basically interfered with their learning of good safety practices. Furthermore they believed that a classroom based test such the CSCS, National Vocational Qualifications (NVQs) and Scottish Vocational Qualifications (SVQs) were not representational of real site experiences. Such tests are however good for assessing explicit knowledge but research indicates that construction sites require more of tacit knowledge (Abdel-Wahab *et al.*, 2008; Aboagye-Nimo *et al.*, 2015). The efficiency of the NVQs and SQVs are also questioned in other industries.

### **Personal responsibility and autonomy**

Participants believe that workers should have some form of responsibility for their own actions. They believed that newer workers were not capable of taking up such responsibilities and hence needed to be guided. On this issue of workers taking responsibility of their own safety, participants stated: "*Young people are one of the biggest issues for me*" (John). He explained that young people (specifically newcomers to the construction sites) did not have a complete understanding of the implications of their actions and inactions. Therefore they do not approach or handle risks and hazards with the same seriousness that experienced workers would. This attitude can lead to incidents and accidents to themselves or workmates. Andy also expressed concern about the lack of safety awareness that some newer workers exhibited. '*Horseplay*' and '*use of mobile phones*' while working were serious matters that created distress for experienced workers with regard to safety. They share John's views. The experienced workers also added that there is a need to shelter and protect new workers who have not yet gained site sense from potentially risky situations. Therefore these experienced workers believe it is their responsibility to ensure the safety of the newer workers.

Kamoche and Maguire (2011) explain that the idea of responsibility has evolved to be shared between workers and managers in the pits. Similarly on construction sites responsibility has evolved to be shared between all workers on site i.e. site operatives, foremen, site managers and other site officers. Also, once managers in pits are comfortable with workers' practices, they allow them to use their own discretion even if it means turning a blind eye to some of their practices (ibid). While mining companies may be owned by large companies, micro construction firms are different. In micro firms (including specialist subcontractors), the managers/owners tend to be part of the working teams on site and key to decision-making (Huang and Hinze, 2006); this was also observed on all sites visited in this study. Noticeably, none of the newer workers on site (with less than five years of site experience) mentioned or implied using common sense/site sense. Although experienced workers rely on site

sense to take care of themselves and other workers, their concept of working outside official policies may not be accepted in the workplace. According to the participants, it is difficult to use site sense as justification in an argument in court because of the lack of records or documentation on such practices. Tom and Phil expressed concerns about the consequences of using site sense and other informal practices that are not documented because they believed that: “*common sense doesn't hold in court*”.

### **Accepting site sense safety as a valid approach**

Unlike the mining industry, construction sites are geographically spread across the UK and the industry employs more than 6% of the entire British workforce (Rhodes 2013, 3). In addition, stakeholders in construction are very different from those of mining, such as employees, passers-by, policymakers and private clients. The Health and Safety at Work etc. Act 1974 makes it the duty of employers to ensure the safety of employees and the general public, but the mining industry may not have to encounter the general public as much as the construction industry. For example, the Construction Design and Management Regulations (2015) place a great deal of responsibility on all stakeholders including clients who may not have any expertise in construction processes and site safety for that matter. The HSE acknowledges that many clients do not have safety knowledge or site sense and offer guidance to clients lacking knowledge in site safety. Unlike the construction industry, mining has always been regarded as a specialised job that requires expert skillset (Harris, 1976; Czaja, 2014). However, due to the many facets of construction projects and the introduction of 'do-it-yourself' (DIY) projects, many non-experts consider themselves as having construction knowledge (Ball, 2014) although they may not possess any site sense. This in addition to health and safety being ridiculed in the media (Löfstedt, 2011) has potentially eroded the level of expertise associated with construction works.

Although construction workers use common sense to mean a more sophisticated level of knowledge that is tacit, situational and unique to years of practice on site, the name makes it difficult for a newcomer or non-construction professionals to accept it in this manner i.e. it is easily confused with the everyday definition of the term.

Interpretation of the term (by non-construction experts) ends up reducing its significance and uniqueness to the industry. Site sense is representative of the situatedness and tacit nature of safety knowledge on site. The term pit sense is unique to pit mines and as such cannot be confused with any phrases found in everyday language. As a result, the introduction of site sense can radically transform public perception of the knowledge learnt on site, thereby giving it the recognition it deserves i.e. a unique safety knowledge acquired from years of site practice.

## **CONCLUSIONS**

This study has introduced site sense and discussed it in relation to pit sense as practices based primarily on tacit and situated knowledge acquired through years of work experience. Primary data was collected from micro construction firms within two regions of the UK. The data confirmed that a significant amount of tacit knowledge is used in managing risks and safety on site. Similarly, pit sense in the mining industry is based on tacit knowledge but over time has been blended with more formal practices. We propose that 'site sense' offers a representative conceptual label for a blended approach to safety knowledge on construction sites. Furthermore, the new terminology open up possibilities for transforming public perception of safety knowledge gained on site because it will be perceived as a specialist knowledge that is gained from a specific industry. Moreover, 'site sense' offers policymakers a less

ambiguous interpretation of the place of tacit knowledge in site safety. The aspects of site sense that are not currently covered by existing rules and regulations can be recognised and incorporated into working practices and so organisations stand to attain the best of both worlds: explicit and tacit knowledge being implemented together. Thus site sense can be included in both onsite and offsite safety training for newer and even experienced workers thereby capturing explicit and tacit approaches in site safety.

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# SETTING THE STAGE FOR EFFECTIVE SAFETY LEADERSHIP IN CONSTRUCTION: THE ANTECEDENTS OF SAFETY-SPECIFIC TRANSFORMATIONAL LEADERSHIP BEHAVIOURS

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Representing about 30% of all fatal injuries in the United States in the past decade, the construction industry is notorious for its poor safety performance. Research suggested that a strong predictor of safety performance is safety leadership. Specifically, safety-specific transformational leadership behaviours (SSTLBs) was found to be the most predictable factor of safety outcomes. However, there has been scant attention paid to how organizational context and personal factors could facilitate construction leaders to engage in SSTLBs. Consequently, it is currently unclear how to develop a supportive environment and effective training programs to help the application of SSTLBs. To narrow such a knowledge gap, this study proposed a conceptual model to study the issue based on the framework of the job demands-resources (JD-R) model in positive psychology. Specifically, we examine how personal resources (psychological capital), job resources (social support and work autonomy), and job demands (risks and hazards) could affect leaders' work engagement in SSTLBs. Following the predictions of the JD-R model, we expect that the relationship between job resources and SSTLBs will be moderated by personal resources, job demands, and work engagement. The implications of the proposed conceptual framework for future research are discussed.

Keywords: job demands-resources model, positive organisational behaviour, safety leadership, safety performance, work engagement

## INTRODUCTION

According to the Occupational Safety and Health Administration (OSHA), about 30% of occupational fatalities in the United States constantly occurred in the construction industry over the past decade. This poor performance has sparked an interest in studying how to improve construction safety. Over recent years, a number of studies have pointed out that safety climate is a strong predictor of safety performance (e.g., Clarke, 2006; Zohar, 2010), on the one hand; on the other hand, research consistently revealed that leadership is a critical factor of safety climate. For instance, in a review of two decades of research on safety climate, Flin *et al.* (2000) found that 72% of the literature concluded that leadership was central to cultivate safety climate because leaders' day-to-day behaviours reflect their priority on safety, and employees can interpret those behaviours to generate norms and perceptions on how they should handle safety at work (Zohar and Tenne-Gazit, 2008).

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As leadership was found to closely be associated with safety climate and safety outcomes, a sizeable body of research has focused on uncovering what leadership styles and behaviours are important for driving such relationships. In particular, transactional and transformational leadership are the most frequently studied styles among those publications. Transactional leadership style refers to employing rewards and punishment for motivating followers while transformational leadership style refers to using influencing power and enthusiasm to motivate followers to work for the benefit of an organization (Bass, 1990). Indeed, scholars such as Barling *et al.* (2002), and Inness *et al.* (2010) found that transformational leadership behaviours predicted safety performance. In the same vein, Clarke (2013) concluded that both transformational and transactional leadership influence employees' safety behaviours across different organizational settings. Furthermore, Hoffmeister *et al.* (2014) found that transformational leadership was a more predictable factor of safety outcomes than transactional leadership in construction work.

Although the existing studies did provide us with a good understanding that transformational leadership or, more accurately, safety-specific transformational leadership behaviours (SSTLBs) have a positive and stronger effect on improving construction safety, little is known about the antecedents or factors that affect leaders' engagement in SSTLBs. Briefly defined, 'engagement' or 'work engagement' is the psychological state to which leaders show energy, enthusiasm, feel a sense of inspiration, and are fully concentrated (Schaufeli *et al.*, 2002) in demonstrating SSTLBs. In addition, 'safety-specific transformational leadership behaviours' refer to transformational leadership behaviours that specifically promote and develop a safe work environment (Barling *et al.*, 2002). Nevertheless, research in non-safety domains has shown that organizational context and personal factors are important antecedents of engagement in leadership (e.g., Barling *et al.*, 2000). Therefore, it is quite possible that different contextual and personal factors may affect leaders' engagement in SSTLBs in different ways and for different reasons. We use the term 'leaders' to stand for both top management and front-line supervisors who indirectly and directly manage construction projects.

In fact, understanding the antecedents that promote SSTLBs is important because by knowing the personal factors and organisational context that support leaders' engagement in SSTLBs, we can develop better interventions to target resources toward enhancing the contributing factors. Against this background, our study focuses on developing a conceptual framework to examine what and how contextual and personal factors could influence leaders' engagement in SSTLBs. Specifically, we will start by briefly reviewing how work engagement can be seen as an antecedent for SSTLBs and then move to discuss what and how contextual and personal factors could affect leader's engagement in SSTLBs by using the job demands-resource (JD-R) model (Demerouti *et al.*, 2001). We conclude with implications for future research.

### **Work engagement as an antecedent of safety-specific transformational Leadership Behaviours (SSTLBs)**

#### *Work engagement*

A recent review of Simpson (2009) provided us with various definitions of engagement. In this study, we use Schaufeli and Bakker's (2004, 2010) widely used definition. Accordingly, work engagement is a psychological state that captures a positive, fulfilling, and work-related state of mind. In particular, it is characterized by

vigor, dedication, and absorption. 'Vigor' refers to having high energy levels and mental resilience during work, being willing to put effort in one's work, and staying persistent even in adverse situation; 'dedication' is characterized by having a strong involvement in one's work and experiencing a sense of significance, enthusiasm, inspiration, pride and challenge; and 'absorption' refers to being fully concentrated and happily engrossed in one's work while time passes quickly, and one has difficulties to detach oneself from work.

#### *Safety-specific transformational leadership behaviours (SSTLBs)*

Safety-specific transformational leadership behaviours (SSTLBs) refer to transformational leadership behaviours that specifically promote and develop a safe work environment (Barling *et al.*, 2002). SSTLBs are categorized into the same four components as transformational leadership behaviours are, namely: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration (Bass, 1990). Specifically, in the context of SSTLBs, 'idealized influence' could be demonstrated when leaders communicate a vision of workplace safety and become role models to promote work safety. For example, leaders do not drive profit and performance at the expense of safe work practices; leaders could show 'inspirational motivation' when they challenge individuals to achieve higher safety standards that exceed minimum safety requirements; 'intellectual stimulation' could be shown when leaders challenge employees to evaluate existing safety practices and develop innovative and improve practices for solving safety-related matters, and leaders could demonstrate 'individualized consideration' for employees by showing their personal concern for the safety and well-being of employees.

#### *Work engagement and SSTLBs*

This study considers work engagement as an antecedent of SSTLBs. As mentioned earlier, transformational leaders use influencing power and enthusiasm to enhance followers' commitment and involvement to the safety goals of the organisation, and motivate followers to perform above and beyond the required safety standard. According to Bass (1990), transformational leaders recruit and engage their followers by using role modelling. In a nutshell, a leader's behaviours show to his followers what kind of safety values and behaviours are legitimate to develop and, thus, followers can model those values and behaviours to deliver better safety outcomes. In psychology theories, one's psychological state directly causes behaviours. In other words, behaviours can be explained by citing the psychological state that gives rise to them: a person behaves in a certain way "because he/she was angry" or "because he/she was happy." Specifically, work engagement is a psychological state, which includes vigor, dedication, and absorption as defined in the earlier section, leads to SSTLBs. Based on the theoretical background, we can probably infer that a leader with high work engagement is more likely to demonstrate SSTLBs. Indeed, our proposition is indirectly supported by the study from Bakker and Xanthopoulou (2013) in which they found that work engagement is an antecedent of charismatic leadership behaviours. Charismatic leadership is generally regarded as highly correlated with transformational leadership (Bass and Avolio, 1993; Conger and Kanungo, 1998), the general form of SSTLBs.

#### **The contextual and personal factors that support leaders' engagement in SSTLBs: Job Demand-Resource (JD-R) model perspectives**

After establishing the proposition that work engagement is an antecedent of SSTLBs in the previous section, we explore what and how contextual and personal factors

could possibly influence leaders' engagement in SSTLBs in this section. To do so, we used the job demand-resources (JD-R) model as the framework for our conceptual model because the JD-R model offers the mechanisms on how contextual and personal factors could relate to work engagement, and then lead to SSTLBs.

#### *Job demand-resource (JD-R) model*

The JD-R model was grounded in positive psychology theories and first introduced by Demerouti and her colleagues in 2001 as a model to predict work engagement and its related outcomes. Since then, it has been widely used in studies on engagement as the theoretical framework more than any other theory or model (Hakanen and Roodt, 2010). Overall, the JD-R model consists of three components as the antecedents of work engagement and its work outcomes: job demands, job resources, and personal resources. In particular, job demands and job resources are contextual factors or working conditions that can be found in every organisation (Schaufeli *et al.*, 2009). Job demands could deplete one's energy and consequently engagement while job resources facilitate one's engagement in the desired outcomes. In addition, personal resources in the JD-R model can be defined as personal factors that help individuals control and impact their environment successfully (Xanthopoulou *et al.*, 2007). In addition, personal resources have a positive association with work engagement in general. In the following sub-sessions, we further define job demands, job resources, and personal resources in detail, and explain what specific factors under each component we propose to study in our conceptual model.

#### *Job demands - risk perception*

Job demands are contextual factors including the physical, psychological, social, or organisational dimensions of the job that potentially impose strain if they go beyond employee's adaptive capability, causing depletion of one's work engagement. Therefore, it is associated with physiological and/or psychological costs. Examples of job demands include high work pressure, destruction work environment, and emotionally demanding interactions (Bakker and Demerouti, 2007).

In the conceptual model, we propose to look into risk perception as a variable under job demands because it constitutes the environmental and workplace conditions in the context of safety. Our definition of perceived risk is consistent with previous work that has defined it in terms of (1) the leader's labelling of situations, (2) probabilistic estimates of the extent and controllability of risk of risks, and (3) confidence in those estimates (e.g., Jackson and Dutton, 1988 and Sitkin and Pablo, 1992). Although there is limited research on studying how an individual's risk perception could affect his or her leadership behaviours in safety context, the impact of risk perception on leadership behaviours has been widely studied in non-safety context. For instance, Bazerman and Moore (2008), Roll (1986) and Slovic (1972) found that a decision maker's level of risk perception is related to his or her exhibiting unwarranted confident in their judgements.

Meanwhile, much of safety studies on risk perception have focused on the relationships between risk perception and safety work behaviours, and contradictory results were found. For example, Rundmo (1996) found that there is a negative correlation between workers' risk perception and risk behaviours in the oil and gas industry. Arezes and Miguel (2008) got a similar result. They found that workers who perceived high risk levels on noise exposure were more likely to use hearing protection devices. On the contrary, Nahrgang *et al.*, (2011) concluded that the increase in risk perception led to the increase in job stress, and thus negatively

impacted on an employees' engagement in safety activities, compliance, and job satisfaction. DeJoy *et al.*, (2004) and Nielsen *et al.*, (2011) shared a similar research finding. Indeed, according to the Yerkes-Dodson's law developed in 1908, people need a certain level of job stress in order to choose the right behaviours for driving positive work performance. However, when people get too much stress, they become disengaged and thus lead to negative work performance.

Based on previous studies and the Yerkes-Dodson's law, we expect that the relationship between risk perception and the engagement of safety leadership behaviours is not in a linear relationship, but in a curvilinear relationship. It means that the increase of risk perception leads to the increase of practising SSTLBs up to a certain point, after which, as risk perception continue to increase, the practice of SSTLBs decreases due to a high level of stress.

#### *Job Resources: work autonomy and social support*

Job resources include physical, psychological, social or organisational aspects of the job that help employees achieve work goals, reduce job demands and the associated physiological and psychological costs, and/or stimulate personal growth and development. Examples include work autonomy, co-worker support, and feedback.

In the conceptual model, we propose to study work autonomy and social support as the variables under job resources. In fact, Conchie *et al.*, (2013) used a focus group method to explore the contextual factors that construction supervisors perceived as being helpful to their engagement in safety leadership behaviours. They found that work autonomy and social support have a positive impact on leaders' engagement in safety leadership behaviours. By studying these two variables in our model again, we are going to empirically validate their findings, and take a step forward by focusing on SSTLBs.

Work autonomy refers to the extent of feeling in control to choose the ways individuals work on their jobs (Breugh, 1999). It promotes work engagement because it encourages ownership for behaviour, feeling of subjective competence and a sense of feeling related to their jobs (Deci and Ryan, 1985). Moreover, previous studies have found autonomy help to promote safety in general. For example, Grote (2007) proposed that autonomy has the strongest impact on safety when desired behaviours are not rule-based and when there is a high level of uncertainty.

As for social support, it can come from the organisation (Mearns and Reader, 2008), supervisors or co-workers (Turner *et al.*, 2010). In fact, Nahrgang *et al.*, (2011) reported that social support is the single most consistent resource that positively influences engagement in safety across different industries. Based on the previous work, we expect work autonomy and social support could be positively related to one's work engagement in SSTLBs.

#### *Personal resources - Psychological Capital (PsyCap)*

Personal resources are personal factors. They refer to individuals' ability to control and impact on their environment successfully (Xanthopoulou *et al.*, 2007). Personal resources generally can help individuals adapt to different work situations to achieve better work performance. Although individuals' adaptation to environment is different, depending on their levels of personal resources, these resource levels are cultivated by environmental factors. In other words, it is proposed that personal resources may function either as moderators or as mediators in the relationship between job resources and work engagement. Examples of personal resources include

self-efficacy, self-esteem, and optimism (Lorente, *et al.*, 2014; Xanthopoulou *et al.*, 2007; 2009a, 2009b).

In the conceptual model, we propose to use psychological capital (PsyCap) as a variable under personal resources. PsyCap is a higher-order construct that consists of self-efficacy, hope, resilience, and optimism. We choose to test PsyCap in our model because substantial empirical research has indicated that PsyCap has significant positive relationships with desirable employee attitudes and behaviours (e.g., job satisfaction, organisational commitments, psychological well-being, and organisational citizenship) (Avey, Reichard, Luthans, and Mhatre, 2011; Larson and Luthans, 2006; Peterson, 2011; Qadeer and Jaffery, 2014). More importantly, Sweetman and Luthans (2010) proposed a sound and detailed conceptual link between PsyCap and work engagement.

Specifically, PsyCap has emerged as a core construct of positive organisational behaviour (POB) in positive psychology. It is a higher-order constellation of four positive psychological constructs: self-efficacy ('having confidence to take on and put it in the necessary effort to succeed at challenging tasks'); hope ('persevering towards goals and when necessary redirecting paths to goals'); optimism ('making a positive attribution about succeeding now and in the future'); resilience ('when beset by problems and adversity, sustaining and bouncing back and even beyond to attain success') (Luthans and Youssef, 2007 p.3). It is revealed that overall PsyCap yields higher correlations with performance outcomes than its constructs independently (Avolio *et al.*, 2007). In addition, PsyCap can be developed and improved through training (Luthans *et al.*, 2010).

As mentioned above, Sweetman and Luthans (2010) proposed PsyCap is the antecedent of engagement. In addition, we consider that PsyCap may be a potential antecedent of SSTLBs in several ways. Leaders who are more hopeful tend to set higher standards on safety performance and become role models of safety behaviours. They are highly motivated to make their followers comply with the safety standards through various actions such as establishing a safety responsibility system, acting on safety policies, and recognizing followers' safety behaviours. Furthermore, their efficacious and optimistic beliefs about succeeding with their objectives on safety improvement lead them to put in the effort and persistence required to succeed. Finally, highly resilient leaders are more able to bounce back from adversity and stay focused on handling safety issues. As a result, they can find ways around difficulties to achieve better safety performance.

Based on our review, we expect personal resources (PsyCap) is a moderator between job resources (social support and work autonomy) and work engagement. It means that the effect of job resources on work engagement would be strengthened when the level of Figure 1 summarises the concept model, showing the hypothesised relations among contextual factors (job resources and job demands), personal factors (job resources), work engagement, and safety-specific transformational leadership behaviours. The model has the following proposition:

21. Job resources (social support and work autonomy) relates positively to work engagement.
22. Personal resources (psychological capital) moderates the relationship between job resources and work engagement. That is, the effect of job resources on work engagement would be strengthened when the level of psychological capital is high, vice versa.

23. Job demands (risk perception) relates positively to work engagement up to a certain point. After that, it relates negatively to work engagement because leaders are overwhelmed with the job stress caused by a high level of risk perception.
24. Work Engagement relates positively to safety-specific transformational leadership behaviours.

PsyCap is high, and vice versa.

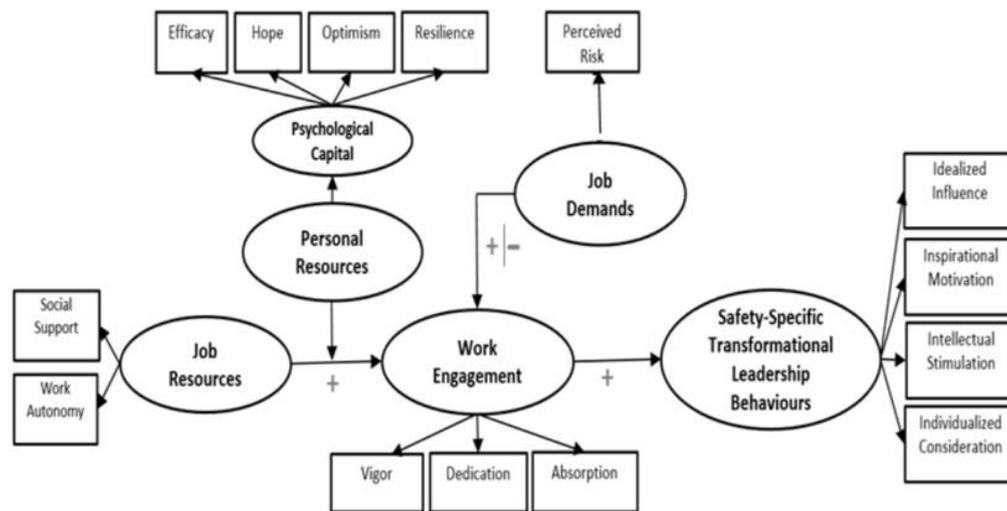


Figure 1. Conceptual model

## IMPLICATIONS FOR FUTURE RESEARCH

Our conceptual framework shown in Figure 1 not only offers new insights into understanding what and how different contextual and personal factors could affect leaders' engagement in SSTLBs, but it also opens a few directions for future empirical research. First, the conceptual model was built based on the mechanism of the JD-R model. The JD-R model posits that job demands and resources, and personal resources influence work behaviours through work engagement. We explained in the above sections why and how our proposed model could mirror the underlying mechanism of the JD-R model. Thus, our conceptual model could lay a foundation for future studies to use the JD-R model for conducting behaviour-based safety research.

Second, we could need a different level and/or combination of contextual and personal factors for supporting top management and first-line supervisors to engage in SSTLBs. For instance, front-line supervisors may need more social support than the top management in order to engage in SSTLBs, because front line supervisors generally have fewer resources and leadership experience. Therefore, we suggest that future research can test the conceptual model in a multiple-level framework that is divided by different managerial levels. In other words, we will make job titles as a control variable in our study.

Last, to empirically test the validity of our conceptual model in future studies, we suggest using survey designs and independent outcome measures, coupled with structural equation modelling (SEM) for data analysis. Basically, all the variables in the conceptual model have their own existing measurements, for example, work engagement can be measured by the well-established Utrecht Work Engagement Scale

(Schaufeli *et al.*, 2002). Furthermore, we propose using SEM as the statistical method for testing our model for two reasons: 1) SEM can examine a series of dependence relationships simultaneously while other multivariate techniques cannot. For instance, in our conceptual model, increasing job and personal resources could increase work engagement, and work engagement could increase the application of SSTLBs. Thus, work engagement is both a dependent and independent variable. In other words, a hypothesized dependent variable becomes an independent variable in a subsequent dependent relationship. To our knowledge, none of the multivariate techniques, except for SEM, can enable us to assess these relationships; 2) SEM allows us to test both measurement properties and test the key theoretical relationships in one technique.

## CONCLUSIONS

Our main focus in this paper has been to develop a conceptual model for understanding what and how contextual and personal factors could affect construction leaders' engagement in SSTLBs, and thus it provides us with insights into how SSTLBs could be better supported and promoted. Our central argument is twofold. First, the application of SSTLBs is positively affected by work engagement. Second, by supporting the job resources (social support and work autonomy) and personal resources (psychological capital), and controlling the job demands that arise from historical accident records and risk perception, organisations have potentially to set a positive wheel of work engagement and SSTLBs for driving better safety climate and performance.

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# USING THE PSYCHOLOGICAL CONTRACT TO MEASURE SAFETY OUTCOMES ON CONSTRUCTION SITES

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The influence of different level managers on safety management in the workplace has been the subject of interest to many researchers. However, senior managers have little contact with ‘workers’ at the construction worksite who instead take daily direction from lower-level managers/supervisors. As a result, the mechanisms of managerial influence on organizational safety outcomes are poorly understood and yet the daily interactions between supervisor and workers influences safety outcomes. This research uses the concept of the ‘Psychological Contract’ (PC) based on perceived mutual obligations between the supervisor-worker. When using this concept to consider safety, it may be termed as ‘PC of Safety’ and the impact of fulfilment/breach of PC on worker behaviour can be hypothetically compared with the impact of PC of safety on workers safety behaviour. This safety behaviour of workers is shaped by the PC of safety between the supervisor-worker, which ultimately causes safety outcomes, e.g. accident rates. Accordingly, a model is proposed of the PC of safety to measure the safety outcomes mediated by workers safety behaviour. Using the supervisor-worker relationship as a unit of analysis, this model has the potential to reveal the relationship between PC of safety and safety behaviour and its effect on safety outcomes.

Keywords: psychological contract, safety behaviour, safety outcomes, workers’ safety.

## INTRODUCTION

Regardless of technological developments and the implementation of robust safety management systems, the construction industry’s chronic level of fatalities, serious injury and ill-health appears difficult to change. This has led researchers and practitioners to focus on organizational and social factors, including safety climate, to induce positive change to the industry’s poor safety performance (Lingard *et al.*, 2010). Safety climate is considered as a sub set of organizational climate and is believed to shape workers’ behaviour through the expectations they form about an organizations value and reward (Zohar and Luria, 2005). Among the most common themes assessed in safety climate research, ‘management commitment’ has been found the most important factor (Flin *et al.*, 2000). Despite this there is a need to better understand the mechanisms by which management commitment to safety “cascades” to lower tiers of management, to ensure that supervisors’ responses remain consistent with organizational commitments (Lingard *et al.*, 2012). There are a few ways to address this gap: (1) understanding the dynamics between senior manager-

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supervisor association and its impact on safety behaviour of workers; (2) analysing the relationship between supervisor-workers and its effect on safety behaviour of workers; and/or (3) examining senior manager/supervisor-worker relationship. Considering the nature of the construction project, the significance of the supervisor on construction sites and timeframe of this PhD-based research project, the research adopts item (2) as the way to identify the influence of supervisor-worker relationship on workers' safety behaviour. As a result, the unit of analysis will be the relationship between first-level supervisor and workers at the construction site and not the relationship between senior manager and supervisor.

According to Lingard *et al.*, (2012), desired safety values and behaviours should be enacted across different hierarchical levels of an organization, and first-level supervisors play a key role in translating top management commitment to safety into safety values and practices within workgroups. The influence of supervisors on safety performance is likely to be increased in a construction context because construction work is highly decentralized, with productive work undertaken at sites remote from the corporate office (Lingard *et al.*, 2012). Although the importance of supervisors to worker safety behaviour has been well-established, the specific behaviours most likely to support subordinate safety performance are less clear, especially in the construction industry (Fang *et al.*, 2015). Another area that has received little attention is the influence that organizationally based social exchanges between workers and supervisors may have on safety (Hofmann & Morgeson 1999). Blau (1964), while discussing social exchange theory, argues that when one party acts in ways that provide benefits to the other party, an implied obligation is generated for future reciprocity. Therefore, the 'Psychological Contract' (PC), which is assumed as a consequent of social exchange theory (Blau, 1964), can be introduced to capture the momentum between supervisors and workers to explore their relationships in terms of safety. Psychological Contract of safety (PCSafety) can be conceptualized as the beliefs of individuals about reciprocal safety obligations inferred from implicit or explicit promises (Walker and Hutton, 2006). This research argues that the notion of PCSafety could provide the cognitive basis for the development of workers safety behaviour and proposes the use of PCSafety to examine the impact of supervision on workers behaviour and safety outcomes in a construction setting. While measuring safety outcomes through the lens of PC, the broader research project will identify the factors of safety climate that are strongly related with components of PCSafety and also measure safety climate at both individual and group level in order to observe their impact on safety behaviour. However, the focus at this stage of the research, and that which is reported in this paper, is the development of a model of the PC of safety in order to measure the safety outcomes mediated by workers safety behaviour.

## **SAFETY CLIMATE, SAFETY BEHAVIOUR AND RESEARCH GAP IN CONSTRUCTION**

In the context of the construction industry, a number of notable safety climate studies have been conducted (Dedobbeleer and Béland, (1991); Glendon and Litherland, (2001); Mohamed, (2002); Siu *et al.*, (2004); Fang *et al.*, (2006); Choudhry *et al.*, (2009); (Lingard *et al.*, 2009). Consistent with research in other industries, there is empirical evidence to support a positive link between safety climate and the safety performance of construction organizations (Gillen *et al.*, 2002). The relationship between safety climate and safety behaviour has been well established in safety research and its consequence are recognized as safety outcomes which are crucial indicators for improved safety on construction sites. However, surprisingly little is

known about the mechanisms by which safety climate influences safety behaviours of individuals in organizations. Furthermore, relatively little is known about the factors that influence safety climate (Neal *et al.*, 2000). The analysis of safety climate has been shown to be generally predictive of safety performance in the workplace (Cooper and Phillips, 2004), but more research is needed to identify specific features of safety climate that are associated with the effectiveness of a behavioural safety process (Wirth and Sigurdsson, 2008). This research gap is depicted in Figure 1.



Figure 1: Missing link between safety climate and safety behaviour

The mechanisms of managerial influence on safety performance within organizations is not well understood (Lingard *et al.*, 2012). In this context, “leaders create climate” (Lewin *et al.*, 1939), and if what supervisors ‘say and do’ are in alignment, it is very likely that supervisor and employee would have a similar interpretation of safety climate (Huang *et al.*, 2014). Such supervisory impact should, in turn, result in the development of shared mental models for both group members and supervisors regarding their experiences in the workplace (Rouse and Morris, 1986). While measuring the influence of the supervisor on the work-group, this project will also measure supervisor’s influence on individual worker’s safety perception and behaviour. The following section describes the significance of supervisors in a construction setting and their influence on safety behaviour of workers.

## **INFLUENCE OF THE SUPERVISOR IN WORKERS’ SAFETY BEHAVIOUR**

Due to multiple levels of organizational structure as well as different roles, responsibilities, and accountabilities at different levels, management behaviours can produce different impacts on workers’ behaviour (House *et al.*, 1995, Kozlowski and Klein, 2000). Supervisors have the most frequent contact with workers among the three management layers and are directly responsible to guarantee good safety performance on site. Simard and Marchand (1997) state that senior management commitment has no significantly direct impact on safety performance, rather, the relations with safety initiatives and supervisors’ involvement as mediating variables have a higher validity (Fang *et al.*, 2015). The fact that the relationship between top management commitment to safety and workgroup injury frequency rates was fully mediated by perceptions of supervisors’ safety expectations highlights the critical role played by supervisors in the safety management process. Construction work is largely non-routine, necessitating the exercise of supervisory discretion in the interpretation of formal safety policies and procedures. In this context, the role of supervisors in shaping subordinates’ safety behaviour is likely to be considerably greater than in stable work contexts characterized by routine production processes (Lingard *et al.*, 2012). This paper limits its research scope between the relationship of frontline supervisors and workers in construction sites.

Although the importance of supervisors to worker safety behaviour has been well-established, the specific behaviours most likely to support subordinate safety performance are less clear, especially in the construction industry. Previous studies on supervisors’ influence on worker safety behaviour in construction is limited, in the studies undertaken the interpretation of implications of supervisory behaviour on

worker safety behaviour tends to be simplified. Practitioners not only need to know how managers can affect worker safety behaviour but also have to grasp the impact, and what are the implications (Fang *et al.*, 2015)?

Sully (2001) argued that to better understand the relationship between safety behaviour and an individual employee, it is important to understand the dynamics underlying the relationship between employees and their organization. Considering the construction setting, the supervisor is the most influential entity to represent the organization. In addition, they have been shown to develop high levels of physical and psychological closeness with their direct subordinates through bonds that begin to develop during their supervision of employees' day-to-day tasks. These bonds noticeably affect employees' perceptions of their psychological contracts [Bass (1991); Krackhardt *et al.*, (1981); Lee and Taylor (2014)]. The PC literature has tended to treat immediate managers exclusively as key agents representing the interests of organizations with respect to the PC between employees and organizations [e.g., Conway and Briner (2002); Robinson and Morrison (2000); Lee and Taylor (2014)]. However, the dilemma of the dual role of supervisors presenting themselves as principal and primary agent in front of their sub-ordinates still leads to confusion (Lee and Taylor (2014)). It has been suggested that managers should avoid to develop such impression as being the principal agent for long term benefit (Lee and Taylor, 2014), this study does not intend to identify whether managers/supervisors are following this strategy at the construction site as the data will be collected from workers only. In order to address this limitation to some extent, supervisors and senior management will be considered and presented as separate entities while designing the survey questionnaire and analysing the data collected from workers.

Noteworthy to this context, Sully (2001) proposed the PC as means of exploring this relationship, arguing that safety was already based on reciprocity involving a duty of care on the part of the employer and a reciprocal obligation to uphold safety standards on the part of the employee. Since safety climate is based on the perception of workers (Zohar, 1980) and PC is also developed from perceived obligations through the relationship with the supervisor (Rousseau, 1990), it can be expected that PC of safety is developed from safety climate and it influences worker's behaviour in the same way that psychological contract influences behaviour of the employees in an organization setting (Walker, 2013). This hypothetical relationship is shown in Figure 2.

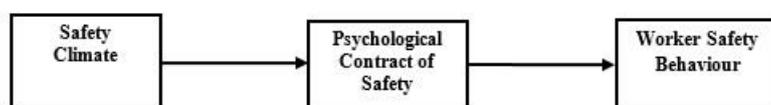


Figure 2: Mediated relationship of psychological contract of safety between safety climate and safety behaviour

### Psychological contract of safety

Blau (1964) while explaining social exchange theory, argued that if employees perceive that the organization is concerned for their well-being they will develop an implicit obligation to reciprocate by carrying out behaviours that benefit the organization. Evidence suggests that employees may reciprocate the positive experiences they have in an employment relationship by carrying out their core tasks at a high standard and by carrying out citizenship activities (Tsui *et al.*, 1997). In addition, Hofmann and Morgeson (1999) argued that when employees work in an environment in which safety is a concern, they reciprocate by complying with

established safety procedures. Considering the distinctive nature of construction and recognising the influence of supervisors and their reciprocal relationship with workers, this research proposes to use psychological contract of safety (PCSafety), instead of using safety knowledge and safety motivation as determinants of safety performance, as used in Griffin and Andrew (2000) model, since PCSafety is based on the reciprocal relationship between worker and supervisor in terms of safety. It is suggested that the concept of psychological contract of safety inherently endorses safety knowledge and safety motivation since psychological contract of safety is based on a mutual obligated relationship between the supervisor and workers. Accordingly it is assumed that if supervisors cannot develop the mutual and obligated relationship with workers in general then it would be difficult for them to improve safety knowledge among workers nor can they motivate employees to promote safe behaviour on construction sites. As a result this research tests the concept of PCSafety to address the gap between safety climate and safety behaviour and endeavours to develop a model that explains the mechanism by which safety climate factors influence safety behaviour and safety outcomes in a construction setting.

The PCSafety is defined as the beliefs of individuals concerning reciprocal safety obligations between employer and employee, inferred from implicit or explicit promises (Walker and Hutton, 2006). Employees form expectations about workplace safety that then lead them to believe that certain actions will be reciprocated. These expectations constitute a PC when employees believe that perceived employer safety obligations and perceived employee safety obligations are contingent on each other (Walker, 2013). The seminal work of Rousseau (1990) on PCs found two underlying contract dimensions characterized by the type of employment relationship perceived between the two parties: transactional and relational. Transactional contracts are short-term contracts that have an economic focus and are observable and explicit in nature. Characteristic of transactional type contracts are performance-related pay and career development in exchange for longer working hours and multiple work roles. Relational contracts, on the other hand, are longer-term contracts with a socio-emotional focus. These types of contracts are subjective and implicit in nature, with traits such as hard work and loyalty being exchanged for job security (Walker, 2010). Figure 3 illustrates the two elements of PC of safety: employer safety obligations and employee’s safety obligations and two aspects of obligations: relational and transactional.

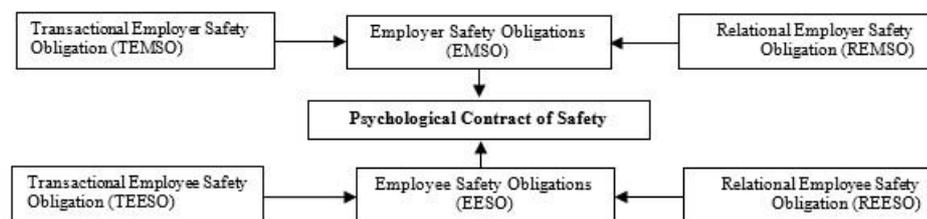


Figure 3: Model of Psychological Contract of Safety adapted from Walker (2010)

The impact of breach and fulfilment of the PCSafety on employee safety behaviour has not been specifically researched in construction. Nevertheless, it is expected that this relationship will be similar to the relationship between the PC and employee attitudes and behaviour established in the organizational literature (Walker, 2013).

## SAFETY BEHAVIOUR (PERFORMANCE) OR SAFETY OUTCOMES

From the perspective of accident investigation, construction workers' unsafe behaviours are often the primary cause of accidents on construction sites (Reason, 1990). Suraji *et al.* (2001) identified that 88% of the accidents in construction projects involved unsafe behaviours. Work behaviours relevant to safety can be conceptualized in the same way as other work behaviours that constitute work performance (Griffin and Andrew, 2000). However, the term *safety performance* may be used to refer to two different concepts. At times, safety performance might refer to an organizational metric for safety outcomes, such as number of injuries per year (Burke *et al.* (2002), conversely, safety performance may refer to a metric for safety-related behaviours of individuals (Neal and Griffin (2004). Distinguishing safety-related behaviours from the outcomes of those behaviours is important, because each might have differential relationships with antecedents. Thus, in this paper the researchers consider safety performance behaviours and safety outcomes to be distinct. In contrast to safety performance behaviours, safety outcomes are tangible events or results, such as accidents, injuries, or fatalities (Christian *et al.*, 2009).

On the other hand, Burke *et al.*, (2002) argue that safety performance behaviours can be scaled by the frequency with which employees engage in the behaviours and are distinguishable in terms of their antecedents and co-variation with safety outcomes. Thus, the model of performance can be applied to safety performance in the workplace. The components of performance describe the actual behaviours that individuals perform at work. Borman and Motowidlo (1993) proposed two major components of performance: task performance and contextual performance. These two components of performance can be used to differentiate safety behaviours in the workplace. First, based on definitions of task performance, the researchers use the term *safety compliance* to describe the core safety activities that need to be carried out by individuals to maintain workplace safety. These behaviours include adhering to lockout procedures and wearing personal protective equipment. Second, based on definitions of contextual performance, the researchers use the term *safety participation* to describe behaviours such as participating in voluntary safety activities or attending safety meetings. These behaviours may not directly contribute to workplace safety, but they do help to develop an environment that supports safety (Griffin and Andrew, 2000). Figure 4 shows the two types of workers' safety behaviour, which are considered as safety performance in this paper and extends the link between safety performance and safety outcomes.

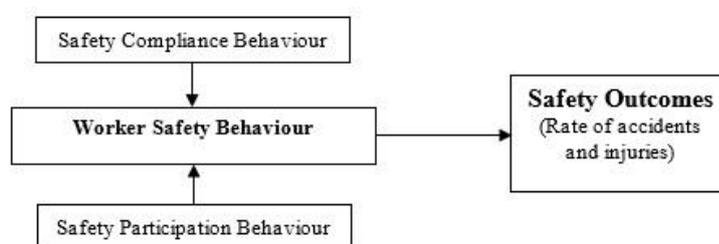


Figure 4: Safety Behaviour (Performance) and Safety Outcomes

In order to validate the model and establish the link between all the factors with safety outcomes, this paper intends to measure both safety performance (participation and compliance behaviour) and safety outcomes (rate of injuries and near misses). The

majority of the safety climate and safety behaviour researchers have validated their model by establishing a link with safety outcomes (Clarke, 2006).

## DEVELOPMENT OF THE PSYCHOLOGICAL CONTRACT OF SAFETY MODEL

The relationships shown in Figure 3 are used to extend the concepts via the model below (Fig 5). In order to get an extended view and create a link among them all, previous figures are merged into one, i.e. Figure 5, this expresses the relationships between different components of the model. The new model adopts the model of Neal *et al.*, (2000), concerning safety climate and safety behaviour, along with Walker's (2010) model of PC of safety. However, as an alternative of using safety knowledge and safety motivation as determinants of safety performance in the Neal *et al.* (2000) model, a psychological contract of safety (PCSafety) is offered as a determinant/mediator of safety performance.

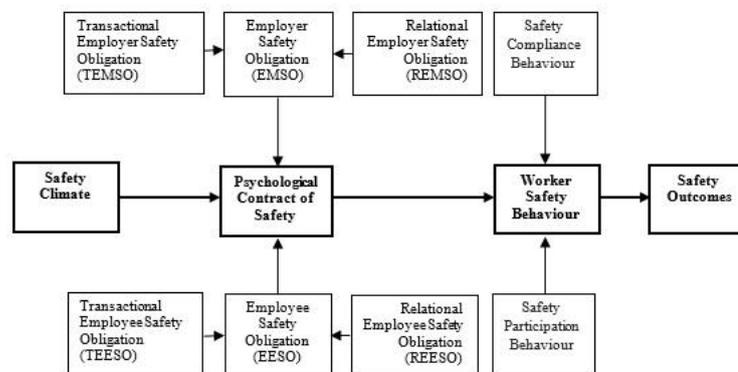


Figure 5: Hypothetical Model of Psychological Contract of Safety

Walker's (2010) tested model of PCSafety is incorporated in order to capture the dimension of relational and transactional aspects of employee and employer safety obligations to reveal a comprehensive analysis of safety obligations from the employee's point of view and their impact on construction safety performance (worker's safety behaviour). It is crucial to decide the factor structure of safety climate considering the effect of the factors on PC of safety and safety behaviour. Though previous research has sought to explore safety climate factors (Glendon and Litherland, 2001) and ways of improving and measuring it (Zhou *et al.*, 2008) there is little agreement on which dimensions or factors constitute the most common safety climate factor structure. Researchers continue to explore different factor structures to study safety climate, whereas there is a call to develop industry specific safety climate factor structures for ease of understanding the prime causes of positive and negative outcomes of safety initiatives (Zohar, 2010). The authors of this paper are currently working with a meta-analysis to develop a relevant safety climate factor structure for construction and after the analysis of empirical data the results will be presented in another forum.

This hypothetical model has number of implications. This is a unique model explaining the relationship between safety climate and safety behaviour, mediated by the PC of safety in construction. In addition, the research will identify how PC of safety is formed from safety climate. The association between PC of safety and safety behaviour will also express the strength of relationship between different PC of safety elements and safety behaviour components. Finally, in order to achieve the predictive validation of the model, relationship of all the three factors (safety climate, PC of

safety and safety behaviour) with safety outcomes (rate of accidents/injuries) will be examined through empirical evidence for this model, which will reveal the strength of their association both individually and collectively.

## CONCLUSION

After more than 30 years of safety research, it is still unclear how safety climate influences safety behaviour. To address this gap, this research argues that the psychological contract of safety is the key to explain the dynamics between safety climate and safety behaviour, especially in construction. In addition, this research identifies the theoretical formation of the psychological contract of safety arising from safety climate. It proposes a framework to examine the mediated relationship of safety climate and safety behaviour by psychological contract of safety which influences safety outcomes in a construction setting. The implications of this research are useful for managers, supervisors, safety advisors and workers on construction sites, helping to understand how safety activities should be managed and to identify the factors that shape worker safety behaviour and safety outcomes. The next stage of the research is to collect data from a mega-construction project in New South Wales, Australia. The researchers intend to test the proposed model and present the analysis of the empirical data at the next ARCOM conference.

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# CONSTRUCTION WORK AND THE HOUSEKEEPING CHALLENGE IN LESOTHO

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A key element of advances in site management practice is the provision of an environment in which construction work is completed without exposing people to harm. Among other issues, the removal of physical hazards on construction sites is dependent on housekeeping, which is a source of genuine worry in the industry in Maseru, Lesotho. With improvement intentions, this paper reports the outcome of a research, which sought responses to "why is housekeeping a continuing challenge in Lesotho construction?" Using a multiple case study research design in which the field work involve direct site observations and focus group interviews of construction site management and workers, the study established the poor state of housekeeping in Lesotho. The use of the 5-Why root cause analysis shows that unsafe work practices go hand-in-hand with poor housekeeping on observed project sites. Inadequate method of keeping the construction site clean was worsened by poor storage and disposal of materials and wastes on the sites. The importance of housekeeping in a craft based industry, such as Lesotho, is hinged on the health, safety, and wellbeing of workers, apart from site productivity. The evidence from the research shows that it is time for multi-stakeholder interventions that would eliminate poor housekeeping in the industry. Such interventions should apply behaviour-based safety techniques to support the efforts of compliance-based safety.

Keywords: health & safety, housekeeping, construction site, Lesotho

## INTRODUCTION

Organisational culture, which plays a major role in work performance and effectiveness, can be influenced by a country where a firm is based and it can also be influenced by the history of success and failure recorded in a firm (Zhang and Liu, 2006). In like manner, the safety culture in a contracting firm may be influenced by where the firm is operating and how the location is regulated. Safety culture may also be influenced by the vision, values, and beliefs of top management of a firm. While these influences make it difficult to objectively provide the definition of a "good" safety culture that fit into every setting, firms with a "good" safety culture have mechanisms in place to collect safety-related data, measure safety performance, and bring people together to learn how to work more safely (Ostrom, Wilhelmsen and Kaplan, 1993).

Firms with a good safety culture use these mechanisms to solve immediate safety problems so that all groups in the firm participate in addressing concerns while promoting positive attitude to safety (Ostrom *et al.*, 1993). High safety standards in

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construction work thus require collective values, norms and behaviours that support effective safety controls (Torner and Pousette, 2009). It is however notable that such a practice is lacking in developing countries such as Lesotho where poor safety performance is often recorded in construction (Kheni *et al.*, 2008; Bust *et al.*, 2008). To address poor housekeeping that is reported to be an expression of a prevailing safety culture in a workplace (Becker, 2001), this paper attempts to provide a response to "why is housekeeping a continuing challenge in Lesotho construction"?

## HOUSEKEEPING AND SAFETY CULTURE

Housekeeping, which is the day-to-day cleaning and keeping tidy of all parts of the construction site, is essential to avoid injuries and accidents in a workplace (Lingard and Rowlinson, 1994). This perception resonates in an empirical study where Haslam *et al.*, (2005) observe that workplace factors, especially poor housekeeping that is evident through site layout and space availability problems, contributed 49% of the 100 accidents they studied in Great Britain. The problems observed include hazards in the form of objects that are protruding or causing slip and trip on sites. They also record uneven ground, debris, and muddy conditions. Haslam *et al.*, (2005) note that these problems occurred with ill-defined walkways and poor housekeeping, which they say, "from the perspective of those familiar with safety in a wide range of other industries, poor site conditions found in construction appear to be a symptom of the weak safety and risk management culture in the industry (p. 410)".

The concept of safety culture is often cited with accident causation factors (Peckitt, Glendon and Booth, 2004). The concept emerged from the attempt to explain the Chernobyl nuclear disaster of 1986 (Ostrom *et al.*, 1993; Glendon and Stanton, 2000). It is concerned with shared attitudes, behaviours, beliefs, norms, practices, systems, and values necessary for effective safety controls (Guldenmund, 2000; Glendon and Stanton, 2000; Peckitt *et al.*, 2004). Although the concept of safety culture emerges from the Chernobyl disaster of 1986, its constituent of beliefs and attitudes that is manifest in actions, policies and procedures that determine safety performance are traceable to Heinrich's Domino Theory of accident causation (Ostrom *et al.*, 1993). In addition, the typologies of safety culture shows that regulation, engineering, procedure and behaviour constitute its main categories (Shillito cited in Peckitt *et al.*, 2004). From the four categories, the behavioural category indicates that workers are motivated to give their best when offered adequate training that enable them to get the job done. Studies show that empowering workers and delegating safety activities are consistently related to lower injury rates (Torner and Pousette, 2009). The behavioural category of safety culture is inclusive of policies, goals, objectives, procedures, manuals, records and audits that are used as tools to aid improved performance. In essence, companies are encouraged to adopt a positive organisational safety culture in order to eliminate accidents in their operations (Clarke, 2003) since the behavioural category of a safety culture is an enabler of safety compliance (Hafey, 2015). For instance, the motivation / morale of workers could be enhanced by reshaping rules into policies, objectives and targets (Peckitt *et al.*, 2004).

The motivation of workers is necessary as poorly motivated workers could make a workplace untidy, apart from the manifestation of rework, poor craftsmanship, fatigue, and poor technical supervision (Loushine *et al.*, 2006). The 'motivation' illustration aligns with the meaning of safety culture, which relates it "to the product of individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's safety programs

(Health and Safety Commission, 1993 cited by Glendon and Stanton, 2000: 201)". In brief, where workplace conditions are poor, major positive shift in standards of site layout and housekeeping is required from contractors who are well placed to uphold acceptable safety practice (by implication safety culture) on construction sites (Haslam *et al.*, 2005). Good housekeeping is expected to eliminate safety problems, improve morale, and increase productivity because workers generally appreciate a clean and orderly workplace where tasks could be completed unhindered (Becker, 2001).

## **RESEARCH METHODOLOGY**

This research employed a multiple case study approach that describes current situation and then attempt explanations from observations that are supported with follow-up focus group interviews. The use of case study research emanates from the principal feature of case studies: to gain up-close assessment of a "case" within its real world context (Yin, 2013). The research was designed so that it can capture the complexity of housekeeping on multiple project sites, and attend to contextual conditions impacting on the case by observing human activities and the physical settings in which such activities take place (Angrosino and Rosenberg, 2011). In case studies, observations often take place in settings that are the natural loci of activity. Structured observations were conducted in this study. Structured direct observations were undertaken because human activities and physical attributes on selected project sites could be broken down to bits that researchers could note.

To make the notes, the use of a protocol is necessary (Yin, 2013, Thomas, 2015). Instead of compiling a protocol from the reviewed literature, a standard problem solving A3 tool was adopted for the study. The A3 tool was used as it is a recognised structured and standard work problem solver in both manufacturing and construction industries (Rubrich, 2012). Forbes and Ahmed (2011) note that the problem solving A3 sets the stage for analysing and improving construction operations through appropriate application of its seven sections, which include background, current condition and problem statement, goal statement, root-cause analysis (5-Whys), countermeasures, check, and follow-up actions. In other words, with modifications, the A3 tool with its origins in manufacturing is now used in construction (please see Rubrich, 2012; Forbes and Ahmed, 2011). The template of the A3 tool that was used in this study was obtained from MCS-Media (2012). The 5-Why analysis segment in the A3 tool aided the compilation of the discussion section of this paper, and the brainstorming segment of the A3 tool assisted in the facilitation of the focus group interviews with workers and site management after the analysis of the observation data from the four visited project sites. Site management and workers were interviewed after the site observations because of their on-site task responsibilities and direct involvement in housekeeping. In project A, a site agent, three general workers (labourers), and two foremen were interviewed. In project B, one site agent, one foreman, and one H&S officer were interviewed, and in project C, one H&S officer and one foreman were interviewed. In the 4th project (D), only one foreman agreed to be interviewed. The twelve (12) interviews were confidential, though permitted, due to the nature of the phenomenon being studied. All the participants of the focus group interviews took part in the sessions because they have the responsibility of keeping their individual project sites clean and tidy.

To account for the complexity of a case, and its associated context, case studies should rely on multiple sources of evidence, which vary from interviews to field observations

(either direct or participant). As such, the direct observations on the four project sites were supported with follow-up focus group interviews to confirm and corroborate the research findings (Yin, 2013). The collected data through on-site observations and subsequent focus group interviews were obtained from four project sites in Maseru the capital city of Lesotho. The gatekeepers (management personnel) of the project sites were contacted on phone and emails before access was granted to each project site in July - August 2015. Repeated visits were made during the field work. The initial visits were made to observe the sites as 'it is' before follow-up focus group interviews were conducted. With the use of the described A3 tool, the observations were recorded in each visit on the A3 report while photographs were used to provide supportive evidence. With the permission of the gatekeepers on selected project sites, photographs were taken in the field work so as to convey case features to outside observers (Yin, 2013). And in order to enhance reliability of observational evidence, two observers / researchers were utilised in the study. The observers, who are also co-authors of this paper, were final year built environment bachelor degree students at a South African university that is in close proximity to Lesotho. The study forms part of the 4th year research methodology subject in the South African university. The observations were concluded before the focus group interviews were conducted. The findings of the observations informed the open ended questions that were used to facilitate the focus group interviews. The interviews were tape recorded and transcribed after each session. Employing the thematic analysis procedure, the resultant interview transcripts were analysed based on the open ended questions of the focus group interviews.

## **RESEARCH FINDINGS**

The findings of the site observations and follow-up focus group interviews are herein presented. As mentioned earlier, the direct structured observations were conducted with the use of an A3 tool. In general, the observations on the four projects reveal the untidy nature of work organisation on the sites (Figure 1). This is compounded by limited site size. Most of the sites were not able to accommodate needed materials on site. For clarity, the results are presented by following the findings from each project site as follows.

### **Project site A**

On project site A, the observers noted that excess materials that could be likened to be wastes were enormous on the site. After the initial site visit, dialogues were held with the workers on the sites and a subsequent visit indicates a slight improvement of the state of housekeeping on the project (Figure 1 and 2). Notable issues that emanate from the observations include the non-classification of wastes on site and poor storage of materials; blockage of the walkways by reinforcing bars from demolished wall; lack of proper working methods that bring electrical cables into close contact with flammable liquids; and wasteful use of materials due to defects, rework and poor workmanship.

In particular, the observers noted that a waste disposal was situated along the walkway to the site and excess materials were all over the site. These two issues were further interrogated in the focus group interviews with the site agent and three workers on the project. The interviewees were requested to state reason why the walkway was blocked by wastes and materials that were lying around. From their responses, it was clear that there was no division of work regarding different tasks in line with specific job description, so proper placement of materials and waste seems to be suffering. No

one took responsibility for housekeeping. In addition, the interviewees say that there are too many foremen that claim the same authority to the extent that one foreman cannot over rule another. For example, the workers suggest that they often get instructions from different foremen with different tasks to perform. When such instruction is given, the workers will leave some tasks uncompleted and in so doing, tools or material will be left lying about to the detriment of proper housekeeping. In his own part, the site agent states that having too many foremen on site leads to lack of planning or deviations from plans as every foreman plans his tasks his way to suit his targets in relation to the work programme.

Similarly, the interviewees were asked to comment on 'excess materials' and its impact on housekeeping on the project. For this question, two foremen comment that material management issues that consistently occur on the project are responsible for the excess. They agree that having excess materials on site have escalated storage facility issues and negatively affected housekeeping on the project. The foremen also say that 'fear of running out of material stock' is fuelling the presence of excess materials on the site. They cited an incident that nearly got them dismissed from the project. The main problem happened when the site ran out of course aggregates due to unexpected weather conditions that disrupted supply and work plans. Apart from official reprimand, the foremen noted that the mistake of running out of materials impacted upon their income so much that repeat situations have to be avoided. In other words, they opine that having excess materials on site always protects them from troubles and they further say "So it is a good thing to do, even to address or prevent variation caused by inflation."

### **Project site B**

On project B, it was observed that the walkway was also blocked with materials and wastes because of lack of appropriate instructions from the foreman. It was recorded that signage that would have alerted workers and the general public to hazard were missing on this particular project, and it appears that the municipality that is supposed to intervene ignored the situation. Another major issue on this site is improper work sequencing as the field observers perceive that the 'workers do the second activity before the first activity': working backwards. More worrisome is the fact that materials were not stockpiled, wastes were on every space on the site, and the lack of control over where waste must be dumped was clear. These issues contributed in no small measure to the state of housekeeping on the site and they form the basis of the interviews that were conducted with 2 personnel on the project, an H&S officer and a senior foreman.

The interviewees were requested to give reasons why wastes were not classified on the site where aggregates are left to mix with each other: flammable liquids such petrol were mixed with live electrical cables; and reinforcing bars from the demolished concrete elements were left projected and blocking the walkway to the extent that people could trip and become injured. On his part, the H&S officer report that he had instructed cutting of the reinforcing bars that constituted clear hazard on the walkway, but the instruction is awaiting execution because of the non-availability of required equipment to do the job because a grinder to be used has to be transferred from another site in Masaru, Lesotho. The foreman on the site provide additional information when he mentioned that the reinforcing bars have been in the state of 'protrusion' which constitute an hazard for almost a month, although the H&S officer kept on requesting their removal. The site agent said that the bars should just be bent

due to lack of tools. Such a response from the site agent is a symptom of ineffective management practices that is contributing to the malaise. While recognising the danger in having such protruded bars in a walkway, the site agent indirectly mentioned the 'not so positive' role that the managing director of the firm is playing with the situation. The agent noted that despite notifying the managing director of the small and medium sized firm of the need to clear the site of the reinforcing bars, required actions are still pending.

### **Project site C**

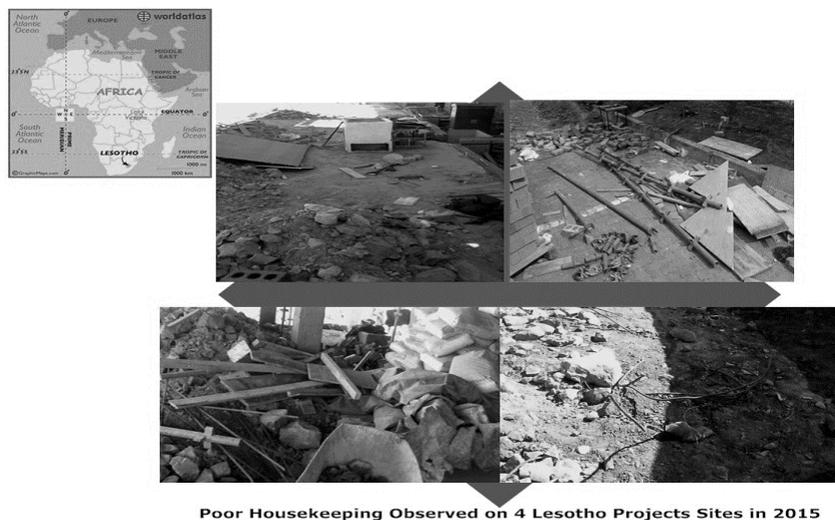
The field work on project site C equally highlight lack of storage facilities on the project and more concerning is the surplus workers' toolboxes that can be seen in multiple locations on the site. The site is also crowded with workers because of lack of space for doing the necessary work. In fact, bulk materials for the project were stockpiled offsite and when needed, their transportation to the site is not handled properly. On this project, the observers were also able to interview an H&S officer and a foreman. The interviewees were requested to explain why the storage facility was so far from the site because there was no storage on site. They were also asked to explain why wastes were not properly disposed of or even classified and stored properly. The two interviewees responded that apart from space issues, the storage of aggregates on site cannot be easily done because of the wind due to the fact that the project is an extension of an operational shopping mall. For example, it was noted that aggregates would produce dust that would affect people or operations of the mall. The foreman said there were gaps in the planning of the work because they have to store a very small amount of aggregates to be used only on site to the detriment of productivity and H&S. The interviewees were concerned about their experience regarding the disposal of waste materials. For instance, they mention that for a plant or truck to dispose wastes a lot of time is wasted because there is a usual lengthy and unnecessary paper work to be completed.

### **Project site D**

In the final project observations, it was noted that yet again, the lack of storage facility due to minimum space on site is a major problem. The workers in this particular project appear to be incompetent as they tend to forget service ducts (that often have defects) prior to installation and even after installing them, correction was still needed. These ducts litter the entire site. On this same project, overcrowding of workers in a limited space was observed. Such situations heightened motion / mobility needs that do not contribute to the realisation of activity completion. For instance, some workers would walk about pretending to be searching for items while hoping another worker would complete their portion of assigned tasks. A major hazard observed on the site is the chaotic locations of electrical cables and water pipes, which portend danger on the site. This is clearly a case of poor space management and site layout.

These issues were further assessed through the interviews that were conducted 'post observations' on the site. Although only one foreman made himself available for the follow-up interview on this particular project, his comments could be deemed to be credible as he doubles as the H&S officer on the project. The foreman was requested to explain why the site is not clean and lack safe access due to wastes and raw materials that are blocking walkways to the extent that even the emergency assembly point was blocked. The foreman responded by saying that the site has a problem of communication, especially between the principal contractor and the subcontractors. For instance, the subcontractors tend to always place their materials at any spot of

their choice because they do not have to report to him directly. In fact, the foreman mentions that there are lot of subcontractors on site with similar tasks, so it is a little bit difficult to manage them because they always blame each other: "For example, one will leave empty cement bags lying around site and I tell them to properly dispose, they will point each other and put a blame." Another major issue that the foreman highlight is quoted verbatim as " One other problem is our company's policies and subcontractors and policies of not being the same, we paid our people daily rates while subcontractors pay them as per work done or covered, so after work when we clean the site, subcontractors do not clean but they keep on working to cover a lot of work as to increase their money. So they keep on increasing waste without reducing it. There is no one to talk to directly on site because the managers are not there, we only talk via phone to report, he will just agree but nothing will change. All they are interested in is money. As long as they produce a lot of work that's what matters. The manager is always not always on site, he is interested in production too in order to claim big payment certificates."



Poor Housekeeping Observed on 4 Lesotho Projects Sites in 2015

Figure 1: Illustration of pre focus group interview project site observations

## DISCUSSION

As shown in Figure 2, there appears to be an effort to clean up the visited construction sites after the focus group interviews were concluded. While other factors may be responsible for the sudden improvement of the housekeeping conditions of the four project sites, the shared information during the focus interview sessions may have somehow influenced a change in the photographic evidence. When the data collection exercised ended, the 5-Why analysis was conducted to further illuminate the issues contributing to the current situation. The 5-Why analysis is a problem solving tool that helps a team to identify the root causes of a problem without statistical calculations (Andersen and Fagerhaug, 2006). It involves looking at a potential cause of a problem and asking 'why' and 'what' lead to this problem many times. For this study, Figure 3 shows the possible qualitative causal pathways that may be responsible for the pervasiveness of poor housekeeping on construction sites in Lesotho.

Essentially, by using the 5-Why analysis, the reasons why housekeeping is a continuing challenge in Lesotho construction could be discerned from the focus group interviews. The changes shown in Figure 2 may have occurred with the aid of candid dialogue using the 5-Whys based on the fact that non-compliances have been observed

(Santorella, 2010). The non-compliances clearly deviated from how people should act on construction sites (Glendon and Litherland, 2001). The challenge from the study is about "getting people to want to act in ways that are safe" regardless of the perceived effects of such safe actions (Santorella, 2010). There should be no place for 'indifference and complacency' in a hazardous work environment (Figure 3). While enforcement has a key role to play in ensuring a safe work environment in the construction industry, bad behaviour of everyone involved in site work should be discouraged (Glendon and Litherland, 2001). This is relevant in a context where compliance to regulations appear to be lax (Kheni *et al.*, 2008). The noted changes in Figure 2 confirm that behaviour-based safety (BBS) techniques are very effective in bringing about improved performance in construction site housekeeping (Lingard and Rowlinson, 1998).



Figure 2: Illustration of post focus group interview project site observations

The changes in Figure 2 were recorded few weeks into the fieldwork without a major intervention from concerned regulatory authorities. In other words, it is important to amplify the use of attitude and behavioural tools to engender safety on construction sites (Lingard and Rowlinson, 1998). When danger is not imminent, such tools could improve the status of construction safety and some of the tools include asking everyone on site to recognize the safe behaviours of others, that is, keeping a work area clean and hazard free (Santorella, 2010). Clearly, Figure 3 implies that a culture change is necessary on the researched projects and discipline alone cannot be used.

Rather, the leaders in the industry and the firms involved in the specific projects would have to go beyond compliance requirements and provide the leadership, which would build up a new culture where everyone care about safety on project sites (Hafey, 2015). In a developing country context, it appears that compliance-based safety would have to be complemented by BBS before a substantial improvement could be propagated.

## CONCLUSIONS

This paper shows a practice that produces poor housekeeping on construction sites in Lesotho. The apparent indifference and self-righteousness of workers, foremen, site agents and H&S officers on the four projects highlight a major question: "how do we get people to care about safety".

### 5 Whys Worksheet

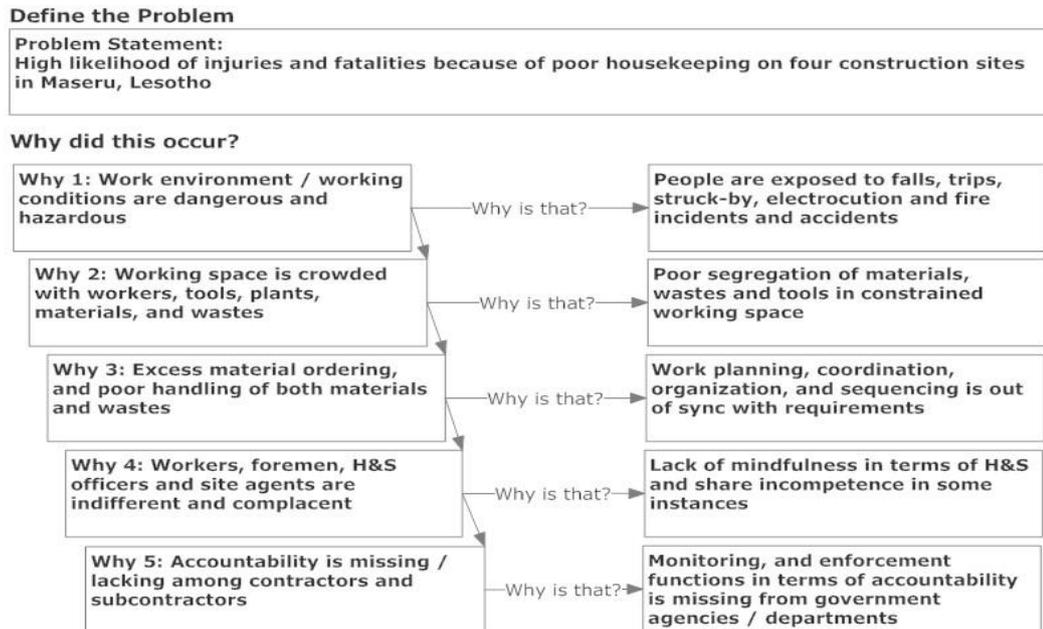


Figure 3: 5-Why illustration of causal factors observed from the housekeeping study

This question is relevant in an environment where other excuses or considerations always preoccupy the minds of site operatives when non-compliance is observed and interrogated. Proper work planning, sequencing and site layout that is backed up with open communication would make changes on a site even if space is constrained. Providing a safe access to sites by keeping all walkways clean and tidy through appropriate handling of materials and wastes should be a priority on every construction site anywhere in the world. Among the site operatives, the contributions of foremen to current practice could not be ignored. The control of work spaces on site by foremen impact upon activity completion and the state of a site. In the researched projects, the foremen were not able to handle space issues and the management of subcontractors. These lapses could make a difference on the projects in terms of safety. Even though in this study, the site operatives tried to minimize the major issues that were observed after dialoguing with them, there is a need to verify if the driver of the change is compliance to regulations or a change in culture in Lesotho. A future study would assess the reason for the improvement while assessing how to get people to care about construction site safety in Lesotho.

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# DEMOGRAPHIC AND LIFESTYLE DETERMINANTS OF THE HIV SEROSTATUS OF CONSTRUCTION WORKERS

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Testing for HIV/AIDS is essential for determining HIV serostatus and initiating subsequent treatment for those found to be infected. Construction workers are regarded as a high-risk group in the context of the HIV/AIDS pandemic in South Africa. Factors associated with the HIV+ serostatus of construction workers are thus important. A self-administered questionnaire survey of 512 construction workers in the Western Cape explored this issue and found that HIV+ workers have poorer education levels and lower AIDS-related knowledge than non-infected workers. However, contrary to claims in the literature, lifestyle factors, while inter-related to some extent, were not found to be significant correlates of serostatus. More active, and more carefully directed, awareness, counselling and testing campaigns are advocated for construction companies as part of their HIV intervention management policies. Imparting appropriate AIDS-related knowledge and lifestyle advice at a much earlier point in school curricula is also recommended.

Keywords: construction workers, HIV serostatus, determinants, South Africa.

## INTRODUCTION

The construction industry in South Africa has been identified as one of the economic sectors most adversely affected by HIV/AIDS, and also as one of the least responsive to the pandemic (Meintjes *et al.*, 2007; Bowen *et al.*, 2013). Bowen *et al.* (2008) reported that HIV prevalence amongst construction workers exceeded that of the national statistic (Shisana *et al.*, 2014). The high incidence of HIV in construction has been attributed to its formal and informal sectors; its labour employment structures; its high utilisation of migrant workers; its fragmentation of firms; its use of unskilled labour; and its geographical spread of project locations (Meintjes *et al.*, 2007). Harinarain and Haupt (2014) provide a comprehensive description of the vulnerability of the construction industry to HIV and AIDS. Small construction firms (which proliferate in the industry) generally do not have the resources to provide meaningful HIV prevention and treatment programmes. At best they tend to focus on awareness and prevention campaigns i.e., posters and dispensing condoms (Bowen *et al.*, 2013, 2014). In addition, the diversity of construction work and project locations makes it difficult to standardise or implement

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meaningful HIV interventions on construction sites. The workforce changes frequently due to the nature of the production process, the number of sites to be covered, and the use of sub-contract and temporary labour.

Voluntary counseling and testing (VCT) is an essential contributor to controlling the spread of HIV/AIDS and for initiating the provision of care to those infected (Denison *et al.*, 2008; Shisana *et al.*, 2014). VCT is also important in helping to change adverse patterns in risky sexual behavior which places individuals at risk of infection, by decreasing the number of sexual partners and by increasing condom use (Sherr *et al.*, 2007; Fonner *et al.*, 2012). HIV/AIDS testing satisfactorily clarifies both the HIV serostatus of individuals and their knowledge thereof, e.g. Tested (HIV+); Tested (HIV-); Don't know (tested but result not accessed); Don't know (not tested). This information is useful to construction organisations wishing to plan, resource and implement, HIV intervention management strategies. Knowing the demographic and lifestyle factors that correlate strongly with HIV serostatus would help to design and target interventions more appropriately.

The uptake of testing services by individuals is influenced by several demographic, lifestyle and psychosocial factors. Demographic factors positively related to testing in South Africa include gender (women), older age, higher levels of education, greater knowledge of HIV, and higher risk perception (MacPhail *et al.*, 2009; Ropelewski *et al.*, 2011; Shisana *et al.*, 2014). Lifestyle factors negatively related to testing include inconsistent condom use (Hargreaves *et al.*, 2007), excessive alcohol consumption (Parry *et al.*, 2004), and illegal drug use (Myers *et al.*, 2013). Negative psychosocial factors include attitudinal fear of testing (Venkatesh *et al.*, 2011) and stigma (Deacon *et al.*, 2009); while limited access to treatment may also be an influencing factor (Asante, 2007). Many of these factors are themselves inter-related. Despite extensive research in South Africa into HIV prevalence and its antecedents, little relates directly to the extent to which any of these factors are associated with the HIV serostatus of construction workers. This study addresses that issue and focuses on the demographic and lifestyle determinants of the HIV serostatus of workers in the South African construction industry. The aim of the study, therefore, was to better understand how demographic and lifestyle factors of construction workers are associated with HIV serostatus.

## RESEARCH METHOD

The epistemological assumptions underpinning this study were of a positivist nature. Moreover, the analysis and interpretation of the data adopted an objectivist / determinist ontological paradigm in that it is possible that the HIV status of workers is partially or completely determined by the socio-economic environment in which they find themselves.

### Participants and setting

A survey questionnaire was used to collect data. Convenience sampling was used for the selection of construction firms and sites, as well as the workers interviewed. Participants ( $n=512$ ) were site-based unskilled and skilled workers and site office-based staff drawn from 6 firms on 18 construction sites in the Western Cape. The sample frame consisted of all employees present when the researchers visited the sites by prior arrangement. Ethics clearance was obtained from the University of Cape Town.

Questionnaires were available in English, Afrikaans and *isiXhosa* (an indigenous African language), the most commonly spoken languages in the Western Cape. Participants were briefed on the nature of the study, assured that their participation was entirely voluntary

and anonymous, and informed that they could withdraw at any time. Workers who provided informed consent then proceeded to complete the questionnaires, usually in site-office containers. Between them, the field researchers administering the questionnaire were proficient in all three languages.

## Measures

*Demographic and lifestyle characteristics:* Age was measured in actual years and then converted into five discrete age categories: 20 or under; 21-30; 31-40; 41-50; and over 50 years. Ethnicity was captured in terms of the following classifications: 'Black' African; 'Coloured' (mixed race); 'Indian'; and 'White', with the latter three classes being combined as 'Others' in the statistical analysis. Level of education was categorised as 'no schooling', 'primary', 'secondary', 'tertiary', or 'postgraduate'. Employment status was classified as 'permanent', 'temporary/contract', or 'casual'. Marital and family status was categorised as either 'married or in a long-term relationship', or 'single'; and if participants had children ('yes' or 'no'). Participants also reported their lifestyle risk behaviour characteristics. Risk behaviour items included alcohol consumption and cannabis ('dagga') use, sexual intercourse with multiple partners in the preceding three months, and use of a condom at last coital act. The list of variables is given in Table 1. Participants were asked to report on their HIV testing status: HIV+ (tested), HIV- (tested), 'Don't know' (tested), and 'Not tested'. Additionally, HIV+ participants were asked whether or not they were currently taking antiretroviral (ARV) medication ('yes'; 'no'). These characteristics were drawn from Kalichman and Simbayi (2003, 2004).

*AIDS-related transmission knowledge:* Table 2 lists the seven items used to compile the AIDS-related transmission knowledge scale (the '*knowledge scale*'). The items were drawn from Kalichman and Simbayi (2003). Response options were 'yes', 'no' or 'do not know'. The scale was scored for the number of correct responses: 1=correct; 0=incorrect; 0='do not know' (score range 0 to 7; higher score = higher levels of knowledge).

Exploratory factor analysis (EFA) using maximum likelihood and oblimin rotation was undertaken on the knowledge scale (see Pett *et al.*, 2003). To assess the suitability of the sample for factor analysis, Bartlett's Test of Sphericity (BToS) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were used. The Bartlett's test was significant ( $\chi^2=934.01$ ,  $df=21$ ,  $p<0.001$ ), and the KMO value (0.758) supported the suitability of the data for factor analysis. However, the EFA revealed two factors with eigenvalues exceeding 1. After rotation, the two-factor solution explained 47.0% of the common variance, with Factor 1 contributing 33.2% and Factor 2 contributing 13.8%. Items K1 and K2 (see Table 2) loaded strongly onto Factor 1, whilst the remaining items loaded strongly onto Factor 2. When a single factor solution was forced, 31% of the common variance was explained. All items loaded strongly onto the single factor, with the exception of item K3 (0.227). However, given that Hair *et al.* (2014) stress the need for a minimum of three items per factor for the scale to be successfully identified, a single factor was retained.

Following on from the EFA, the observed factorial structure was specified and subject to a CFA using structural equations modelling. No correlated errors were specified in this initial model. In considering factor loadings, a threshold of 0.50 was determined to be acceptable for individual items (Hair *et al.*, 2014). Four critical fit indices were applied to determine the degree of fit of the structural equation model as follows (indices reflecting good model fit indicated in parenthesis):  $\chi^2/df$  ratio (less than 4) Bentler CFI (comparative fit index (0.95 and greater)); RMSEA (root mean square error of approximation (0.05 and less)); and Hoelter (critical N (CN) index) (200 and greater).

The initial model was a very poor fit to the data ( $\chi^2 /df$  ratio=18.975, CFI=0.736, RMSEA=0.188, and Hoelter (95%)=46). The modification indices indicated the need for the error terms of items K1 and K2 to be permitted to co-vary. With this path specified, the resultant model proved an excellent fit ( $\chi^2 /df$  ratio=1.431, CFI=0.994, RMSEA=0.029, and Hoelter (95%) =615). All factor loadings in this model were statistically significant ( $p < 0.001$ ). Internal consistency was good,  $\alpha = 0.76$ . A 1-factor model of AIDS knowledge was retained.

## Statistical analysis

Table 1. Demographic and lifestyle risk characteristics of HIV+ and HIV-construction workers participating in the survey (n=354)

Characteristics	HIV+ (n=34)		HIV- (n=320)		$\chi^2$ p-value
	n	%	n	%	
<i>Demographic characteristics</i>					
Age <sup>†</sup>	M=38.5	SD=10.4	M=37.0	SD=10.7	0.458 <sup>‡</sup>
20 and younger	3	9	8	3	
21 to 30	3	9	99	32	
31 to 40	9	28	96	31	
41 to 50	13	41	60	20	
51 and over	4	13	43	14	
Gender					0.555 <sup>§</sup>
Male	31	94	282	89	
Female	2	6	35	11	
Race / ethnicity					0.854 <sup>§</sup>
'Others'	14	41	123	39	
'Black' African'	20	59	194	61	
Level of education					0.027 <sup>*</sup>
No schooling	4	12	10	3	
Primary	6	18	67	21	
Secondary	21	64	163	52	
Tertiary	2	6	61	20	
Postgraduate	0	0	12	4	
Nature of employment					0.575
Permanent	22	65	210	67	
Temporary / Contract	12	35	96	31	
Casual	-	-	8	2	
<i>Lifestyle characteristics</i>					
Alcohol use in the past 3 months					0.654
No	13	38	147	46	
Once only	4	12	35	11	
More than once	17	50	135	43	
'Dagga' (Cannabis) use in the past 3 months					0.482
No	28	85	288	91	
Once only	2	6	9	3	
More than once	3	9	20	6	
Use of condoms: Did you use a condom the last time you had sex?					0.857 <sup>§</sup>
Yes	19	56	166	53	
No	15	44	149	47	
Sex partners: Have you had $\geq 2$ sex partners in the last 3 months?					0.349 <sup>§</sup>
Yes	8	24	54	17	
No	26	76	261	83	
AIDS-related transmission knowledge (scale)	Mean	SD	Mean	SD	0.006 <sup>****</sup>
Knowledge score (Range 0-7)	4.09	2.18	5.05	1.90	

Notes: <sup>†</sup>Age measured in years, but presented here in intervals. <sup>§</sup>Fisher's Exact Test used rather than Chi-square test for independence. <sup>\*\*</sup>Independent Samples 't' Test. \* $p < 0.050$ ; \*\* $p < 0.010$ .

Table 2. Scale items and Cronbach's alpha reliability coefficient for HIV/AIDS transmission knowledge scale (n=354)

Factors	Items	( $\alpha$ )
HIV/AIDS transmission knowledge		0.758
Correct response=1	K1. Can men give AIDS to women? (Yes)	
Incorrect response=0	K2. Can women give AIDS to me? (Yes)	
Don't know=0	K3. Must a person have many different sex partners to get AIDS? (No)	
Range: 0-7	K4. Does washing after sex help protect you against getting AIDS? (No)	
	K5. Can a pregnant woman give AIDS to her baby? (Yes)	
	K6. Can the use of vitamins and healthy foods cure AIDS? (No)	
	K7. Can traditional African medicines cure AIDS? (No)	

Note: Correct responses indicated in parentheses against each knowledge question.

The data were analysed using IBM SPSS Ver. 23.0 For Macintosh (IBM Corporation, 2015a). The CFA was undertaken using IBM Amos Ver. 23.0 For Macintosh (IBM Corporation, 2015b). Chi-square ( $\chi^2$ ) tests were used to examine bivariate relationships between HIV serostatus and categorical demographic and lifestyle factors. The independent samples 't' test was used to compare the mean scores for age and transmission knowledge of HIV+ and HIV- participants. Logistic regressions were used to calculate unadjusted and adjusted odds ratios (ORs) for the determinants of HIV serostatus. Variable selection for the regression analyses was based on the literature (Kalichman and Simbayi, 2003, 2004) and the bivariate analyses. Unless otherwise stated, frequencies and percentages provided relate to the number of valid responses to individual questions.

## RESULTS

### Participant characteristics

Most participants in the full dataset ( $n=512$ ) were male (91%;  $n=461$ ). Ages ranged from 18 to 69 years (mean = 36, SD = 10.9), with most being in the 21-30 year age group (34%;  $n=168$ ). Almost two-thirds (62%;  $n=313$ ) of participants were 'Black' African (as distinct from the other ethnic groupings). Over a quarter (29%;  $n=144$ ) had at most primary level education, whilst 52% ( $n=260$ ) had secondary level education. Permanent employees accounted for 62% ( $n=304$ ) of the survey participants; while 34% ( $n=167$ ) were contract workers (employed on a project basis); and 4% ( $n=22$ ) occasional (casually hired) workers. Sixty-five per cent ( $n=320$ ) were either married or in long-term relationships, and 76% ( $n=380$ ) had children.

Sixty-three per cent ( $n=320$ ) claimed to be HIV- (tested); 7% ( $n=34$ ) reported being HIV+ (tested); 26% ( $n=131$ ) had never been tested; 4% ( $n=20$ ) had been tested but claimed not to know the results; and 1% ( $n=7$ ) failed to respond to this question. Of the 34 HIV+ participants, 14 (42%) reported taking their ARV medication, 10 (29%) claimed not to be taking ARV medication, and 10 (29%) did not answer this question. Public health clinic policies relating to treatment delay (based on CD4 count) could explain the results for HIV+ workers (Bowen *et al.*, 2014).

Unless otherwise stated, the remainder of the analyses were performed on the serostatus sub-samples of HIV+ ( $n=34$ ) and HIV- ( $n=320$ ) participants, the demographic characteristics of which are shown in Table 1.

In comparing the two sub-samples, significant differences between them occurred with respect to level of education ( $p=0.027$ ) and AIDS-related knowledge scores ( $p=0.006$ ). Proportionately less-educated workers were encountered more frequently in the HIV+

group than in the HIV- group; while the HIV- group demonstrated a significantly higher level of AIDS knowledge than did the HIV+ group (HIV+: mean score=4.09; HIV-: mean score=5.05). However, the considerable discrepancy in size of the two-sub samples renders these comparisons subject to caution in interpretation.

### **Correlates of demographic and behavioural variables**

The correlation coefficients between HIV serostatus and all demographic, lifestyle and knowledge variables were determined (statistics not shown here). For the key associations:

- Level of education was found to be significantly negatively correlated with age and positively correlated with gender. Older workers, and male workers, recorded significantly lower levels of education than did females and younger co-workers. Additionally, 'Black' African workers reported significantly lower levels of education than did their counterparts in the combined ethnic group (all  $p<0.01$ ).
- AIDS-related knowledge was significantly positively correlated with gender, level of education, and alcohol consumption, and significantly negatively correlated with age and race (all  $p<0.01$ ); older, male, 'Black' African, and poorer educated workers possessed lower levels of AIDS-related knowledge than did females and other groups.
- Alcohol consumption was significantly positively correlated with both level of education and extent of AIDS-related knowledge (both  $p<0.01$ ). Better-educated and more knowledgeable workers reported greater alcohol consumption than did their counterparts.
- Alcohol consumption and dagga smoking were significantly positively associated ( $p<0.01$ ).
- Better education was significantly positively associated with higher levels of AIDS-related knowledge. Better-educated and more knowledgeable workers were significantly less likely to report HIV+ serostatus.

### **Correlates of HIV serostatus**

While the research objective was not to undertake comparisons across multiple reference categories for every variable, Table 3 indicates the unique and relative significance of the relationship between HIV serostatus and the various participant characteristics (unadjusted and adjusted). The reference category for the dependent variable (HIV serostatus) is HIV+.

*Demographic factors:* Of all the demographic variables, only level of education (OR=1.69; 95% CI 1.09-2.62;  $p<0.05$ ) was significantly associated with HIV serostatus in the unadjusted model. The odds ratio for level of education (aOR=1.93; 95% CI 1.09-3.42;  $p<0.05$ ) remained significant and increased in the adjusted model when controlling for all the other correlates (see Table 3).

*Lifestyle and knowledge factors:* AIDS-related transmission knowledge (OR=1.25; 95% CI 1.06-1.47;  $p<0.01$ ) was significantly associated with HIV serostatus in the unadjusted model and slightly increased in the adjusted model (aOR=1.26; 95% CI 1.03-1.53;  $p<0.05$ ). No other lifestyle factors were associated with HIV serostatus in either the unadjusted or adjusted models (see Table 3).

Table 3. Simple and multiple logistic regression models for the relationship between HIV serostatus and characteristics of construction workers (n=354)

Characteristics	Unadjusted		Adjusted <sup>++</sup>	
	OR	95%CI	OR	95%CI
<i>Demographic characteristics</i>				
Age	0.99	0.96 - 1.02	0.99	0.95 - 1.03
Gender	1.92	0.44 - 8.39	0.68	0.14 - 3.45
Race / ethnicity	1.10	0.54 - 2.27	1.63	0.63 - 4.22
Level of education	<b>1.69*</b>	1.09 - 2.62	<b>1.93*</b>	1.09 - 3.42
Nature of employment	1.01	0.52 - 1.99	1.06	0.49 - 2.26
<i>Lifestyle and knowledge characteristics</i>				
Alcohol use <sup>+</sup>	0.84	0.58 - 1.22	0.69	0.43 - 1.09
Dagga (Cannabis) use <sup>+</sup>	0.76	0.42 - 1.37	0.70	0.36 - 1.38
Condom use at last coital act	0.88	0.43 - 1.79	0.57	0.24 - 1.33
Multiple sex partners (>=2) <sup>+</sup>	0.67	0.29 - 1.57	0.63	0.25 - 1.60
AIDS-related transmission knowledge	<b>1.25**</b>	1.06 - 1.47	<b>1.26*</b>	1.03 - 1.53

Notes: <sup>+</sup>Reported for the past three months; <sup>++</sup>Model adjusted for all covariates; \* $p < 0.050$ ; \*\* $p < 0.010$ . The reference category for the dependent variable (HIV serostatus) is HIV+.

### Multivariate analysis

To examine the demographic, lifestyle and knowledge determinants of HIV serostatus, binary logistic regression was performed (see Table 4). Listwise deletion of cases with missing values resulted in 312 cases for the binary logistic regression.

Table 4. Multivariate logistic regression analysis of predictors of HIV/AIDS serostatus (n=312)

HIV/AIDS serostatus	Odds Ratio	p-value	95.0% C.I. for Odds Ratio	
			Lower	Upper
<i>Demographic characteristics</i>				
Age	.989	.614	.949	1.031
Gender	.682	.643	.135	3.445
Race / ethnicity	1.625	.319	.625	4.220
Level of education	1.928	<b>.025*</b>	1.087	3.417
Nature of employment	1.056	.889	.493	2.262
<i>Lifestyle &amp; knowledge characteristics</i>				
Alcohol use <sup>+</sup>	.686	.107	.434	1.085
Dagga (Cannabis) use <sup>+</sup>	.700	.302	.355	1.379
Condom use at last coital act	.568	.193	.243	1.332
Multiple sex partners (>=2) <sup>+</sup>	.630	.330	.249	1.596
AIDS-related transmission knowledge	1.258	<b>.022*</b>	1.033	1.532
Constant	1.195	.929	-	-

Notes: <sup>+</sup>Reported for the past three months; \* $p < 0.050$ ; \*\* $p < 0.010$ .

The reference category for the dependent variable (HIV serostatus) is HIV+.

A test of the full model against a constant-only model was statistically significant, indicating that the predictors as a set reliably distinguished between HIV+ and HIV- workers ( $\chi^2 = 20.21$ ,  $p < 0.05$  with  $df = 10$ ). The -2 Log Likelihood was 181.76. The Nagelkerke's  $R^2$  of 0.132 indicated that 13.2 per cent of the variability in HIV serostatus was explained by this set of variables. The Hosmer and Lemeshow Goodness-of-Fit test ( $\chi^2 = 7.23$ ,  $p = 0.512$  with  $df = 8$ ) indicated a good-fitting model.

Education (OR=1.93; 95% CI 1.09-3.42;  $p<0.05$ ) and AIDS-related transmission knowledge (OR=1.26; 95% CI 1.03-1.53;  $p<0.05$ ) were statistically significant determinants of HIV serostatus (see Table 4). The Likelihood Ratio Test statistics (obtained using the multinomial logistic regression routine in SPSS;  $n=312$ ) provided an indication of the *unique* contribution of each independent variable to the prediction of HIV serostatus. A statistically significant *unique* contribution was made by education ( $\chi^2 = 5.27$ ,  $p<0.05$  with  $df = 1$ ) and AIDS-related transmission knowledge ( $\chi^2 = 5.09$ ,  $p<0.05$  with  $df = 1$ ).

## DISCUSSION

The survey results are tempered somewhat by the limitations of the study. These include the cross sectional nature of the survey, the geographical bias of the sample (Western Cape), the convenience sample (workers from six willing construction companies), and any potential deliberate misreporting of risky lifestyle behaviors and HIV serostatus by the survey participants.

In this study, 73% of participants reported prior testing for HIV. This testing rate exceeds the 66% population-level testing rate reported by Shisana *et al.* (2014). Nevertheless, it is cause for concern that, given the reality of the pandemic, more than a quarter of participants reported never having been tested. A more alarming result is that less than half of the HIV+ sub-sample (42%) reported taking ARV medication. Possible reasons for this include poor family support, depression, and internalised stigma (see Nsimba *et al.*, 2010), but conclusive explanations will require deeper investigation.

Alcohol consumption and ‘dagga’ use were significantly positively associated, as was the use of these substances and multiple sex partners. Thus risky lifestyle behaviour is rarely a single factor phenomenon. However, none of the lifestyle factors (alcohol and ‘dagga’ use, condom use, and multiple sex partners) was significantly associated with reported HIV serostatus. This conflicts with much of the literature (see, for example, Shisana *et al.*, 2014). Possible reasons to explain this anomaly could relate to the small sample of HIV+ participants, language issues, low education/literacy levels, and deliberate misreporting of risky lifestyle behaviours and HIV serostatus. This will be explored more fully in future research.

Construction workers’ level of formal education is clearly linked to the extent of their AIDS-related transmission knowledge, and their reported HIV serostatus. Better-educated workers, and more knowledgeable workers, were 1.9 and 1.3 times more likely, respectively, to be HIV- when compared to HIV+ workers. Level of education and AIDS-related knowledge were significantly positively associated, with better-educated workers possessing greater levels of transmission knowledge. These results align with the literature (see Ropelewski *et al.*, 2011; Shisana *et al.*, 2014).

None of the other demographic characteristics were associated with HIV serostatus, a finding that is at odds with studies relating to age, gender, ethnicity, and nature of employment (see MacPhail *et al.*, 2009; Shisana *et al.*, 2014). A possible explanation could lie in the more proactive interventions offered by the companies participating in the survey (see Bowen *et al.*, 2013).

## CONCLUSIONS

The demographic and lifestyle determinants of the HIV serostatus of workers in the South African construction industry were explored. HIV+ construction workers were found to have significantly lower levels of education and AIDS-related knowledge than HIV-

workers. Level of education and AIDS-related knowledge were strongly and positively associated. Alcohol consumption, dagga use, condom use and multiple sex partners were significantly positively associated, but were found to be unrelated to HIV serostatus. Age, gender, ethnicity and level of employment were also unrelated to HIV serostatus.

The link between workers' level of formal education, the extent of their AIDS-related transmission knowledge, and their HIV serostatus has important implications for HIV/AIDS interventions implemented by construction firms. It suggests a need for more carefully structured interventions specifically designed to actively 'reach' workers possessing lower levels of education and poorer AIDS-related knowledge. Such interventions need to move beyond the passive approaches of posters and similar general communication media, and engage workers in a more active and targeted way that recognises language and cultural differences and educational shortfalls. If construction workers continue to enter the industry before completing (or even reaching) high school, then national education policies should incorporate AIDS-related knowledge (and lifestyle advice) much earlier than the later high school years, possibly at a point where the onset of puberty and adequate literacy intersect.

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# COMPETENCE MANAGEMENT IN THE UK HERITAGE RAILWAY INDUSTRY

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There are over 100 heritage railways in the UK, operated primarily by volunteers. They run vintage trains for leisure and tourism and also undertake construction work in the form of track and infrastructure maintenance including significant new-build, with around 1500 staff involved in such activity. Recent accidents, including a fatality in 2012 have led to competence management being highlighted as a key issue to be addressed by the UK heritage railway industry. Factors such as the volunteer culture, the prevailing language, the diversity of skills, qualifications and learning abilities, are all key factors to be addressed in managing competence effectively. The intention of this research is to identify the issues that need to be satisfactorily addressed when defining and implementing an approach to competence management that is appropriate for the unique structure and challenges of the UK heritage railway industry and to determine whether the contrast of volunteer and professional environments is likely to yield lessons of general applicability to competence management in construction-related activity. A full review of literature and interviews with discourse analysis have highlighted the importance of competence factors such as management, leadership and non-technical skills which resonate with the volunteer culture of heritage railways, and four key discourses have been identified for future study.

Keywords: heritage railway, safety, competence, volunteer

## INTRODUCTION

The UK heritage railway industry operates vintage trains for leisure and tourism and carries out construction works to maintain and renew infrastructure. There are now over 100 railways in this sector carrying ever increasing numbers of passengers (Heath, 2013), almost all primarily staffed by volunteers. However, heritage railways still require to be managed and operated in a safe manner, subject to the same overall requirement for safety as the mainline rail network. Safety is thus a key issue in the heritage railway industry, and incidents, including a serious injury in 2010 on the Foxfield Light Railway and a fatality in 2012 on the North Yorkshire Moors Railway, have led to competence management being highlighted by the Rail Accident Investigation Branch (RAIB) as a key issue to be addressed by the industry.

Competence management within the UK heritage railway sector affects all aspects of the industry including construction and maintenance of infrastructure and rolling stock, train operations, corporate management and governance and the overall project management and delivery of change. Although the incidents referred to above are not

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construction related, construction works within the heritage railway sector are significant and routinely involve track maintenance, drainage and occasionally more significant works involving structures, earthworks or major track relays are undertaken, and these can involve the application of large items of plant and significant human resources. The heritage railway working environment poses particular challenges with respect to an effective competence management system, with a largely part time volunteer workforce overseen in some cases by a small full time paid staff. There has been no systematic analysis of this subject matter carried out to date and the intention of this research is to identify the issues that need to be satisfactorily addressed when defining and implementing an approach to competence management that is appropriate for the unique structure and challenges of the UK heritage railway industry.

## **BACKGROUND**

The ability to operate and maintain heritage railways safely is key to ensuring the ongoing viability of the industry. Customers at heritage railways rightly assume that their experience will be safe, as well as enjoyable, and any change to this perception could be very damaging to the industry. The recent incident at the Alton Towers leisure park, where two carriages on a roller coaster ride collided, resulting in significant injuries to some customers, serves as an example of the potential impact that such incidents can have on business performance. The need for competent and appropriately trained staff is therefore vital.

With its origins in the early narrow gauge preservation schemes of the 1950s, the evolution of the UK heritage railway industry gathered pace in the 1960s as a wholly volunteer run endeavour, as groups of railway enthusiasts sought to preserve branch lines that were being closed by British Rail. These enthusiasts came from a variety of backgrounds, with a diversity of reasons underpinning their desire to be involved, and their numbers have grown consistently since then (Rolt 1953). In 2013, there were 18,528 individuals recorded as volunteers on UK heritage railways (HRA 2013). Of these, some 1500 are involved in construction related activities, including maintenance of track and other assets and occasional new construction such as line extensions and new station facilities.

Construction engineering, together with the project management and corporate governance that facilitates it, is therefore a key element of the heritage railway industry where effective competence management is required, in a challenging and unique environment, to ensure the continued viability of the industry. A key aspect to effective implementation of a competence management system in the UK heritage railway sector is the need to understand the issues associated with a largely volunteer workforce drawn from a variety of backgrounds and often working on an informal or “ad-hoc” basis with no effective pre-employment screening in place. Factors such as the volunteer culture, the prevailing jargon, the diversity of skills, qualifications and learning abilities are all potential limitations or constraints to be taken into account for the effective application of any competence management system (Sherratt *et al.*, 2015).

By contrast, in the UK construction industry candidates for specific construction related roles are often required to attend a formal, usually competency based, interview as part of the selection process together with a pre-employment medical, and it is only after successful completion of all of these stages in the recruitment process that a candidate may be offered a position of employment.

## RESEARCH OBJECTIVES

This paper sets out to identify the issues that need to be satisfactorily addressed when defining and implementing an approach to competence management that is appropriate for the unique structure and challenges of the UK heritage railway industry, including construction related activities and the management systems that govern them, and to determine whether the contrast of volunteer and professional environments is likely to yield lessons of general applicability to competence management in construction-related activity.

### **Applicable legislation and codes of practice**

Legislation applicable to heritage railways includes the Health and Safety at Works Act 1974, the Management of Health and Safety at Work Regulations 1999 and, more specifically for the rail industry, the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS). All this is prescriptive, placing obligations on employers and employees with respect to competence management in the workplace, but without recognising specific issues that may affect the application of these requirements. ROGS takes into account the heritage railway industry with a risk based and less onerous application of the requirements.

In addition to legislation, there are relevant codes of practice such as the construction industry's Construction Skills Certification Scheme and the Network Rail "Sentinel" personal track safety competence scheme. Guidance on competence management for minor railways is also published by the Office of Rail Regulation (ORR) and for heritage railways by the Heritage Railway Association (HRA). Again, whilst providing a clear basis for effective competence management, these publications do not address the potential factors that may affect effective application.

### **Information in public domain**

The report produced in early 2014 entitled *Competence in Construction* (Pye Tait Consulting, 2014), and commissioned by the Construction Industry Training Board (CITB) with support from the Health and Safety Executive (HSE) was reviewed as part of our research. This includes various consultations and initiatives that have taken place within the construction industry at all levels since 2011. Furthermore, competence management systems from individual heritage railways, publications by relevant professional institutions and examples from other industries have also been considered as part of a general review of books, articles and other publications from internet and other sources in the public domain.

This review has revealed a diverse approach to addressing competence, with no single definition of what competence is. This is summed up well in the *Pye Tait Consulting Report* referred to above as "interpretations and uses of the word are as varied and numerous as the contexts in which the word is employed...Every sector's approach to competence is shaped by the nature of its working activities but all are concerned with ensuring a safe, efficient and skilled workforce. Most approaches would agree broadly that competence designates the ability to independently perform a role or task to the required standards".

### **Peer-reviewed research**

Considering the peer-reviewed research on competence management, we are able to define a series of clusters of research topic as shown in Figure 1.



Figure 1: Competence Management Research Topic Clusters

In terms of the heritage industry, and UK heritage railways in particular, it should be noted that a considerable amount of peer-reviewed research does already exist, however none of this research addresses the specific issue of competence management which is the subject of this paper. There are currently a myriad of factors to be taken into account and different approaches to addressing competence management issues. Considering Chinese SMEs, Yan (2011) used a conceptual model to demonstrate the linkage between performance of the company and competence in the key areas of entrepreneurship, marketing and project management. Meanwhile Fu *et al.*, (2014) advocated an evaluation index system for core competence, having applied the entropy weight method to determine the relative weights of the evaluation indices.

The need for a methodical approach within the rail sector to developing a competence management system is highlighted with the application of a competence profile advocated as providing an objective and transparent evaluation of an employee's performance in the process of certification (Bayirbekova, 2012). As a result of an assessment and review against leading practice from within and outside the rail industry, risk-based training needs analysis is advocated (Shah *et al.*, 2013). Through developing an understanding that knowledge is usually created in higher education institutions and research organisations, continuous improvement of competency within the nuclear industry through lifelong learning is recommended (van Goethem, 2010). Finally, the application of systematic training programmes was determined as a means to address the need to maintain or enhance competence, within an environment of ageing personnel and assets, (Patrakka, 1999).

The Rail Safety and Standards Board (RSSB) mentored the top management teams of many UK rail companies through a self-assessment process and results suggested strengths in areas of strategy, policy and operational control and weaknesses in the areas of risk control, resourcing and support, with human factors being a particular area of concern. As a result, the application of good practice guidelines is advocated to ensure that the top management within an organisation is sufficiently competent to discharge its duties (Johnson and Nelson, 2004). An empirical study that aimed to increase understanding of the involvement of the project manager in competence management within Swedish project-focussed organisations came to the conclusion that this also applied to project managers (Medina and Medina, 2014). A study was undertaken to determine how workers perception of leadership involvement in daily work operations affected the level of safety compliant behaviour in the offshore industry, with leadership seen as a key organisational factor affecting the level of safety compliance (Dahl and Olsen, 2013). In the project management domain, leadership development questionnaires were utilised to profile the required intellectual, managerial and emotional competences of project managers and the

results suggested that more needs to be done in addressing training in the “soft” factors of leadership (Muller and Turner, 2010).

The setting up of a Supervisor Development Centre, providing supervisors with the skills to challenge non-compliance with procedures, is advocated by Leach *et al.*, (2013). As the results of the analysis of a safety climate survey undertaken with 4479 Norwegian offshore petroleum employees, on a number of key dimensions including competence, the working environment is also determined as having an influence on attitudes to health and safety (Hoivik *et al.*, 2009).

Based on the feedback obtained from a RSSB research project undertaken to develop non-technical skills (NTS) training courses, the inclusion of NTS within an overall competence management system for rail staff is recommended (Bonsall-Clarke and Pugh, 2013). Research undertaken has demonstrated that NTS such as decision-making and situational awareness underpin safe performance at work for safety critical staff, and are therefore particularly relevant for train drivers (Russell *et al.*, 2013). Following a review of the implementation of the Manila 2010 amendments [2] to the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention and Code, recognising the importance of soft skills is advocated with respect to competence in the maritime industry, (Vervoot, 2012).

Related to this, following the development of a generic hierarchical framework to assist future projects to categorise relevant factors for consideration, local knowledge is suggested as important to supplement basic competence (Pickup *et al.*, 2013). A case study describing how local knowledge was applied at an assessment centre is used to advocate that this should also be included in the design of assessment tools (Ripamonti and Scaratti, 2012). Finally, based on an assessment of the characteristics required for managers in offshore installations, emergency management simulations are recommended for training and assessment (Slaven and Flin, 1994).

In summary a wide variety of research into competence management across various industry sectors has shown that the competence of managers, particularly in relation to leadership, human factors, and NTS are key factors. All of these resonate with the diverse and voluntary nature of the heritage railway sector as discussed above, suggesting that research into competence management in heritage railways will yield useful insight both in terms of safe operation of heritage railways and also into competence management in safety critical industries, including construction.

## **METHODS**

In view of the potential gains from a study of competence management in the UK heritage rail industry, the following methods have been identified as possibly fruitful ways to progress this research: Reflective study of the authors’ own experiences as volunteers working in the heritage rail industry with benchmarking against corresponding experiences in the UK mainline rail industry. Meetings with managers at UK heritage railways with an analysis of the resultant discussions to identify trends and common themes across UK heritage railways for more detailed investigation. Interviews of experienced staff engaged in the maintenance and operation of a representative UK heritage railway with discourse analysis applied to evaluate what issues are revealed through the naturally occurring language and ethnography applied to reveal key competence issues from their perspective.

## RESULTS AND DISCUSSION

Based on their own experiences, as volunteers in the UK heritage railway industry and working within the UK mainline industry, the authors have been able to record some initial observations with respect to the different applications of competence management systems within these two environments. Although both entities are involved in the maintenance and renewal of UK standard gauge railway infrastructure, due to the operating and staffing differences of these two environments the approach to, and the application of, competence management systems is quite different.

### *Comparison with UK mainline rail industry*

Initial observations have identified a significant difference to the approach adopted when recruiting and inducting staff for roles, including those that are safety critical. Selection criteria in the heritage railway sector are generally limited to age and physical limitations, contrasting with competence based assessment and pre-employment medicals in the mainline rail sector.

For example, at a typical UK heritage railway, the start of the recruitment process for volunteer roles can take the form of an open day where interested candidates are asked to attend an introduction to the railway and to the various disciplines and departments seeking resources. With a limited introduction to the various (often safety critical) voluntary roles on offer and no formal assessment of competences or medical condition undertaken, candidates are asked to indicate their preference for specific volunteer roles. Candidates are then contacted by the railway at a later date to attend an induction for their chosen volunteer role, with competence assessment and certification coming only later at various stages of advancement within the role (for example the transition from cleaner to fireman and then to driver on steam locomotives). This is generally limited to technical skills and knowledge with no formal assessment of aptitude for any given role.

By contrast, in the UK mainline rail industry candidates for specific roles are required to attend a formal, usually competency based interview as part of the selection process. For some roles, psychometric testing (RSSB, 2013) will also be carried out to determine that candidates possess the necessary attributes for the role. Prospective candidates will also typically be required (always for a safety critical role) to attend a pre-employment medical and this will include, as part of the Network Rail Sentinel scheme, screening for drugs and alcohol usage (NR 2014). It is only after successful completion of all of these stages in the recruitment process that a candidate may be offered a position of employment. As a result of the recruitment process, heritage railway induction processes have to address new recruits with mixed backgrounds and capabilities whereas in the mainline industry these are tailored to defined standards of competence and aptitude.

### *Meetings with heritage railway management*

Four meetings with UK heritage railway management have been conducted and provided some interesting insights into competence management issues that are currently being addressed. A full time paid Operations Manager at a UK heritage railway explained that although the Operations department at their railway has an effective and documented competence management system, they believe that the non-safety critical staff do not have an effective system. Customer-facing skills is one particular area highlighted by this manager which is not addressed by the current system but which is critical to the competence criteria for many operations roles. The same manager explained that regular mutual improvement classes are undertaken and

that their employing heritage railway has its own website for this purpose which is accessible by anyone interested in the subject matter. They believe that the heritage railway movement should share more information about best practices, lessons learned, etc. and is happy for their railway to be one of the leaders in being as open and transparent as possible.

The General Manager at another UK heritage railway explained that corporate memory fade is an issue that is of great concern, as the founding volunteers from the early days of railway preservation now retire from the industry. The same manager explained that with many different types of motive power and a multitude of different operating requirements, it is difficult for staff to maintain competence for all assets on the railway. Competence is managed through a focus on what is important, an example being a register that is maintained of competent footplate staff.

A meeting with the Safety manager of a UK heritage railway revealed that compliance with ROGS is achieved through a Safety Management System that is stored on a central database, including the competence management system (CMS). There are some policies missing such as lifting, etc. There is currently no mechanism or process in place to address skill fade. At the same UK heritage railway, the Infrastructure Manager explained that volunteer signalling engineers are often better qualified than the full time staff, bringing with them qualifications from their own day to day employment. Due to the transient nature of the workforce, they believe it is particularly important that all staff have grade cards in order that they are able to prove their competence if required, particularly in emergency situations.

#### *Interviews with heritage railway volunteers*

Structured interviews were conducted with two heritage railway volunteers and digitally recorded and transcribed as 'verbatim with dialect' (Gibbs 2007). The common notation of I for interviewer and R for respondent was applied to the transcripts. Access to the socially constructed realities of competence in the heritage rail industry can be granted through the analysis of this discourse through examining its linguistic exchange (Sherratt *et al.*, 2012).

Due to space constraints, only the four most significant discourses are presented below with extracts from the interview conversations utilised to illustrate the analysis undertaken and how these enhance the understanding of competence management issues to be addressed in the UK heritage railway industry. Effectiveness of Processes - Analysis of the interview data revealed that the volunteers consider the current heritage rail processes that they apply to carry out construction and operations activities to be effective and safe. This can be seen in the extract below:

I: How would you describe the effectiveness of the processes you've had to comply with?

R1: Erm, I think with, with, most of the competences we are safe.

R2: I think, I think they have been effective, erm, because, erm, er, at the end of the day, er, if you, you know, if you have to refresh your memory and re-check and re-learn something for a test it does make you read it because otherwise you can forget things and one of the issues that can happen with volunteers, particularly with the seasonal nature of the railway, is that people will be working the season, they will then go away for the winter months and when they come back people some will have forgotten an awful lot over that period of time.

A key point is made by one of the respondents that due to the seasonal, and non-contracted, nature of volunteer employment on heritage railways, there is a real risk of

“skill fade” particularly when a particular competence has not been utilised for a considerable period of time. What Should be Changed - The data obtained from the interviews revealed that there is room for improvement with the way that competence is currently managed and this can be seen from the extract below:

I: What would you do differently if you could change anything?

R1: I think there is still room for improvement with regards to training people...if people had been better trained could we have worked more efficiently.

R2: I think, erm, I think there can be more, erm, practical assessments.

The need to train staff is clearly considered as important, together with the need to verify that training has been effective in practice, with the suggested application of practical assessments. As well as the obvious safety critical dimension of having trained staff, the potential efficiencies that would arise are also seen as a potential benefit.

The Effects of Competence Management on Volunteer Motivation - What is clear from the analysis of the interview data is that being competent, and having competent trained staff working with you, is a motivating factor for workers. However, the counter to this is that if the worker does not feel competent or competent co-workers are not available, for whatever reason, this can be a source of frustration as can be seen from the extracts below:

I: How does competence management affect your motivation working here?

R1: Erm, you get frustrated sometimes that, that, erm, you may not have the people, you know. Erm, so I think that's one of the things that frustrates me, that we don't get enough, and that's because we haven't got the time within the company to, to, specifically train people.

R2: Erm, I think, I, I, I think that knowing what the competencies are that you need for a particular job does motivate you. If you didn't know what you are meant to be doing I think it would have a demotivating effect.

It is interesting to note that the requirement to train staff, and the inability of the heritage railway to provide this, is seen as a key issue to be addressed. The Importance of Competence Management to the Heritage Railway Industry - The final significant discourse is on the subject of the importance of competence management to the UK heritage railway industry. From analysis of the interview data, on this issue the respondents are clearly of the same view that it is vitally important as can be seen from the extracts below:

I: Could you describe the importance of competence management to the UK heritage railway industry?

R1: Well I think it is vitally important because if we work in an incompetent manner...the heritage railways are not going to, you know, continue much longer.

R2: Well I think any, I think the heritage railway industry has to be professional in it's approach and it can be no different from the big railway in terms of, what, how it runs itself and so therefore, er, I think it's essential that there is competency management in heritage railways.

The respondents clearly view the future viability of the industry as dependent on being safe, and being seen to be safe, today with a view that there should be no distinction between the UK mainline industry and the UK heritage railway industry in basic standards.

## CONCLUSIONS

Research has been carried out to identify issues with competence management in the UK heritage railway industry, bearing in mind the volunteer nature of its workforce, including approximately 1500 staff engaged in construction-related activity. A review of literature across a range of safety-critical industries concludes that the competence of managers, particularly in relation to leadership, human factors, and non-technical skills are key factors, all of which resonate with the diverse and voluntary nature of the heritage railway sector. This has been complemented by the authors' reflective analysis of their own experiences in both heritage and mainstream industry contexts, indicating that research into competence management in heritage railways will yield useful insight both in terms of safe operation of heritage railway and also into competence management in safety critical industries, including construction.

A series of interviews with heritage railway staff, investigated by discourse analysis has identified key discourses for future study as Effectiveness of Process, What Should be Changed, Effectiveness of Competence Management on Volunteer Motivation and The Importance of Competence Management to the Heritage Railway Industry. Further research activities will seek to build upon these initial findings through further interviews in the disciplines of infrastructure, operations, project management and at board level, in order to determine how competence management can be effectively applied to the largely volunteer workforce within the UK heritage railway industry and any lessons of general applicability to industry can be learned.

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# A LONGITUDINAL ANALYSIS OF SAFETY CLIMATE IN THE DYNAMIC CONSTRUCTION PROJECT ENVIRONMENT

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This study longitudinally measured safety climate at construction projects, and explored the overall safety climate change patterns. Safety climate was measured with a multi-level safety climate measurement instrument. At the organizational level, the instrument measured workers' perceptions of client organization's safety response (COSR) and principal contractor's organizational safety response (PCOSR). At the workgroup level, the instrument measured workers' perceptions of supervisors' safety response (SSR) and co-workers' safety response (CWSR). Three waves of data collection were undertaken at four processing plant construction projects in New Zealand. The research results indicate that workers' perceptions of client organization's safety response and principal contractor's organizational safety response generally declined across all projects over the three surveys, and the declines were statistically significant at several projects. The changes in workers' perceptions of supervisors' safety response were insignificant for all projects. Moreover, a significant increase was observed for workers' perceptions of co-workers' safety response at one project. The research suggests that the construction project management should consistently emphasize the importance of safety, even when they are facing production pressure. The research also highlights the potential role played by supervisors in managing boundary relationships between their workgroups and the organizational environment, and maintaining a positive safety climate in their workgroups.

Keywords: safety climate, longitudinal, multi-levels, construction project.

## INTRODUCTION

Safety climate was first defined as 'a summary of molar perceptions that employees share about their work environments' by Zohar (1980, p.96). Later Neal and Griffin (2006, p.947) defined safety climate as 'individual perceptions of policies, procedures, and practices relating to safety in the workplace'. The concepts safety climate and safety culture have been theoretically differentiated in previous research (see for example, Glendon and Stanton, 2000; Guldenmund, 2000). Guldenmund (2000) argues that it is more appropriate to define safety culture as the aspects of organizational culture that have impact on safety-related attitudes and behaviours. This is because the core underlying assumptions that characterize an organizational culture shape the whole operation of the organization, including how safety is prioritised and enacted. It is generally accepted that safety climate represents the surface features of cultural influences on safety, which can be discerned from

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workforce's attitudes and perceptions at a given point in time. Alternatively, safety climate is a 'snapshot' assessment of cultural influence on safety that prevails in an organization at a particular point in time (Mearns and Flin, 1999).

Recently, there has been a growing interest in the measurement of safety climate across various industries. Safety climate measurement has been recommended as a useful diagnostic tool for organizations, which aim to foster organizational cultures supporting safety, to identify problematic areas for improvements (Zhang *et al.*, 2015). The growing interest in the measurement of safety climate across industries is also predicted by the expected links between safety climate and safety related behaviors and performance indicators, e.g. risky behaviour in the rail industry (Morrow *et al.*, 2010), voluntary safety participation in the health sector (Neal *et al.*, 2000), and accident rate in the construction industry (Siu *et al.*, 2004).

### **Safety climate as a multilevel concept**

The majority of safety climate studies in the construction industry used the 'organisation' as the unit of analysis, assuming that workers share homogenous perceptions of all safety issues organization-wide (Zhang *et al.*, 2015). However, there is growing recognition of the importance and influence of safety climate perceptions relating to different levels of managerial response. Zohar (2000) suggested that safety climate is a multilevel construct, and that workers' perceptions of safety climate can stem from two sources, i.e. formal policies and procedures related to organizational level analysis, and supervisory practice related to group level analysis. Due to supervisors' discrepant interpretations and local implementations of formal procedures, workers in different sub-groups are likely to form different perceptions of supervisory practices. Lingard *et al.*, (2009; 2010) tested Zohar's multilevel safety climate proposition in the construction industry, and demonstrated that subcontracted work groups in construction projects developed unique safety climates relating to supervisory practices that can be distinguished from shared perceptions of the principal contractor's organizational safety responses. Later, Lingard *et al.*, (2011) extended Zohar's idea of group level safety climate to embrace the role of co-workers' safety attitude and behavior in influencing safety in workgroups. They empirically illustrated that co-workers' safety response does represent a separate facet of group safety climate.

Recent studies that examine safety climate in construction projects have started to include perceptions of the client's safety response as a separate aspect of project-level safety climate (see for example, Zhang *et al.*, 2015; Shen *et al.*, 2015). Clients are initiators of construction projects, and they make decisions about the project budget, timeline, project objectives and performance criteria, which can create pressure and constrains that significantly impact safety in construction process (Lingard *et al.*, 2008). Their acts and expectations in relation to safety play a critical role in shaping safety climate in construction projects. Recent studies have identified various client-led initiatives that positively influence construction project safety performance, including setting contractual safety requirements, monitoring safety performance, reviewing and analyzing safety data, funding safety initiatives, participating in on-site safety activities, etc. (Huang and Hinze, 2006; Votano and Sunindijo, 2014).

### **The unstable nature of safety climate**

The majority of existing safety climate studies measured safety climate using a cross-sectional approach, assuming that safety climate remains stable over time. However, given that safety climate is defined as workers' perceptions of their work

environment, the perceptions are likely to vary if there is perceivable change in the work environment. Consistent with this, evidence is emerging to suggest that safety climate is not stable but changes over time. For example, Tharaldsen *et al.*, (2008) reported significant increases in mean scores of four safety climate dimensions on offshore oil platforms on the Norwegian continental shelf (NCS) between 2001 and 2003. The positive changes were believed to be associated with safety initiatives that occurred in the Norwegian petroleum industry.

Research also indicates that in circumstances where completing goals (e.g. safety, speed and cost) exist, changes in the relative priorities placed on these goals subsequently leads to changes in workers' perceptions of safety climate (Zohar 2010; Zohar 2008). In line with this, it is unlikely that safety climate would remain stable over time in the context of construction projects, where decision-making is highly dynamic in nature and decision-makers change their focus in response to contingent and emergent events (Humphrey *et al.*, 2004). The relative emphasis that project participants place on safety and other project goals can change across the life of a single project (Humphrey *et al.*, 2004). A changed response to safety, even if quite subtle, can be interpreted by workers and expressed in changed perceptions of the safety climate. The unstable nature of safety climate highlights the need to conduct longitudinal multi-wave safety climate measurement to monitor change in construction projects and inform the implementation of intervention if necessary.

## **RESEARCH AIM**

The study attempts to longitudinally analyze safety climate in the dynamic construction project environment. With a multilevel approach, this study explored changes in the pattern of safety climate at four construction projects in terms of workers' perceptions of: 1) the client organization's safety response; 2) the principal contractor's organizational safety response; 3) workgroup supervisors' safety response; and 4) co-workers' safety responses.

## **RESEARCH METHOD**

### **Safety climate measurement instrument**

A multilevel safety climate measurement tool was used to longitudinally assess safety climate at participating construction projects. The measurement tool analyses safety climate from the perspective of safety agents, who perform or take responsibility for safety activity/issue in each safety climate statement (Meliá *et al.*, 2008). The agent analysis of safety climate would enable a clear identification of safety effort required from a specific agent for safety improvement. At the client level, the client organization's safety response (COSR) was measured by the measure of general management commitment to safety, which was developed for the UK Health and Safety Executive by Davies *et al.*, (1999). At the principal contractor level, the global organizational level safety climate scale developed by Zohar and Luria (2005) was adapted to assess the principal contractor's organizational safety response (PCOSR). At the group level, supervisor's safety response (SSR) was measured by the scale developed by Zohar and Luria (2005), which covers various interactions between supervisors and group members through which supervisors indicate the priority of safety in relation to competing goals. Co-workers' safety response (CWSR) was measured by the scale of co-workers' safety climate developed by Brondino *et al.*, (2011), which reflects co-workers' general safety values and practices. The

development and validation of the multilevel safety climate measurement tool has been reported in Zhang *et al.*, (2015).

### Data collection

Longitudinal safety climate surveys were conducted at four processing plant construction projects commissioned by a manufacturing organization in New Zealand. The surveys were conducted from January 2013 to August 2015. Three waves of data collection were undertaken at projects A, B, C and D.

The surveys were administered using the ‘TurningPoint’ automated response system with ‘KeePad’ hand held devices. Survey questions were projected onto a screen one by one and read out by a facilitator. Workers were required to press a number on the hand held devices to indicate their responses to the statement in each survey question against a 5-point scale ranging from ‘1 Strongly Disagree’ to ‘5 Strongly Agree’. The number of participants involved in each survey for each project is listed in Table 1.

*Table 1: Number of participants who completed each survey by project and wave*

Project ID	Survey Session	No. of Participants
Project A	Survey1	21
	Survey2	36
	Survey3	45
Project B	Survey1	16
	Survey2	25
	Survey3	44
Project C	Survey1	31
	Survey2	50
	Survey3	58
Project D	Survey1	31
	Survey2	31
	Survey3	41

## DATA ANALYSIS AND RESULTS

### Mean safety response scores

For each individual survey, a mean safety response score was calculated for each safety agent. This was achieved by averaging the mean scores of all questions relating to each safety agent. The mean safety response score is an indication of workers’ perceptions of each safety agent’s overall safety effort. Mean safety response scores were calculated for all surveys at each project, including mean scores for client organization’s safety response (COSR), principal contractor’s organizational safety response (PCOSR), supervisor’s safety response (SSR), and co-workers’ safety response (CWSR). Figure 1 - 4 illustrate the mean safety response scores for all surveys conducted at the four projects.

### Stages of project completion

The time at which each survey was conducted was converted into the percentage of project completion, which was calculated by:

Percentage of project completion = (Project duration to the date of survey / Total project duration) x 100%

Table 2 lists the stages of project completion at which the surveys were conducted for each project.

Table 2: The stages of project completion at which the surveys were conducted<sup>2</sup>

Project ID	Project duration	Survey 1		Survey 2		Survey 3	
		Survey date	% of completion	Survey date	% of completion	Survey date	% of completion
A	Jan 2013 – Oct 2013	19 Feb 2013	16.80%	18 Apr 2013	36.00%	04 Jul 2013	61.30%
B	Jun 2013 – Nov 2014	10 Dec 2013	35.11%	25 Mar 2014	54.50%	06 Aug 2014	78.83%
C	Mar 2014 – Aug 2015	27 Jun 2014	21.67%	12 Nov 2014	46.67%	05 Mar 2015	67.56%
D	Mar 2014 – Sep 2015	29 Jan 2015	57.89%	30 Apr 2015	73.68%	05 Aug 2015	90.32%

### Longitudinal safety climate assessment for each project

The mean safety response scores and the stages of project completion were then plotted to graphically illustrate the longitudinal safety climate assessment for each project, which were shown in Figure 1 - 4. One-way analysis of variance (ANOVA) was performed to assess whether the safety climate changes at each level over the three survey phases were statistically significant for each project. The significant changes were reported in the following descriptions.

At Project A, workers' perceptions of principal contractor's organizational safety response (PCOSR) generally declined over the three surveys. The decline was statistically significant ( $F(2, 99) = 4.553$ ;  $p = 0.013$ ). Workers' perceptions of the client organization's safety response (COSR) and co-workers' safety response (CWSR) slightly increased after the 1st survey (at approximately 15% completion), but then declined after the 2nd survey (at approximately 35% completion). Although workers' perceptions of supervisors' safety response (SSR) slightly decreased after the 1st survey, the perceptions increased between the 2nd and 3rd surveys while the perceptions of safety responses at the other levels all declined during the same period.

At Project B, workers' perceptions of the client organization's safety response (COSR), supervisors' safety response (SSR), and co-workers' safety response (CWSR) deteriorated over the three surveys (at approximately 35% completion, 55% completion and 80% completion respectively). Workers' perceptions of the principal

<sup>2</sup> Note: The calculation was based on the assumption that each project was commenced on the first day of the starting month and finished on the last day of the completing month. For example, the duration for project A is 10 months. The first survey for project A was conducted on 19 Feb 2013, and therefore the duration to the date of survey was approximately 1.68 months. Then the percentage of project completion was calculated as 16.8%.

contractor's safety response (PCOSR) remained similar between the 1st survey and the 2nd survey, but then dramatically declined after the 2nd survey. The change in PCOSR was statistically significant ( $F(2, 82) = 4.107; p = 0.020$ ).

At Project C, workers' perceptions of the principal contractor's safety response (PCOSR) and supervisors' safety response (SSR) slightly declined after the 1st survey (at approximately 20% completion), but then increased between the 2nd survey (at approximately 45% completion) and the 3rd survey (at approximately 70% completion).

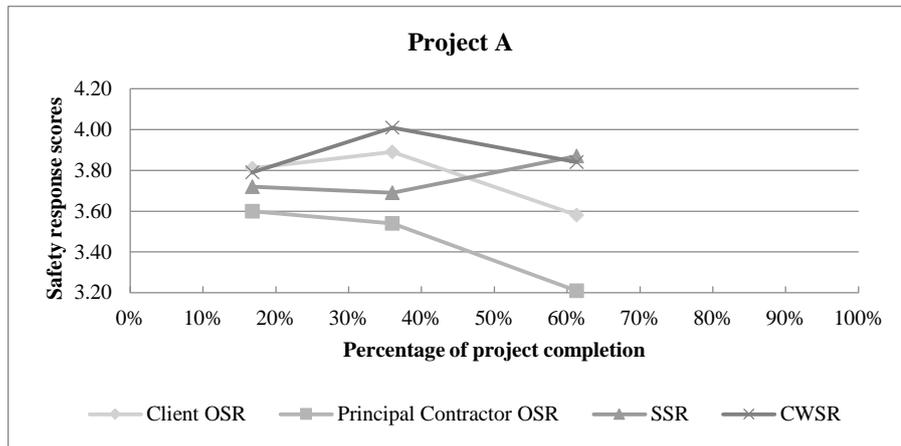


Figure 1: Longitudinal safety climate assessment for Project A

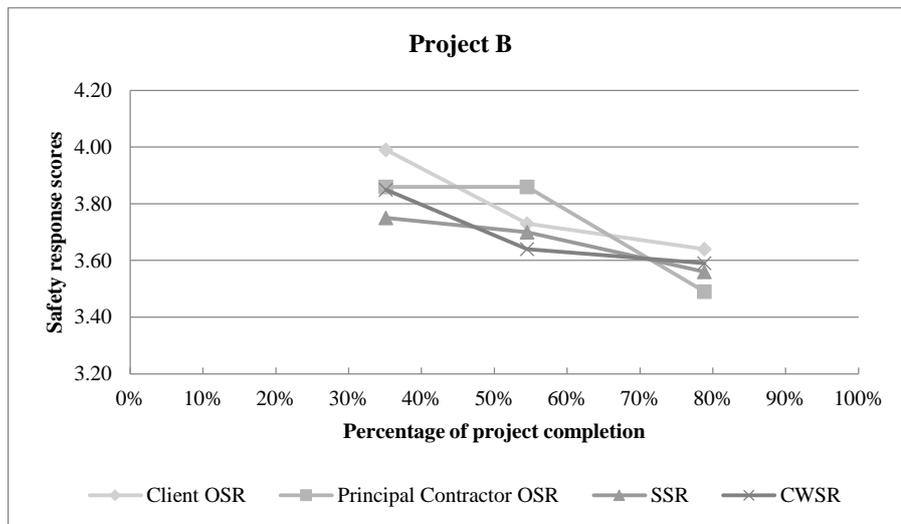


Figure 2: Longitudinal safety climate assessment for Project B

Workers' perceptions of the client organization's safety response (COSR) slightly declined over the three surveys, while workers' perceptions of co-workers' safety response (CWSR) increased over the three surveys. The increase in CWSR was statistically significant ( $F(2, 136) = 3.083; p = 0.049$ ).

At project D, workers' perceptions of the client organization's safety response (COSR) and the principal contractor's organizational safety response (PCOSR) decreased over the three surveys as the construction project progressed (at approximately 60% completion, 75% completion and 90% completion respectively). The decrease in COSR was statistically significant ( $F(2, 100) = 3.428; p = 0.036$ ). Workers' perceptions of supervisors' safety response (SSR) deteriorated between the 1st survey

and the 2nd survey, but then slightly increased between the 2nd survey and the 3rd survey.

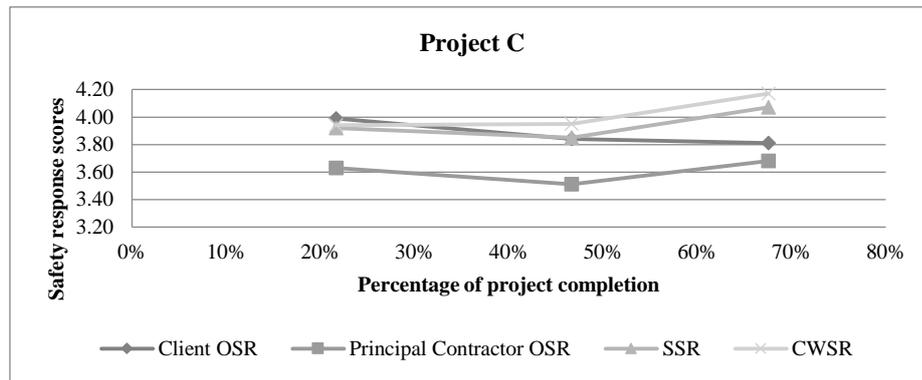


Figure 3: Longitudinal safety climate assessment for Project C

Workers' perceptions of co-workers' safety response (CWSR) increased after the 1st survey, but then declined after the 2nd survey.

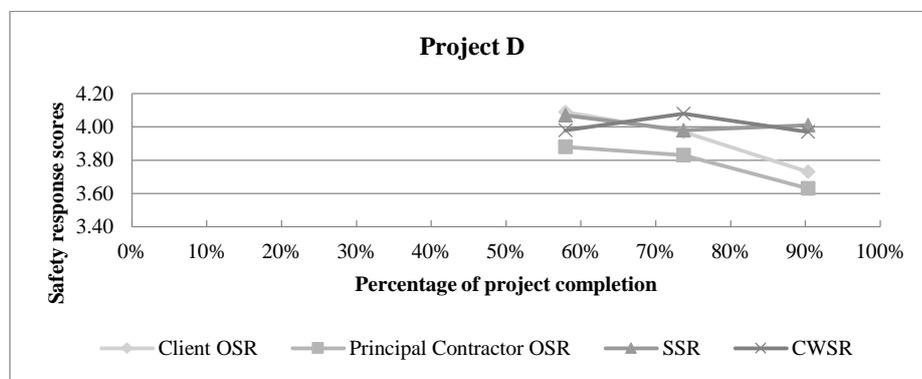


Figure 4: Longitudinal safety climate assessment for Project D

## DISCUSSION

### Longitudinal safety climate measurement in construction project environments

The research indicates that safety climate does significantly change at certain levels in dynamic construction project environments. The significant changes observed in this research suggest that multi-wave longitudinal safety climate measurement is more appropriate than cross-sectional safety climate measurement in the construction industry. Longitudinal safety climate measurement over the life of a construction project helps the project management team to monitor the change in safety climate, and informs the implementation of managerial interventions when a significant negative change is identified. For example, at Project C, notable improvements were observed for safety responses between the 2nd survey and the 3rd survey. These improvements may be attributed to the implementation of a health, wellbeing and fatigue management initiative. The client established a program named 'safety-first, quality-second, time line-third' to emphasize the importance they placed on safety as a project objective. As the research suggests, the safety climate improved following the implementation of this program.

### Generally declined safety responses at organizational levels

The research results show that workers' perceptions of the client organization's safety response (CORS) generally declined over the three surveys across all the projects,

while the principal contractor's organizational safety response (PCOSR) generally declined at Project A, Project B and Project D. The decline in COSRS at Project D and the decline in PCOSR at Project A and Project B were statistically significant. In addition, the declines in CORS and PCOSR between the 2nd and the 3rd surveys at those projects were more obvious than those between the 1st and the 2nd surveys. Previous research suggests that as a project progresses to the final stage, completion of the project becomes the primary focus of the project team (Garland and Conlon, 1998). This can sometimes detract from emphasis placed on other project objectives (including safety) which may have been more salient during earlier stages of the project. It is possible that as those construction projects progressed toward completion, the relative emphasis placed on competing project goals by project management may have changed with a greater emphasis on 'getting the job done on time'. It is important that construction project managers consistently emphasize the importance of safety over the life of a construction project, and do not inadvertently reduce the focus on safety when they reinforce the importance of keeping the production on schedule.

### **Relatively stable safety responses at the group level**

The results show that workers' perceptions of supervisors' safety response (SSR) were relatively stable with the changes in SSR being insignificant for all the four projects. The relative stability in SSR suggests that workers working at these projects perceived their supervisors to be consistent in terms of safety acts and expectations over the project life course. Supervisors were perceived not to reduce the emphasis placed on safety even at the later stages of the projects when production pressures were normally high. It is noticed that, at Project A and Project E, although both the client organization's safety response (COSR) and the principal contractor's organizational safety response (PCOSR) declined between the 2nd survey and the 3rd survey, supervisors' safety response (SSR) increased during the same period. The result is consistent with previous research findings that supervisors can act as 'gatekeepers' of group level safety climate, i.e. in circumstances where organizational management indicates higher priority of production than safety, supervisors whose leadership is strong and effective are expected to better manage boundary relationships between their groups and the organizational environment, thereby maintaining high safety priorities in their own groups (Zohar and Luria, 2010). The research suggests the potential to further examine the role played by supervisors' leadership as an antecedent to group level safety climate.

Despite slight fluctuations, no significant change was observed for workers' perceptions of co-workers' safety response (CWSR) over the three survey phases at Project A, B and D. This suggests that workers of these projects perceived their co-workers to be consistent in holding safety values and demonstrating safety practices over the project processes. At Project C, CWSR increased over three phases of surveys and the increase was statistically significant. This is in line with the claim that workers' concerns for the safety and wellbeing of their co-workers may increase as they develop stronger social ties and greater knowledge about their co-workers over time (Burt, *et al.*, 2008). Although the safety responses at the organizational levels generally declined across all the projects, CWSR remained stable or even increased as the projects progressed. This outcome, again, may be attributed to the 'gatekeeper' role played by supervisors' in maintaining positive group safety climate despite the deterioration in organisational safety responses.

## CONCLUSIONS

The present research provides evidence that in the dynamic construction project environment, the relative priority placed on safety by the project management tends to decrease over the life course of construction projects. It is likely that as a construction project progresses, adverse events arise and production pressure increases, leading the project management to direct their focus away from safety to production. The research suggests that it is important for construction project management to place a high priority on safety consistently over the life of a construction project, and consciously avoid inadvertently reducing the emphasis on safety, even when they are under pressure to keep production on schedule. The research also highlights the potential role played by supervisors in managing a positive safety climate in their workgroups. There may be great value in better understanding the role played by supervisors' leadership as an antecedent to group level safety climate and ultimately to group-level performance. The research also suggests the opportunities to further study cross-level relationships between managerial activities and locally experienced safety climates.

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# AN ESTIMATE OF FATAL ACCIDENTS IN INDIAN CONSTRUCTION

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The construction sector is very hazardous across the globe. However, in some countries there is an absence of standard recording and notifications system for construction accidents while in countries such as India, the systems exist but their implementation is an issue. In both cases, statistics on construction accidents are either unavailable or highly underreported and this leads to a situation where due attention to safety is not paid. This paper attempts to estimate fatal accidents of construction sector for all states in India. These estimates are based on reliable information derived for the construction sector of National Capital Territory (NCT) Delhi region using different sources. This study further projects the fatal accidents for all states based on working population data obtained from Census. The quantum of construction work in all states are differentiated based on their data on cement consumption using linear inter and extrapolation methods. In line with this estimate the minimum number of people that would have died annually in Indian construction sector from 2008 to 2012 was 11,614. The estimates presented here would help in drawing attention of all stakeholders to take remedial measures.

Keywords: estimating, accident, injury, safety, India

## INTRODUCTION

Safety is a basic physical and psychological need of human beings. Every day some 950 people die and over 720,000 workers get hurt because of occupational accidents. Annually, over 48,000 workers die because of occupational accidents in India and there are almost 37 million occupational accidents which causes at least 4 days' absences from work (Hämäläinen 2010). In terms of economics, the International Labour Organization (ILO) has estimated that the total costs of occupational accidents and work related diseases are 4% of the gross national product (GNP). The total GNP of the world was approximately 75,592,941 million USD in 2013 (World Bank 2013) which means that worldwide the annual cost of work-related injuries and diseases is approximately 3,023,718 million USD ( $0.04 \times 75,592,941$ ).

The construction sector is the second largest employer in India; however, according to Hämäläinen et al. (2010), accident statistics of the Indian construction sector are not properly and regularly published. Therefore, they are not easily available. However, it is expected that many fatal and non-fatal accidents would be happening in Indian construction due to its characteristics such as dynamic nature and involvement of

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many stakeholders including migrated labours in a project, and a less controlled environment. Whatever data is available our research shows that they are underreported (Patel 2015). Although, there is a system prescribed for compiling and recording these statistics the implementation at every places in country is not done in full seriousness. According to Zhou et al. (2015), this is one of the reasons for not conducting sufficient research on construction safety in India. Therefore, this study sets the following objectives: (1) to study the existing global and national accidents statistics of construction sector; and (2) to estimate the number of fatal construction accidents in India.

In the following sections, the review of existing literature on the subject and thereafter research method are presented to achieve the objectives. The different methods utilized to obtain the realistic estimate have been explained and thereafter the discussions and finally the conclusions are presented.

## **LITERATURE REVIEW**

Safety performance is generally measured by reactive (after the event) and proactive indicators (Hinze *et al.*, 2013). The choice of safety performance measures or indicators relies upon the purpose of measurement. The reactive measures are most suitable to be used for the evaluation of past safety efforts or for the purpose of comparison; while the proactive measures can be used to indicate whether the current systems or efforts are working properly (Hinze and Godfrey 2003; Holt 2005). According to Hale (2009), validity, reliability, sensibility, representativeness, openness to bias, and cost effectiveness are criteria to select good safety performance indicators. Hinze (2013) also suggests safety regulatory agencies, insurance companies and other companies to continue using the lagging indicators. However, sometimes, even reputed companies are not willing to share accident and injury data for their projects. The unavailability of accident statistics is a hurdle in conducting research on construction safety in India (Patel 2015).

In India, the estimated numbers of persons employed in Construction Industry are 53.45 million for year 2012 (Indian Labour Statistics 2012 and 2013) and there is a shortage of trained man power. On account of natural attrition and the need of skills of contemporary trades, construction industry still needs infusion of at least six million persons per year (CIDC report 2007). This clearly shows the importance and value of workers in construction industry and thus an inspiration to review the existing accident statistics of Indian construction sector.

In general, the tendency of constructors is to keep away from reporting accidents to the relevant authorities. Therefore, it becomes difficult to study the trend of accidents and review the safety performance of the construction sector at state and national level. As a result, it also becomes difficult to compare the safety performance of India with other countries. Nonetheless, Indian Labour Statistics (2012-2013) consists of the records of fatal and non-fatal accidents of mines, factories, railways. However, it does not include the estimates of fatal and non-fatal construction accidents. Therefore, there is a pressing need to estimate the fatal and non-fatal accidents in Indian construction sector.

## **FRAMEWORK OF THE STUDY**

Some researchers (Hämäläinen 2010, Nelson et al. 2005, Leigh et al. 1997) attempted to estimate the occupational accident and disease at global and national level. ILO (1996) emphasizes the estimation of occupation accidents and diseases and

has prepared a code to assist the countries to set the system to record the same. So far existing literature lacks the standard research methodology to estimate accidents in construction sector. Therefore, a framework of the study has been developed and discussed briefly in the following sections to estimate fatal accidents in the Indian construction sector.

### **Identifying and evaluating the list of sources for accident records**

A number of plausible sources were consulted for the accident data. These sources were identified based on past researches and interaction with experts and professionals. While some of them were part of direct approach some of them were indirect. A total of 10 different sources were employed for the data collection. These are briefly explained below under the data collection section.

### **Data collection**

As pointed out above, the data were collected and compiled from the following 10 sources.

25. National and International Journals
26. Websites of Government Departments and Private Bodies
27. Non-government organizations (NGO)
28. First Information Reports (FIRs) in Police Stations
29. Medical Legal Registers (MLR) at Public Health Centres and Hospitals
30. Insurance Companies
31. Right to Information (RTI) Act, 2005: The Right to Information (RTI) Act 2005 mandates timely response to any Indian citizen requesting for information from a government agency
32. Rajya Sabha: The Rajya Sabha or Council of States is the upper house of the Parliament of India
33. Leading newspapers
34. Online search engines

### **Review of the collected accident data**

There are no sound basis on which the accident statistics in Indian construction are reported in International and National Journals. Similarly there are limitations with the available Government (such as the concerned departments, ministries, and Rajya-Sabha) and NGO records as these records capture the data only for an incident which are reported. Police Stations do not sort and maintain the FIRs based on industry in India. All leading newspapers and online search engines do not cover all accidents. The Right to Information Act 2005 also has the same lacunae as under this Act the available data only need to be shared with general public.

In the global context, reporting of construction accidents to the relevant authorities varies among countries. Member countries of the European Union have mainly two types of system to record their occupational accidents: (1) an insurance-based system, public or private, or (2) legal obligation based system to notify accidents (Hämäläinen 2010). The reporting level is typically quite high - around 100 per cent in the insurance-based system, while the reporting level is only 30 to 50 per cent in reporting based on the legal obligation system. In India, the insurance companies and Medical Legal Register (MLR) do not consist of information regarding cause of accidents and the data is also not sorted industry-wise. In fact, due to lack of effective enforcement, accident data is still widely under reported in India. Even in the global context, there is huge underreporting in accident statistics. The accidents reported to ILO comprise

only 3.9% of the estimated number of accidents that have occurred across the world (Hämäläinen 2010). Leigh et al. (2004) have found that 33% to 69% of all occupational injuries were missing from the injuries reported in the USA. It means that under reporting accident data is the major global issue.

In the absence of a credible source, it was decided to make a beginning by relying on the reports published in prestigious newspapers and complementing it with the Right to Information Act. The data from the Delhi Metro Rail Corporation (DMRC) and Indian express seem more reliable due to their effective accident recording and reporting system. However, the collected accident statistics could not be generalized at national level as it is not able to reflect the full estimate of fatal and non-fatal accidents in Indian construction sector. Therefore, it needs to make a projection based on the reliable base and suitable method to estimate the accident statistics of construction sector at the national level.

### **Assumption and establishment of a baseline for the estimation**

The National Capital Territory (NCT) Delhi has been considered as the baseline for the national accident estimation. The capital of India, New Delhi is within this NCT Delhi. The NCT Delhi covers 1483 Square Kilometre (km) and has a population of about 16.78 million making it the second most populous city and second most populous urban agglomeration in India. Such is the nature of urban expansion in Delhi that its growth has expanded beyond the NCT to incorporate towns in neighbouring states. Since 1991, under the constitution of India, the NCT has been given special status as the National Capital Region (NCR) which includes the neighbouring cities of Gurgaon, Ghaziabad, Noida, Faridabad, Greater Faridabad, Greater Noida, Bahadurgarh, Sonapat, Karnal, Rohtak, Bhiwani, Rewari, Baghpat, Alwar, Bharatpur, Panipat, Meerut and other nearby towns. To manage the urban traffic of this territory, Delhi metro construction project is set up in year 2000 as a project of national importance and is funded partly by Japan International Cooperation Agency. The Delhi metro is the World's thirteenth largest metro system in terms of length and it is expanding its network in the NCR also. The DMRC has good accident recording system as it regularly collects, compiles, and reviews the accidents records of the Delhi metro rail construction projects. In fact, such is the importance of safety in this organisation that they have a separate contract conditions on safety running into about 100 pages. Moreover, in 2010, 19th Commonwealth Games (CWG) was held in the NCT Delhi. Therefore, a large number of construction projects were speedily completed before commencing that mega event in the NCT Delhi.

Arguably, accident statistics collected from the Indian Express newspaper and DMRC New Delhi appear more reliable than the remaining sources discussed earlier. The accident statistics of DMRC collected through the RTI 2005 Act is considered for the estimation due to its greater reliability. All these have led to consider the NCT Delhi as the baseline for the accident estimation for other states of India in this study.

### **Estimation of fatal accidents in the NCT Delhi**

As mentioned earlier, the accident statistics of the NCT Delhi has been estimated based on the Indian Express Newspaper reports and the records obtained through the DMRC under the RTI Act, 2005. Authors have referred all hard copies of the Indian Express newspaper from 2008-2012 and enlisted all of them to avoid their duplication from different sources. The accident report from the Indian Express Newspaper is categorised into three sources: (1) reports pertaining to projects of DMRC in the NCT Delhi (10 fatal); (2) reports pertaining to projects of Commonwealth Games (CWG) in

the NCT Delhi (43 fatal); (3) reports pertaining to other construction projects of the NCT Delhi (176 fatal) as shown in Table 1. In brief, from 2008 to 2012, a minimum of 229 fatal accidents would have occurred in NCT Delhi region alone based on the records of the DMRC and the Indian Express. However, the coverage of construction accidents by the Indian express may not be 100% as the Indian express has only reported a total of 10 fatal accidents in Delhi metro construction project as against the record of DMRC which says that a total of 56 fatal accidents occurred from 2008 to 2012 as shown in Table 1. It is assumed here that DMRC has covered all accidents. In other words, the Indian Express reported only 17.85 % fatal (10 fatal against 56 fatal accidents) accidents in the NCT Delhi during 2008-2012.

Therefore, using the linear interpolation method and rate of underreported accidents (17.85 % for fatal accidents), the data of 229 fatal accidents can be adjusted. Based on this adjustment, it can be safely assumed that 1282 ( $229 \div 0.1785$ ) fatal accidents would have occurred in NCT Delhi from 2008 to 2012. In other words, on an average, a minimum of 256 fatal accidents must have happened every year in the NCT Delhi between 2008 and 2012. Post analysis, safety personnel of few leading companies were contacted to comment on the results. On the condition of confidentiality, they agreed that they were not much surprised with this result as they were fairly in line with the statistics they maintain with them.

*Table 1: Actual and estimated fatal accident statistics of the NCT Delhi from 2008-2012*

Category Actual/ Estimated* Fatal Accidents (numbers)	Fatal Accidents (numbers) reported by The Indian Express	Actual / Estimated * Fatal Accidents (numbers)	Remarks
Reports related to projects of Delhi Metro Rail Corporation (DMRC) in the NCT Delhi	10	56	The underreporting percentage in fatal accidents is derived from the newspaper reported accidents and the actual accidents obtained from the DMRC using the Right to Information Act 2005.
Reports related to projects of Commonwealth Games (CWG) in the NCT Delhi	43	241*	
Accidents reports related to other construction projects of the NCT Delhi	176	985*	
Total of above for the NCT Delhi based on The Indian Express (five years)	229	1282	
Average Annual Value	45	256*	

*(\*These figures have been estimated based on the underreporting percentage which works out to be  $(10/56) \times 100\% = 17.85\%$  for fatal accidents.)*

### **Selection of parameters (working population, accident rate and cement consumption) for the estimation**

According to Hämäläinen (2010), number of total employment, Gross Domestic Product (GDP), urbanization, number of women, and time series analysis of developed countries could be useful to estimate the occupational accidents and work related diseases. To estimate the global estimate of the occupational accident, Hämäläinen (2010) used the accident rate of each country to its respective economical active population. However, as per the records available with Government agencies, under the BOCW 1996 Act, only 30,603 and 27,248 construction workers have been registered in central sphere across the country for the year 2011-12 and 2012-13

respectively. The figure for the NCT Delhi region as per the records is only 473 and 317 for the year 2011-12 and 2012-13 respectively. Registered workers can avail many financial benefits and perks under welfare scheme of the governments. Less number of registered workers reflects the non-availability of the sound record of the workers associated with construction sector.

The study requires estimating the number of workers employed in construction sector in various states in 2012 as the above statistics fail to reveal the number of workers employed in construction sector. However, working population is available as per record of census 2011 published by Indian labour Statistics (2012). According to the report of Planning Commission of India (2012), the projected share of employment in construction sector for the year 2011-12 is 10.91% and the growth rate of the population is estimated as 1.77% per year (Indian labour Statistics 2012). Based on this information, the working population in construction sector is estimated state-wise for the year 2012. As per this record, in the NCT Delhi region, 619,767 persons are employed while 53,455,595 are employed all over the country in the construction sector in 2012.

Hämäläinen (2010) formulated accident rates for India by using the rates for Kazakhstan and the total rates for Malaysia to fill up the missing gaps related to occupational accident data of India. In India, the fatal accident rates per 100,000 employees in agriculture, industry, and service sector is estimated 10.2, 26.4, 6.9 respectively for 1998 and similarly 9.5, 18.3, 5.2 respectively for 2001 (Hämäläinen 2010). However, this study does not report the accident rate of Indian construction sector. Moreover, India is a vast country and it has geographical and economical diversity among the states. Therefore, it becomes essential to consider the quantum of the construction works in each state. But estimation of the amount of the construction work in a state seems difficult using direct measures. Thus an indirect measure such as the consumption of cement state wise was adopted to estimate the quantum of construction work.

This is because cement is the basic construction material and is used mainly for the construction works. The data of cement consumption per year is available on the web portal of Cement Manufactures Association (CMA). The proportion of consumption of the cement is derived for each state. The NCT Delhi consumes 3.8 million tonnes (2.20%) out of the total consumption of 172 million tonnes at the national level. Maharashtra state consumes 19.57 million tonnes. This is the highest among all the states. It shows that Maharashtra has the maximum amount of construction works. In brief, for extrapolating, measures such as the number of construction workers and cement consumption are selected to estimate the fatal accidents in the Indian construction sector.

### **Estimation of fatal accidents in Indian construction sector**

The NCT Delhi has the total working population of 5,685,940 and so working population in construction sector is estimated to be 619,767 ( $=5,685,940 \times 10.9\%$ ). The construction sector of the NCT Delhi consumed 2.20% (3.8 million tonnes) of the total national cement consumption in 2012. Under these circumstances, the accident rate, 256 fatal accidents per year, is derived in the construction sector for the NCT Delhi region (refer Table 1). Considering this data, accident rate of each state and union territory can be calculated using the linear extrapolation and interpolation methods. For illustration, Jammu and Kashmir has a total population of 4,399,225 in which 479,516 ( $=4,399,225 \times 10.9\%$ ) working population is associated with its

construction sector and the cement consumption was 0.46 million tonnes in 2012. Comparing with the number of fatal accidents and working population of NCT Delhi, Jammu and Kashmir should have a minimum 198 fatal accident ( $= 256 * 479,516/619,767$ ) for the year 2012, assuming safety standards are similar to that followed in the NCT Delhi. Similarly, considering the consumption of cement by Jammu and Kashmir state, and the NCT Delhi, number of fatal accidents is estimated to be 31 ( $= 256 * 0.46/3.8$ ). Thus, as shown in Figure 1, the estimated fatal accidents of each state and union territory based on its consumption of cement and population associated with construction sector is shown in the left side (31) and right side (59) respectively within a small bracket on the map of India, such as Jammu and Kashmir (31/59).

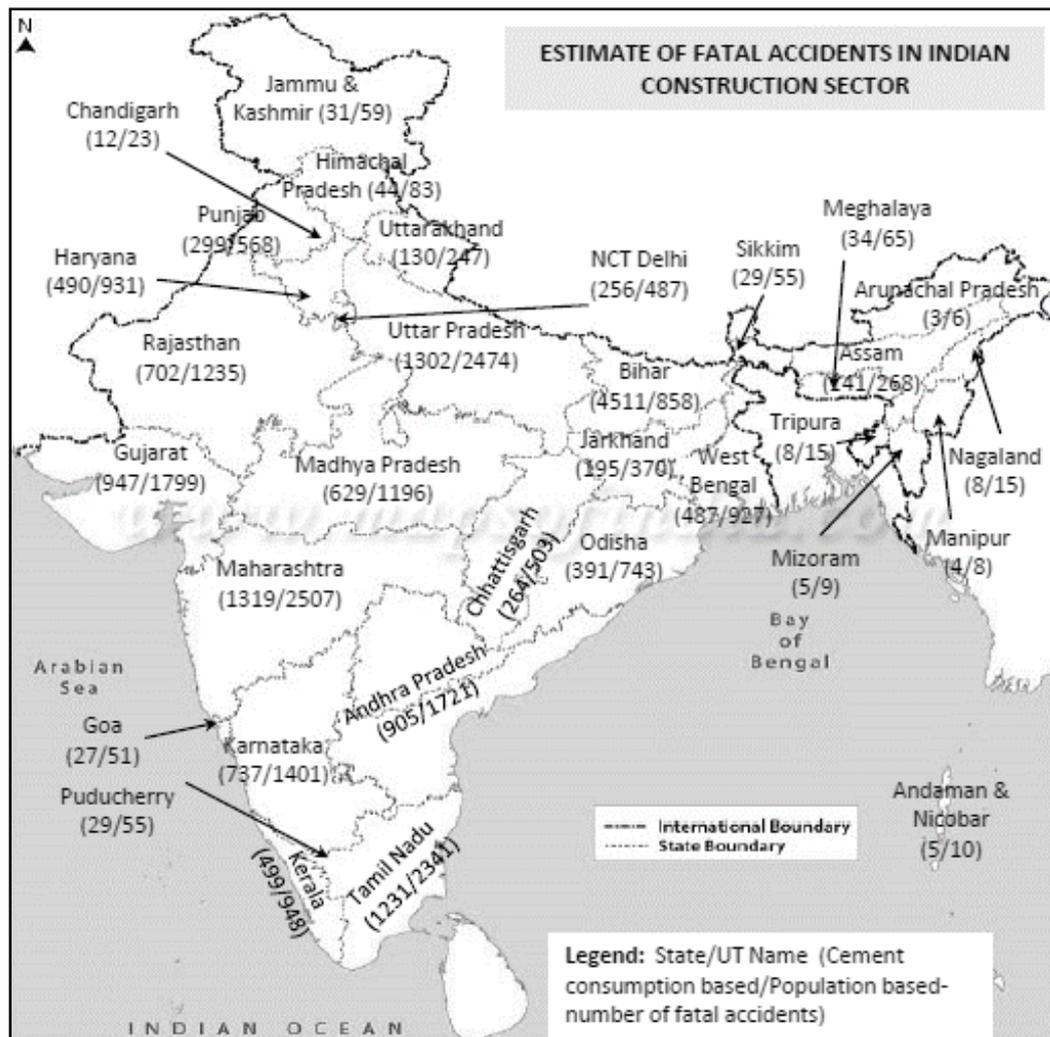


Figure 1. State-wise estimate of average annual fatal accidents in Indian construction sector from 2008-2012.

Based on this empirical analysis, in year 2012, approximately 11,614 and 22,080 fatal accidents might have occurred based on the consumption of cement and working population respectively in Indian construction sector. Estimate based on the cement consumption, 11,614 fatal accidents seems conservative because some construction projects may have activities where cement consumption may not be considerable, for example, excavation of lakes, construction of bituminous road, pipe laying, roofing work etc. Therefore, it is expected that the figure of real fatal accidents might be between 11, 614 and 22,080 in Indian construction sector. Thus, a minimum of

11,614 fatal accidents must be occurring in Indian construction. In other words, on an average 38 (=11,614/300 working days in a year) fatal accidents occur per day in Indian construction sector. Based on this data, the fatality rate (fatal accidents/1000 workers), of Indian construction sector works out to be 0.22. Indian Labour Statistics (2012 and 2013) estimates fatality rate of 0.24, 0.09, and 0.05 for coal mines, factories, and railways respectively. In terms of fatality rate, the data shows that the construction sector is second most hazardous in India. Although mining sector is the most hazardous in terms of fatality rate, it kills 84 persons as against the 11,614 minimum estimated fatal accidents in construction. This calls for adoption of stricter measures in construction.

## DISCUSSION

As mentioned earlier, a few researchers (Hämäläinen 2010, Nelson et al. 2005, Leigh et al. 1997) estimated the occupational accident and disease at global and national level. However, in the Indian construction sector, this study has followed a novel and simple approach to estimate fatal accidents in the absence of reliable accident statistics. The estimates of fatal accidents presented in the previous section show poor safety performance of the Indian construction sector. The occupational health and safety policy should be focused on in every region and all types of construction works. This estimate will be useful to state governments to recruit labour officers and supervisor to monitor safety issues regularly. The accident statistics of construction sector should be collected, compiled and published by some designated agency or government body in India. These data will be useful to analyse and differentiate the trend of accidents in different sectors and regions. Time series analysis of such data will be helpful to review the implementation of occupation health and safety policy of the state or nation. Further research can be conducted to find out causes of accidents. Although there is a provision of keeping records of accident from construction sector, its implementation is not enforced. Whatever data are available, they are not reliable and complete. Every state government has its own labour ministry and a labour officer is available at each district level. Central government has a national informatics centre at each district head quarter. So, government can use these facilities and make a data collection network to collect the data regularly. Government should register the information about causes of death in the death certificate also. Leading newspaper and TV channels, insurance companies, hospital may be linked to this network to provide or verify the relevant information about accidents. The data will be helpful to know the causes of accidents and accordingly new policy may be framed to prevent accidents in future.

This study attempts to estimate only fatal accidents in the Indian construction sector, because the media do not cover and report the non-fatal accidents in all seriousness. The extrapolation and extension of results for the non-fatal accidents may cause large error and lead to misleading insights.

Moreover, this study does not include the investigation of causes of construction accidents, identification and implementation of the preventive measures. Several assumptions have been made to estimate the figures of fatal accidents. For example, it has been assumed that the safety management systems applicable in the NCT Delhi would be there throughout the country. Cement consumption has been directly related to the amount of construction and so on. Safety culture of each state may vary and depend on rules and regulations of that state. These limitations can be addressed in

future study. There is always a room to refine the study and to estimate more accurately.

## CONCLUSIONS

Hämäläinen et al. (2010) estimated occupational accidents across the world. However, due to absence of a standard methodology to estimate accident statistics in the construction sector, this study attempted to estimate fatal accidents in the Indian construction sector. Generally many countries depend on their insurance sector and legislations to compile accident records. However, in India, insurance sector does not maintain such data separately for the construction sector and many accidents are under reported under legislations. Therefore, this study explores different types of sources where accidents statistics of construction industry may be available. Afterwards, this study relies on some reliable sources and estimates the fatal accidents for NCT Delhi region using linear extrapolation and interpolation methods. It extends derivation of the estimate at national level based on number of construction workers employed in states and their cement consumption.

As a result, in Indian construction sector, the number of people dying in construction could be anywhere from 11,614 to 22,080. Considering the minimum estimate of fatal accidents, i.e. 11,614, Indian construction sector alone adds 24.20% ( $=11,614 \times 100 / 48,000$ ) fatality in the total 48,000 occupational accidents occurring annually in India. The fatality rate (fatal accidents/1000 workers) of UK, Singapore, and Taiwan are reported to be 0.02 in 2013, 0.05 in 2012, and 0.125 in 2011 respectively in their construction sectors while fatality rate is estimated to be 0.22 in Indian construction sector as per this estimate. The comparison also shows the safety performance of construction industry in India in poor light in comparison to UK, Singapore and Taiwan. In fact, this estimate will draw the attention of various stakeholders of construction sector and motivate them to make safe work places and thus save the lives of workers.

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# FACTORS THAT PROMOTE ZERO FATALITIES, INJURIES AND DISEASE IN CONSTRUCTION

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For the past three decades, the idea that accidents, fatalities, injuries, and disease should be reduced to zero has been gaining traction in safety management research and practice. As most literature on zero targets focus on its application to industrial health and safety (H&S), there is a need to increase the knowledge of how it could be implemented in construction. This is more so that limited 'zero' findings have only focussed on its use in developed countries. To make a contribution from a developing country, a South African exploratory research survey was conducted among a convenience sample of 'better practice H&S' general contractors in 2015. The survey determined that people are the most important resource in an enterprise, and zero harm, incident, and accident that are anchored on 'respect for people' and 'continuous improvement', should be adopted as very important for a worksite in construction. The perceptions of the respondents in the study could be seen in the light of a theory, which indicates that people learn to behave in ways that lead to desired outcomes and they also learn not to behave in ways that leads to undesired outcomes. Furthermore, based upon Factor Analysis, six factors that promote fatalities, injuries, and disease were identified. In essence, if an outcome is set as 'zero', there is likelihood for members of an organisation to work towards it by incrementally decreasing accident and fatality rates in such a firm. If H&S statistics are to be believed, such a decrease is most needed in South Africa.

Keywords: fatalities, health and safety (H&S), injuries, zero

## INTRODUCTION

The overall aim of industrial H&S research is to define a 'safe' work site as one where injuries and fatalities constitute 'zero' sum (Young, 2014). In construction, contractors have adopted such targets in order to keep their workers safe and abide with regulations in a compliance-based H&S` environment (Wilkins, 2011). However, from limited information on its attainment, such a target is elusive. Case studies show that zero targets are goals that are difficult to attain. For instance, a New Zealand hazardous plant industrial study assessed the effects of such a target and noted that even though a firm focused on a 'zero target' for decades, accomplishment has been unclear for various reasons that manifest through hazard misunderstandings and misinterpretations (Young, 2014). Although the firm has recorded an astonishing reduction in lost time injuries (LTIs) owing to the use of the target, minor incidents have deprived the firm of complete success.

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Despite the expansion in the use of compliance-based H&S that supports programmes such as 'zero targets', construction H&S deviations are continually reported in South Africa (Construction Industry Development Board, 2009), where injuries and fatalities in the sector are excessively high when compared to other industrial sectors (Emuze and Smallwood, 2015). To amplify the need for a goal in the sector, the statistics from the main mutual compensation insurance provider in South Africa (Federated Employer's Mutual Assurance (FEM)) indict almost 50% of the industry with a record 2997 accidents in 2014 (Emuze and Smallwood, 2015). These accidents led to 54 fatalities and 377 permanent disabilities, which in turn, contributed 8129 lost days in 2014. Clearly, the goal of zero fatalities, injuries, and disease is not a reality at both industry and organisation levels, and as such, interventions that are beyond compliance-based safety are required in South Africa.

This paper is premised on the need to realise improved construction H&S, which is evident in an industry that could promote zero harm to its workers. The objective of this paper is to report on a study that explored the perceptions of contractors regarding the use of zero 'goals' / targets to improve H&S performance in South Africa. The study explored how important actions / beliefs / interventions / practices / states are in terms of achieving zero accidents, injuries, fatalities, and disease in construction, and their perceptions relative thereto and construction H&S in terms of concurrence with a range of statements.

As a way of introduction to the paper, the challenges of implementing zero targets are highlighted in the next section of the paper before a brief description of the primary data collection procedure is presented. The findings of the exploratory study are thereafter described and the discussion section compares the findings with the literature. The conclusion motivates for future case studies that would enhance knowledge regarding the use of zero targets in South African construction.

## **CHALLENGES OF ZERO TARGET VISIONS**

While the use of goals has been advocated because of improved H&S performance (Zwetsloot et al., 2013), a range of challenges exist in various contexts where such goals are supposed to eliminate hazards and accidents. Socio-technical work setting and negative effects of such goals constitute reported challenges. In terms of a socio-technical environment, multiple incident and accident causations are a major hurdle in an industrial setting similar to the one in a construction project. The BP incident of 2010 in an industry that have superior H&S programmes serves as an example. An excerpt from the BP report (2010: 31) is indicative of incident causation complexity with the quote: "The team did not identify any single action or inaction that caused this incident. Rather, a complex and interlinked series of mechanical failures, human judgements, engineering design, operational implementation and team interfaces came together to allow the initiation and escalation of accident."

Thus, multiple causal factors contribute to accidents and this perception can be seen in most incident investigation reports similar to the BP report. The BP accident occurred in an industry where large organisations are committed to goals in the form of 'zero harm', and 'zero accident vision (ZAV)', to mention a few. Such goals are often seen in company reports, policies, H&S manuals, and even websites where construction firms in the United Kingdom (UK) (and elsewhere, including South Africa) also indicate their commitment to higher standards of H&S (Rawlinson and Farrell, 2010). Even in less sophisticated industries, accident causation has multiple pathways. A forklift incident in Hafey (2015) is a case in point. According to Hafey (2015: 67),

"the incident that was investigated involved a forklift that slid on a wet floor in the shipping area of the plant. The initial focus of the investigators was the forklift driver and the speed at which he was driving. It was implied that he should have slowed down because he knew the floor was wet. By asking why five times I tried to steer them away from the person and toward the real root cause. Why did the forklift slide? Why was the floor wet? Where did the water come from? .....Are there different tires that would be more suited to wet conditions? Further analysis of the incident as reported by Hafey (2015) moved the focus away from the 'who' to the 'what' and 'why' questions, which in turn beamed the light on how the hazard should have been addressed (Young, 2014). These incidents show that setting goals is not enough in a socio-technical environment where a causation model for hazard-related incidents emphasizes the influence of organisational culture and the gaps that may exist in controls when H&S policies, standards, procedures, and the accountability system are insufficient (Manuele, 2014).

Dekker et al. (2015) in a response to the advocates of zero goals noted that goals may not necessarily mean a commitment to 'no accident' at all levels of severity and in fact, goals may conceal severe accidents and imply that near-misses and minor accidents are inevitable and required for making learning happen from everyday work failures in a complex socio-technical system. Excessive measurement, erudite data computations, and high bureaucratic systems backed up by regulations from compliance-based safety regimes are some of the reported negative effects of setting goals (Dekker, 2014; Hale et al., 2013). Although the bureaucratic accountability within an organisation has brought gains that are shown through reduction in harm, Dekker (2014) reported that it is generating concerns that run counter to the original goals. Such effects include the inability to predict unexpected events, the so called 'number games', the creation of new H&S problems, and many more. For instance, a study from Finland, which showed a strong negative correlation between incident rate and fatalities, implies that the fewer incidents that are reported from a construction site, the higher its fatality rate (Saloniemi and Oksanen, 1998). In fact, Dekker et al. (2015) citing other authors say that ZAV is yet to become mainstream because little is known about the exact activities and mechanisms that support the reductions in harm that committed companies have reported. In the construction industry, Sherratt (2014) also examined the practical realities of 'zero target' of construction H&S in the UK. The findings in Sherratt (2014), which are based on the information collected from five large contractors operating 'zero target' H&S programmes, show that 'zero' was viewed as a philosophy and a target with different interpretations in practice.

This section shows that there are protagonist and antagonist in the safety management research community with respect to zero targets. The next section briefly highlights the data collection procedure used for further exploration of the issues.

## **DATA COLLECTION**

The exploration of the issues was conducted to determine what can be learned from contractors in terms of using zero targets to eliminate fatalities and injuries in South Africa construction. The purpose of the exploratory literature and opinion survey is to develop pertinent propositions for additional inquiry (Yin, 2014). A convenience sample was used for the survey. The study was conducted not to generalise into a population, but to gain an understanding of the extent of the examined phenomena by measuring the perceptions of the workers within 'best practice H&S' general contractors (GCs) who had achieved a place in regional H&S competitions in South

Africa. The so called 'best practice H&S' GCs have consistently won H&S awards in the industry based on observed compliance during inspections, and reported low incident and accident rates. This intention is recognised in survey research that has moved away from conducting a broad overview to data collection techniques that fulfil specific needs (Andres, 2012). A sample consisting of twelve GCs was used for the survey based upon their commitment to H&S and hence willingness to facilitate the survey. The managing director or H&S coordinator in the respective firms circulated the questionnaire and returned same to the lead researcher / author. The questionnaire consisted of two close-ended five-point Likert scale type questions, and one open ended question. The combination of both closed ended and open ended questions in the instrument was done to ensure that the respondents are able to provide complete and accurate responses (Andres, 2012). At the end of the survey period, 92 responses were received, which were included in the analysis of the data. In terms of demographic information, the mean age of respondents is 39.8 years, the mean years worked for current employer is 5.5 years and in construction is 14.5 years, and 91.1% are male 8.9% are female. A total of 46 qualifications and 31 occupations were recorded. 64.8% of respondents were qualified with either a diploma or a degree. Contract manager (17.9%) and H&S Officer (10.9%) predominated among occupations.

## **RESEARCH FINDINGS**

Given that ordinal levels of measurement are characterised by rank, variables used in the survey were ordinal in nature as tabulated in Table 1 (Salkind, 2015). The computation of the findings was done with descriptive statistics and factor analysis. Due to page limit constraints, only the data for the factor analysis is displayed in Table 1 while the descriptive data is herein explained in paragraph format. The review of related H&S management literature led to the compilation of the 38 variables explored in the study. The analysis of the importance of 38 variables in terms of achieving zero accidents, injuries, fatalities, and disease in construction was done in terms of percentage responses to a five point scale of 1 (least important) to 5 (very important), and means scores (MSs) between 1.00 and 5.00. It is notable that all the MSs are > 3.00, which indicates that the recorded perceptions are very important as opposed to least important. It is also notable that 27 / 38 (71.1%) MSs are  $> 4.20 \leq 5.00$ , which indicates that the importance is between more than important to very / very important.

Furthermore, the first five have MSs > 4.60 i.e. in the upper half of the range. People are our most important resource is ranked first, followed by zero harm, which should be the goal if people are the most important resource. A goal of 'zero harm' is also accompanied by a goal of 'zero accident' ranked fourth, and a goal of 'zero incident' ranked fifth. A mission of 'continuous improvement' is ranked third, which is imperative in terms of the journey towards 'zero'. Consciousness and mindfulness ranked sixth is critical as the former implies cognising in terms of actually observing the environment and mindfulness in terms of realising the implications of the status quo or actions or omissions. H&S management system, and respect for people are ranked seventh and eighth respectively. The former provides the framework for H&S in an organisation, and the latter is necessary if 'people are our most important resource'. Design and construction hazard identification and risk assessments (HIRAs) are ranked ninth and tenth respectively and highlight the role of risk assessments in achieving 'zero'. Furthermore, in the case of the former it is the highest ranked designer action. A vision of a 'fatality, injury, and disease-free work place' is ranked eleventh, and influences the achievement of 'zero'. Furthermore, in the case of

the former it is the highest ranked designer action. Core competencies is ranked twelfth, which influence the achievement of 'zero'. Conformance to requirements, ranked thirteenth, relates to quality, and is a prerequisite for the achievement of 'zero'. However, quality management and Quality Management System are ranked twenty-fifth and twenty-eighth. Furthermore, the latter's MS is in the lower range. Adequate financial provision for H&S, ranked fourteenth, is client, contractor, and cost engineer related and is important in terms of resourcing H&S. Construction Management competencies (knowledge & skills) is ranked fifteenth, which indicates that managing construction H&S is an integral part of construction management. Client H&S requirements, and designing for construction H&S, are ranked sixteenth and seventeenth respectively.

The former is the highest ranked client action, and the latter is the second highest ranked designer action. Eighteenth ranked H&S specifications is the second highest ranked client and third highest ranked designer action. 'Design and construction' method statements is ranked twentieth, and is the fourth highest ranked designer action. A goal of 'Zero deviations' and the belief 'All accidents are preventable' are ranked nineteenth and twenty-first respectively, and influence the achievement of 'zero'. Client focus is ranked twenty-second and is the third highest ranked client action. Integration of design and construction, which is complementary to performance and both a project management and designer issue (fifth highest ranked designer action), is ranked twenty-third. Pre-contract planning, which is ranked twenty-fourth, primarily a contractor action. H&S training, and H&S education, which are ranked twenty-sixth and twenty-seventh, empower and enable workers, and supervisors and managers to conform to requirements. Their ranking is notable as they are perceived to be of major importance in terms of H&S performance. However, their MSs indicate that they are between more than important to very / very important.

The remaining 11 / 38 (28.9%) MSs are  $> 3.40 \leq 4.20$ , which indicates that the actions / beliefs / interventions / practices / states are between important to more than important / more than important. Constructability / Visualisation, which is ranked twenty-ninth, is the sixth highest ranked designer action. Environmental management system, and environmental management are ranked thirtieth and thirty-first. The practice 'H&S is a value, not a priority', and the belief 'Accidents are failures of management' are ranked thirty-second and thirty-eighth respectively, and both influence the achievement of 'zero'. Appropriate conditions of contract, appropriate procurement system, and project duration, ranked thirty-third, thirty-sixth, and thirty-seventh respectively, are all procurement related and influence H&S performance. The thirty-fourth ranking achieved by pretender planning ranked is notable as it is critical stage in terms of contractor planning for H&S. Similarly, the thirty-fifth ranking of tertiary education (all built environment) that includes construction H&S, as it will empower the built environment disciplines involved with projects to contribute to construction H&S.

Five design, all three client, and one procurement related actions' / beliefs' / interventions' / practices' / states' MSs are  $> 4.20 \leq 5.00$  (important to very / very important), and one designer and three procurement are  $> 3.40 \leq 4.20$  (important to more than important / more than important). To understand the analysed data better, factor analysis was conducted so that many variables could be described with a few factors. Factor analysis is essentially a method for investigating whether a number of variables of interest are linearly related to a smaller number of unobservable factors

(Tryfos, 1998). In factor analysis, the parameters of these linear functions are called loadings and there are an infinite number of sets of loadings that yields the same theoretical variances and covariances. Principal component method (PCM) that is widely used for factor analysis was adopted in this study because the method seeks values of the loadings that bring the estimate of the total communality as close as possible to the complete observed variances (Tryfos, 1998). The factor analysis identified six factors as presented in Table 1. The actions / beliefs / interventions / practices / states that have significant loadings have been identified by means of an \*.

Factor 1 (10 No.\*) includes respect for people, people are our most important resource, pre-contract planning, adequate financial provision for H&S, construction management competencies (knowledge & skills), core competencies e.g. values, aptitude, and integrity, environmental management, environmental management system, conformance to requirements, and H&S management system. Factor 2 (5 No.\*) includes a vision of a 'fatality, injury, and disease-free work place', a goal of 'zero deviations', a goal of 'zero incidents', a goal of 'zero accidents', and a goal of 'zero harm'. Factor 3 (9 No.) includes appropriate procurement system, appropriate conditions of contract, project duration, pre-tender planning, pre-contract planning, quality management system, environmental management, environmental management system, and tertiary education (all built environment) that includes construction H&S. Factor 4 (9 No.) includes client focus on H&S, client H&S requirements, H&S specifications, designing for construction H&S, design hazard identification and risk assessments, 'design and construction', method statements, integration of design and construction, constructability / visualisation, appropriate conditions of contract, and construction hazard identification and risk assessments. Factor 5 (6 No.) includes design hazard identification and risk assessments, 'design and construction' method statements, quality management system, H&S management system, H&S education - short learning programmes, and H&S training – workshops and seminars. Factor 6 (4 No.) includes people are our most important resource, integration of design and construction, constructability / visualisation, and consciousness and mindfulness.

The open ended question of the study produced 22 commentaries, which were subjected to qualitative content analysis in order to identify, enumerate and analyse specific messages embedded in the texts. Some of the respondents mentioned similar goals that are used by their firms. The mentioned slogans / goals include "home without harm, everyone, every day." Some insightful literal comments noted include:

- • Zero fatalities, injuries and diseases are achievable, but only if you have the commitment from your organisation and your labour force and that should also include your subcontractors and their management.
- • The 'basic' H&S 'guideline' that is currently seen as acceptable on South African sites is not strict enough to guarantee zero fatalities, injuries, and disease even if planned correctly. This is because H&S will always be planned up to what is acceptable as per the companies' H&S file. Anything more will be seen as slowing down production and a waste of company money. Unfortunately H&S will always come at a cost, whether its money or statistics.
- • A culture needs to be established in an organisation to live out their values. It should be the starting point in any business. It must be felt and leadership needs to walk the talk and talk the walk. It is about discipline and order in the workplace.

Table 1: Pattern matrix for the importance of actions / beliefs / interventions / practices / states in terms of achieving zero accidents, injuries, fatalities, and disease in construction

Action / Belief / Intervention / Practice / State	Loading / Factor					
	1	2	3	4	5	6
The belief 'All accidents are preventable'	.007	.289	.127	.083	-.148	.192
The belief 'Accidents are failures of management'	.115	-.127	-.056	.057	-.109	.191
Respect for people	.378*	.170	-.005	-.114	.018	.200
People are our most important resource	.443*	.281	.152	.051	.041	.423*
A vision of a 'Fatality, injury, and disease-free work place'	.045	.433*	-.024	.043	.022	.082
A goal of 'Zero deviations'	-.100	.452*	-.119	-.056	-.138	.179
A goal of 'Zero incidents'	.014	.737*	-.067	-.032	.033	-.190
A goal of 'Zero accidents'	-.002	.857*	-.063	-.112	-.006	-.150
A goal of 'Zero harm'	.000	.834*	.015	-.221	.014	-.077
A mission of 'continuous improvement'	.200	.265	-.199	-.037	-.097	.253
The practice 'H&S is a value, not a priority'	.033	-.087	-.232	-.030	-.055	.165
Client focus on H&S	-.001	.142	-.098	-.701*	.045	-.003
Client H&S requirements	.107	.062	.041	-.823*	.065	-.111
H&S specifications	.139	.063	-.067	-.737*	-.007	-.106
Designing for construction H&S	.054	.032	-.063	-.557*	-.028	.149
Design hazard identification and risk assessments	.008	-.008	.128	-.641*	-.416*	.073
'Design and construction' method statements	.061	.058	-.248	-.264	-.436*	.226
Integration of design and construction	-.067	.087	-.310	-.438*	-.029	.424*
Constructability / Visualisation	-.036	.061	-.216	-.596*	-.015	.397*
Appropriate procurement system	-.117	.175	-.765*	-.185	.061	.028
Appropriate conditions of contract	.146	.003	-.515*	-.491*	.181	.057
Project duration	.018	-.066	-.549*	-.148	.145	.069
Construction hazard identification and risk assessments	.055	-.053	.013	-.458*	-.271	-.019
Pre-tender planning	.246	.071	-.656*	-.058	.134	.231
Pre-contract planning	.505*	.052	-.500*	.096	.052	.090
Adequate financial provision for H&S	.620*	-.095	-.035	-.121	-.070	.100
Construction Management competencies (knowledge & skills)	.764*	-.155	.097	-.155	-.008	.019
Core competencies e.g. values, aptitude, and integrity	.493*	.125	-.267	.075	-.022	.162
Quality management	-.029	.146	-.717	.021	-.307	-.036
Quality Management System	.047	.127	-.733*	.035	-.363*	-.162
Environmental management	.495*	.000	-.514*	-.101	-.091	-.172
Environmental management system	.561*	.068	-.478*	.018	-.127	-.211
Conformance to requirements	.755*	.160	.109	-.155	-.169	-.122
H&S management system	.395*	.093	-.060	-.267	-.446*	-.133
Consciousness and mindfulness	.119	.007	.046	-.230	-.148	.501*
Tertiary education (all built environment) that includes construction H&S	-.016	.043	-.595*	-.049	-.231	-.075
H&S education – Short Learning Programmes	-.006	.110	-.066	-.068	-.644*	.033
H&S training – Workshops and Seminars	.196	-.052	-.122	-.049	-.688*	.083

## DISCUSSION

Sherratt (2014) noted that though illogicality and contradiction regarding the comprehension of what constitutes 'zero' exist; the concept of 'zero' should be a necessity for H&S management so as to improve construction practice. The suggestion of Sherratt (2014) resonates with the status quo of construction H&S in South Africa in terms of fatalities and injuries. In general, the perceptions of the respondents of this study point to the significance of the practices, and beliefs that were examined in the exploratory study. The respondents perceived that people should be the most important resource in an enterprise, and zero harm, incident, and accident that are anchored on 'respect for people' and 'continuous improvement', should be viewed as very important for a worksite in construction. Some of the

survey respondents also opine that zero fatalities should be pursued in the industry despite the 2014 statistics showing that 54 fatalities occurred in South African construction (Emuze and Smallwood, 2015).

The perceptions of these South African contractors reverberate with two industry examples from the UK. In the first example, Mottram (2005: 14) reported that an H&S programme helped a leading civil engineering firm ".to achieve almost unprecedented zero accident rate, and place the company in the top 1 percent of the UK construction industry for safety." A key lesson learnt on the road to the zero target achievement in the example is that training was instrumental in overcoming challenges and it also made individuals to think about safety at an earlier stage of work, and then make plans to minimize risk involved in tasks. In the second industry example from the UK, Pollitt (2006) reported that a building contractor achieved its target of zero accident through training and awareness initiatives involving its employees. In these two examples, the firms both made H&S a priority in their business plans and also raised its awareness throughout their enterprise.

In other words, the pursuit of zero goals or targets, which may appear to be difficult, could promote sustained efforts for a steady reduction in lost time injuries / lost days of productive work (Young, 2014) and the two examples from the UK that are almost a decade old give credence to the call to encourage zero goals / targets (Zwetsloot et al., 2013). The pursuit of zero goals could be supported by linking the performance of specific behaviours to the achievement of specific H&S outcomes since managers in the industry can motivate their colleagues to perform in ways that help the firm to achieve its goals (Teo et al., 2005).

This idea is based on 'Operant Conditioning Theory', which indicates that people learn to behave in ways that lead to desired outcomes and they also learn not to behave in ways that leads to undesired outcomes (O' Donohue and Ferguson, 2001). The role of training in modifying behaviour of workers is important in this context because a study has shown that increased durations of training are related to lower accident rates. As mentioned by Hare and Cameron (2011), if duration is accepted as a measure of extent of training, then it is possible to hypothesise that increased levels of training could lead to increased H&S performance. Apart from the work of Hare and Cameron (2011) that evaluated the factors contributing to superior safety performance, the two UK examples used in this section of the paper strongly mentioned the role of training in addressing H&S problems on the road to the attainment of zero accident rate by the construction companies.

To sum up this discussion, it is pertinent to understand the issues that surround the adoption or non-adoption of zero targets in construction through multiple views so that appropriate H&S management programmes can be engendered in the industry. Although subject to debates from multiple perspectives, a possible way forward is 'zero target'. Despite its vulnerability to multiple interpretations and understandings among project actors in the construction industry (Sherratt, 2014), the industry needs to set a standard that takes it to where accidents, fatalities, and injuries are not seen as business as usual. The two illustrated examples of a major reduction in fatalities through H&S programmes support this argument. Another recent example aligns with this idea. Wright (2012) reports that zero fatalities was recorded in the London Olympic project in which the Olympic Delivery Authority adopted a 'zero tolerance' approach to unhealthy and unsafe construction practices. This major project involves 12000 people, who worked for 80 million person hours in five years without a single

fatality despite the enormous mobility / logistic requirements of the project. The reality of the approach is the zero fatality H&S record; in spite of the non-attainment of 'zero harm' / 'zero accident' target (Sherratt, 2014). Furthermore, the Factor Analysis amplifies the need for a 'cocktail' of six factors consisting of a range of actions / beliefs / interventions / practices / states in terms of achieving zero targets.

## CONCLUSIONS

The surveyed contractors in South Africa acknowledge the importance of zero targets for the improvement of H&S performance. However, similar to the perceptions of a segment of the H&S management research community, some of the contractors are convinced that such goals are not attainable in practice because of certain conditions that have to be addressed. Such conditions are similar to the reasons why the realisation of ZAV is not widely reported in the industry. The findings indicate that achieving 'zero' requires a multi-stakeholder effort. Beyond multi-stakeholder effort, the use of 'zero target' to lower accident rates requires the implementation of training programmes specific to the challenges that would be encountered. The training programmes should be implemented so that they impact the culture in the work place in favour of lower accident rates.

The eradication of harm to people constitutes a critical aspect that provides the foundation to drive the 'zero' endeavour. As illustrated in the examples of firms that achieved ZAV in the UK and the factor analysis, it is important to set a goal that people could aspire to in a firm. Such a goal could be used to modify behaviour in favour of early hazard minimisation and improved H&S performance. The reported study is however not exhaustive and so, additional work is required to deepen research knowledge regarding 'zero targets' in South Africa. Case studies that document the implementation of 'zero targets' should be conducted to determine the reliability of these targets in order to advance the related agenda in South Africa. The case studies should endeavour to evaluate the implementation challenges and identify practices to be promoted, if there are success stories similar to the reported UK examples in South Africa.

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# SAFETY CLIMATE AS A MULTI-LEVEL AND DYNAMIC CONCEPT: EXPLORING THE VARIANCE AT DIFFERENT LEVELS OVER TIME

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Safety climate was measured longitudinally at a large-scale harbour expansion construction project. The project was commissioned by a single client and undertaken simultaneously by several principal contractors. Two waves of surveys measured participants' perceptions of safety at different levels, i.e. the client's safety response (CSR), the principal contractors' safety response (PCSR), and the supervisors' safety response (SSR). The results demonstrated significant between-site variance in workers' perceptions of PCSR and SSR in early project stage. However, at the later stage, the between-site variance was significant at all three levels. In contrast, the between-site variance in managerial/professional/supervisory personnel's perceptions of CSR and PCSR was significant both at the early and later stages. In this project, individual contractors implemented company-specific safety policies and procedures to meet the client's requirements. Moreover, supervisors locally implemented safety procedures using discrepant interpretations and context-specific action directives. Consequently, between-site variance was observed in PCSR and SSR. Due to the limited direct interactions with the client, workers may gradually form their perceptions of CSR through making sense of the project environment and interpreting safety messages conveyed by contractors and supervisors, causing between-site variance in CSR at later stages. The research provides preliminary evidence as to the impact of the characteristics of construction project organizational structures on shaping workers' perceptions about safety at various levels.

Keywords: dynamic, multi-level, safety climate.

## INTRODUCTION

### Safety climate

Hudson (2007) has suggested that the contemporary safety management efforts have moved into a 'culture stage', where the importance of cultural determinants of safety is emphasised. Safety culture has also been frequently identified, for example by disaster inquiries, as an underlying reason for an organization's success or failure in managing safety related aspects of its operations (Glendon and Stanton, 2000). Developing a positive culture for safety is seen as an important aspect of managing safety worldwide. For example, the Australian Work Health and Safety Strategy 2012 - 2022 establishes as one of its key action areas the need for 'Leaders in communities and organizations [to] promote a positive culture for health and safety' (Safe Work Australia, 2012).

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Previous research has recommended that organizations that aim to foster organizational cultures that support safety can use safety climate measurement to monitor progress and identify opportunities for improvement (Zhang *et al.*, 2015). Safety culture and safety climate are two theoretically different but related concepts. Drawing upon Schein's (1985) organizational culture model, Glendon and Stanton (2000) suggested that cultural influence on safety is a complex and multi-layered phenomenon and that at the deepest level, the basic assumptions which permeate the whole organization, influence safety. The basic assumptions are deeply rooted, unconscious, and unspecific (Guldenmund, 2000). Individuals who hold these basic assumptions are likely to take them for granted and may not be able to recognize or articulate their assumptions. Nevertheless, the influence of these basic assumptions is manifested in the two outer layers, i.e. the beliefs and espoused values shared by individuals regarding safety at the intermediate level; and the observed safety-related behaviours and artefacts (e.g. safety documents, rules and procedures; managerial and supervisory actions) at the surface level. The two outer layers are rooted in and logically flow from the basic assumptions, and are reflected in safety climate (Guldenmund, 2000). It is believed that cultural influences on safety are expressed through safety climate, which can be uncovered by measuring employees' attitudes or perceptions (Guldenmund, 2000; Glendon and Stanton (2000)). Flin *et al.*, (2000, p178) suggest safety climate represents the 'surface features of the safety culture discerned from the workforce's attitudes and perceptions at a given point in time'. Consistent with this, safety climate has been defined as 'a summary of molar perceptions that employees share about their work environments' (Zohar 1980, p 96).

### **Multi-level measurement of safety climate**

Safety climate can shape workers' behaviour through influencing the perception that workers form about how organizations reward and support safety (Lingard *et al.*, 2012). An increasing number of studies, conducted across various industries, have measured safety climate. Researchers in these studies expect to identify links between safety climate and safety-related behaviours and objective performance indicators (e.g. occurrence of incidents, injury rate). In the construction industry some studies have reported a significant link between safety climate and various aspects of safety performance (see, for example, Lingard *et al.*, (2012; 2010), Siu *et al.*, (2004), Zhou *et al.*, (2008)).

A recent study by Zhang *et al.*, (2015) highlighted that the majority of safety climate studies in the construction industry have used the 'organization' as the unit of analysis. This approach assumes that workers share homogeneous perceptions of safety roles and responsibilities across an organization. For example, Sui *et al.*, (2004) combined questions relating to workers' own safety attitudes with questions relating to colleagues', managers', safety officers' and supervisors' safety attitudes to create an aggregated safety climate score. However, Meliá *et al.*, (2008) suggested that safety climate should be differentiated at different levels in the construction environment. This is because the "safety agents" along the hierarchical construction supply chain (e.g. principal contractor, supervisor and workers) perform different safety responses, i.e. different safety activities or issues described in safety climate statements.

Consistent with Meliá *et al.*, (2008), there is empirical evidence showing that safety climate is formed at different organizational levels, and that the prevailing safety climate can vary significantly between organizational divisions or subunits (Zohar,

2000; Zohar and Luria, 2005; Lingard *et al.*, 2009, 2010). According to Zohar (2000), safety climate should be interpreted as a multilevel construct. It is argued that policies and procedures are established by top management at the organizational level and are executed by supervisors at the subunit level, therefore the formation of safety climate stems from two sources: 1) formal policies and procedures related to organizational level analysis; and 2) supervisory practices related to group level analysis.

Because of supervisors' discrepant interpretations and local implementation of formal procedures, the perceptions of supervisory practices formed by workers in different subunits are likely to be different. Lingard *et al.*, (2009; 2010) tested Zohar's multilevel climate conceptualization in the construction industry, and provided evidence that subcontracted work groups in construction projects reported different safety climates relating to supervisory practices. Lingard *et al.*, also noted that perceptions of supervisory practices could be distinguished from shared perceptions of the principal contractor's organizational safety response.

Zhang *et al.*, (2015) observe that the majority of safety climate studies in the construction industry only focused on contracting companies without considering the role of clients in fostering a positive safety climate in the construction projects that they procure. As initiators of construction projects, clients make decisions about the project budget, timeline, project objectives and performance criteria, which can create pressure and constraints that significantly impact safety in the construction process (Lingard *et al.*, 2008). It is anticipated that clients are in the best position to drive cultural changes that lead to positive safety outcomes. In fact, the impact of clients on safety behaviour and performance in construction projects has been noted in earlier studies. For example, Haslam *et al.*, (2005) identified client requirements as a causal factor imposing originating influence on construction accidents. Huang and Hinze (2006) reported that project safety performance can be greatly improved through a range of client-led initiatives, such as setting contractual safety requirements, participating in safety recognition programs, monitoring safety performance, funding safety initiatives and participating in on-site safety activities. Accordingly, Zhang *et al.* (2015) suggest that perceptions of the clients' safety response should be included as a distinct aspect of project-level safety climate in the construction project environment.

## **AIM**

The aim of the research was to explore the safety climate at different organizational levels over the life of construction projects. Safety climate was assessed in terms of participants' perceptions of the client's safety response (CSR), the principal contractors' safety response (PCSR), and the supervisors' safety response (SSR).

## **RESEARCH DESIGN**

### *Data collection*

Longitudinal safety climate surveys were conducted at a large-scale harbour expansion construction project. The project was to reconfigure and redevelop the container terminal and freight facilities. The project was commissioned by a single client and undertaken simultaneously by several principal contractors. Works included construction of a new container handling terminal, civil works and landscaping, wharf construction, dredging, and upgrade of roads and services. The total budget was 1.6 billion dollars. The project duration was estimated to be 4 years.

The project was divided into different work packages with a contractor in charge of each work package. From the early stages of the project, the client identified safety as a key deliverable of the project and tried to send a clear message about the importance of health and safety to the project participants. The client developed a safety charter for the project and specified safety objectives which were communicated to the contractors. Two waves of data collection were undertaken at three principal contractors' sites. The three work packages were selected based on the criteria that: 1) they included the majority of the construction work, 2) similar procurement strategy (design and construct) was used for the selected work packages, and 3) researchers were able to get access to the construction sites for the longitudinal data collection. The first round of surveys was conducted at the early stage of the project. The second round of surveys was undertaken between five to eight months after the first survey.

A multilevel safety climate measurement tool was used to longitudinally assess safety climate at the construction project. Suggestions from Meliá *et al.*, (2008) were followed for the development of the tool, i.e. the tool comprised safety climate statements to analyse safety climate from the perspective of safety agents who take responsibility for a particular safety activity/issue. The client's safety response (CSR) was assessed by the measure of general management commitment to safety which was developed for the UK Health and Safety Executive by Davies *et al.*, (1999). At the principal contractor level, the global organizational-level safety climate scale developed by Zohar and Luria (2005) was adapted to assess the principal contractors' safety responses (PCSR). At the group level, supervisors' safety responses (SSR) were measured using the scale developed by Zohar and Luria (2005). This scale covers different interactions between supervisors and work group members through which supervisors indicate the priority of safety in relation to completing goals.

In each of the construction sites, the surveys were administered using the 'TurningPoint' automated response system using 'KeePad' hand held devices. Survey questions were projected onto a screen one by one and read out by a facilitator.

*Table 1: Number of participants from each construction site in each wave of survey*

	Wave 1 survey	Wave 2 survey
Construction site A	Construction workers: 41 Managerial, professional and supervisory personnel: 11	Construction workers: 58 Managerial, professional and supervisory personnel: 30
Construction site B	Construction workers: 10 Managerial, professional and supervisory personnel: 8	Construction workers: 35 Managerial, professional and supervisory personnel: 17
Construction site C	Construction workers: 3 Managerial, professional and supervisory personnel: 20	Construction workers: 40 Managerial, professional and supervisory personnel: 36

Participants were required to press a number on the hand held devices to indicate their responses to the statement in each survey question against a 5-point scale ranging from '1 = Strongly Disagree' to '5 = Strongly Agree'. The responses were anonymously saved in a spreadsheet. Missing values were replaced by the mean score for the relevant question. Participants included construction workers and managerial, professional and supervisory personnel. The number of participants involved in each survey for each of the construction sites is provided in Table 1.

For each individual survey, a mean safety response score was calculated by averaging the mean scores for all items relating to each safety climate level. The mean safety response score is an indication of participants' perceptions of overall safety effort by

the safety agent at each level. Mean safety response scores included mean scores for client's safety response (CSR), principal contractors' safety responses (PCSR) and supervisors' safety responses (SSR). Participants were divided into two groups: 1) construction workers, and 2) managerial, professional and supervisory personnel including senior managers, project managers, site managers, engineers and foremen. Separate mean safety response scores were calculated for each group.

#### Data analysis

The mean safety response scores derived from the two waves of the survey were plotted to graphically represent the data, and to compare the mean safety response scores at each level across the three construction sites. In addition, one-way analyses of variance (ANOVAs) were performed to assess whether the safety response differences between the construction sites were statistically significant at each level. Separate ANOVA analyses were performed for each of the participant groups.

## RESULTS

### Workers' perceptions of client's safety response (CSR)

Figure 1 shows the mean scores for workers' perceptions of the client's safety response (CSR) obtained from the two waves of survey at each of the three construction sites. The data indicates that workers' perceptions of the CSR generally declined in two construction sites (sites A and B) and improved in construction site C between the measurement periods. In addition, the value of mean scores for CSR in different sites ranges from 3.67 to 4.18 in the first survey and from 3.30 to 4.16 in the second survey. So, the range of values of CSR mean scores is larger in the second survey than the first survey. The one-way ANOVA indicated that the between-site variance in workers' perceptions of CSR was not statistically significant in the first round of surveys; however, the between-site variance in CSR became statistically significant in the second-round survey ( $F(2, 130) = 19.661, p = 0.000$ ).

### Managerial, professional and supervisory personnel's perception of CSR

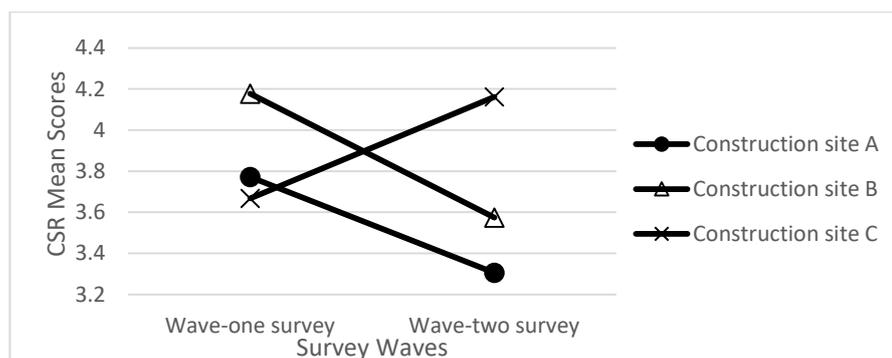


Figure 1: Comparative scores for workers' perceptions of CSR

Figure 2 shows the mean scores for the managerial, professional and supervisory personnel's perceptions of client's safety response (CSR) obtained from the two waves of survey at each of the three construction sites. The data indicates that the trends of change in managerial, professional and supervisory personnel's perceptions of CSR between the two waves of survey were similar to changes in workers' perceptions of CSR, i.e. the data shows a decline in perceptions of CSR for sites A and B and improvement in perceptions of CSR for site C. The one-way ANOVA indicated that the between-site variance in managerial, professional and supervisory personnel's perceptions of CSR was statistically significant in both the first-round ( $F$

(2, 36) = 3.567,  $p = 0.039$ ) and the second-round surveys ( $F(2, 80) = 8.183, p = 0.001$ ).

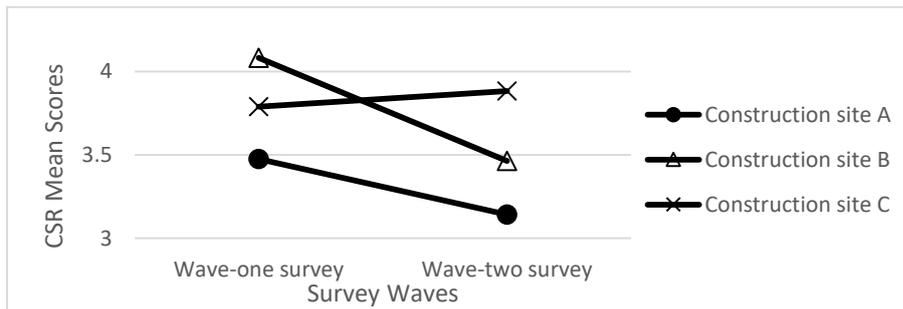


Figure 2: Comparative scores for managerial, professional and supervisory personnel's perceptions of CSR

### Workers' perceptions of principal contractor's safety response (PCSR)

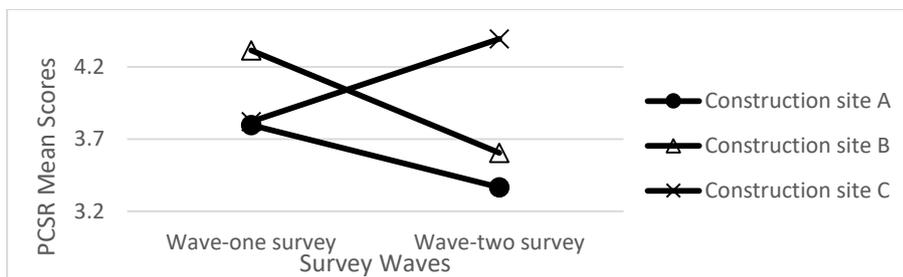


Figure 3: Comparative scores for workers' perceptions of PCSR

Figure 3 indicates the mean scores for workers' perceptions of principal contractors' safety responses (PCSR) obtained from the two waves of survey at each of the three construction sites. The data indicates that workers' perceptions of the PCSR showed a similar trend to changes in the CSR; that is, workers' perceptions of the PCSR declined at two construction sites (sites A and B) but increased at site C. In addition, the mean scores for the PCSR range from 3.80 to 4.32 in the first survey and from 3.37 to 4.40 in the second survey. So, the range of values of PCSR was larger in the second survey than the first survey. The one-way ANOVA indicated that the between-site variance in workers' perceptions of PCSR was statistically significant in the first round of surveys ( $F(2, 51) = 3.452, p = 0.039$ ) and in the second-round survey ( $F(2, 130) = 45.127, p = 0.000$ ).

### Managerial, professional and supervisory personnel's perception of PCSR

Figure 4 indicates the mean scores for the managerial, professional and supervisory personnel's perceptions of the principal contractors' safety responses (PCSR) from the two waves of survey at each of the three construction sites. The data indicates a decline in the perceptions of the PCSR at sites A and B and an improvement at site C. The mean scores range from 3.60 to 4.22 in the first survey and from 3.43 to 4.33 in the second survey. In addition, the one-way ANOVA indicated that the between-site variance in managerial, professional and supervisory personnel's perceptions of the PCSR was statistically significant in the first round of surveys ( $F(2, 36) = 4.256, p = 0.022$ ) and in the second round of surveys ( $F(2, 80) = 14.474, p = 0.000$ ).

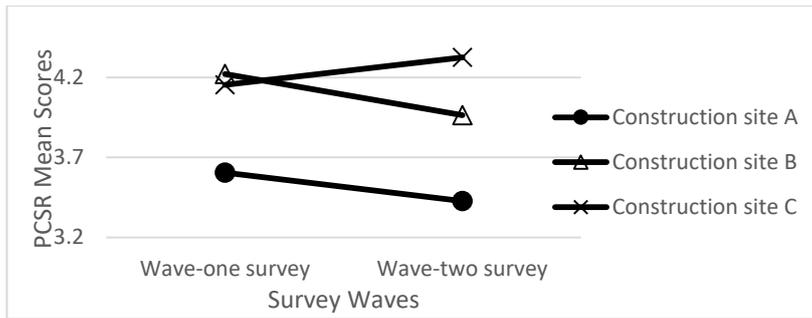


Figure 4: Comparative scores for managerial, professional and supervisory personnel’s perceptions of PCSR

### Workers’ perceptions of Supervisors’ Safety Response (SSR)

Figure 5 shows the mean scores for the workers’ perceptions of their supervisors’ safety responses (SSR) obtained from the two waves of survey at the three construction sites. The data indicates that workers’ perceptions of SSR declined at two sites (sites A and B), and this decline was more dramatic at site B than at site A. In contrast, workers’ perceptions of SSR improved at site C. The mean scores for perceptions of SSR range from 3.65 to 4.25 in the first survey and from 3.32 to 4.26 in the second survey; thus, the range of values of SSR scores was slightly larger in the second survey than the first survey. The one-way ANOVA indicated that the between-site variance in SSR mean scores was statistically significant in both the first survey ( $F(2, 51) = 3.651, p = 0.033$ ) and the second survey ( $F(2, 130) = 21.725, p = 0.000$ ).

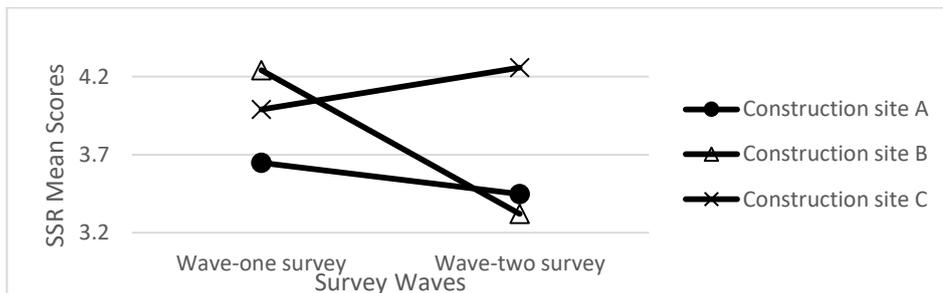


Figure 5: Comparative scores for workers’ perceptions of SSR

### Managerial, professional and supervisory personnel’s perception of SSR

The data in relation to managerial, professional and supervisory personnel’s perceptions of SSR was excluded from this study. This is because the managerial, professional and supervisory personnel in each site attended the same survey sessions as the workers and answered the same survey questions. The survey questions in relation to CSR and PCSR clearly asked about participants’ perceptions of the client and the principal contractors’ safety behaviours. Consequently, both the construction workers and the managerial/ professional/ supervisory personnel expressed their perceptions of the same concept as the client and the principal contractor were the same for all the participants from each construction site. However, the questions in relation to SSR asked participants’ perceptions of their supervisors’ safety behaviour. For the purposes of data collection, the research applied a definition of ‘supervisor’ as the person who gives day to day instructions to the participants in work. Thus, each of the professional/managerial/supervisory personnel could potentially have answered these questions in relation to a different person (depending on their level and position

within the organizational structure). As such, it was inappropriate to aggregate this data to reflect a shared perception of safety climate among this group.

## DISCUSSION

### Safety climate reported by workers

The research results demonstrate that at the early stage of the project, the between-site variance in the safety climate reported by workers was only significant at the lower levels (i.e. the principal contractor and the supervisor levels), but not at the higher level (i.e. the client level). However, at the later stage, the between-site variance in the safety climate reported by workers was significant at all the three levels. This could potentially be explained by the characteristics of project organizational structures in the construction industry. Specifically, in a hierarchical multi-level construction project organization, the workers have few opportunities to directly interact with the client. Therefore they are likely to form their perceptions of the CSR through perceiving the general safety atmosphere (e.g. the client's safety slogans and promotional materials posted around the site) at the project and interpreting safety messages transmitted by the principal contractor to understand the client's safety expectations. At the early stage of the project, workers at different construction sites appear to have developed homogeneous perceptions of CSR, possibly because they received similar safety messages and developed similar beliefs about the safety expectations set by the client for all three principal contractors working in the project.

Despite establishing a single over-arching safety framework for the project, the client left decisions about the way that this vision was operationalized to each of the principal contractors. Thus each of the principal contractors established their own safety policies and procedures to address the client's safety expectations. This may explain why workers at different construction sites developed different perceptions of their principal contractors' safety response (PCSR), even when it was in the early stage of the project. It is also possible that the between-site variance in the perceptions of PCSR contributed to the larger between-site variance in workers' perceptions of CSR in the later stage. It is possible that, as the project progressed, workers began to notice gaps between the slogans and statements made by the client and the way that safety policies and procedures were being operationalized at a local level.

These gaps may have modified their perceptions of the CSR over time, particularly as the client project management team placed greater emphasis on project schedule performance. There is a substantial body of research that suggests higher levels of safety climate have a shaping influence on lower levels of safety climate (see for example, Brondino *et al.*, 2012; Zohar and Luria, 2005). However, one explanation for the findings of this research is that workers may interpret a client's safety expectations through their perceptions of the principal contractors' safety activities and priorities. Furthermore, the research results indicate that workers at the different construction sites had significantly different perceptions of their supervisors' safety responses (SSR) in both waves of the survey. This variation may be due to differences in the local implementation of safety policies and procedures within workgroups, with supervisors possibly using discrepant interpretations and context-specific action directives (Zohar, 2000). Similar research findings in relation to SSR have been reported in previous studies in the construction industry (see, for example, Lingard *et al.*, (2009)).

## **Safety climate reported by professionals**

Compared to construction workers, managerial/ professional/ supervisory personnel have more direct interactions with client personnel (e.g. in project management team meetings, formal and informal project communications, client site walks etc.). The research results revealed that managerial, professional and supervisory personnel at the different construction sites developed different perceptions of the CSR through various interactions, even from the early stages of the project. Unlike workers, site professionals do not merely perceive CSR by receiving indirect - often highly visible and generic - safety messages. In this project, although the client attempted to set similar safety requirements and expectations for all the principal contractors, professionals working in these principal contractor organizations appeared to reflect different understandings about what the client expected in terms of safety. Previous research indicates that what the senior managers “really want” is not always consistent with what is stated in official safety documents (Clarke, 1999). It is possible that the client at this project communicated mixed messages about the relative importance of safety to managerial, professional and supervisory personnel during their interactions. Also the research results show that managerial, professional and supervisory personnel at the different sites developed different perceptions of their own organizations’ (i.e. the principal contractors’) safety responses throughout the project. This difference, again, is potentially explained by variation in the way that the clients’ safety framework was operationalized by the three principal contractors.

## **CONCLUSIONS**

Safety climate is a complex and multi-level construct. In construction projects, there is evidence that safety climate is formed at different organizational levels, and can vary significantly between organizational divisions or subunits. At a high organizational level, the role of clients in fostering a positive safety climate has been highlighted. This is because clients are the initiators of construction projects and their decisions can significantly impact safety in construction process. Similarly, research evidence suggests that the higher level safety climate filters down and has a shaping influence on lower level safety climates. However, the present study suggests that over time, the relationship between the higher level safety climate and the lower level safety climate may, in fact, work in the opposite direction in construction projects. The research provides preliminary evidence that the characteristics of construction project organizational structures may shape workers’ perceptions about the relative safety priorities of players at various levels. It highlights the potential for the local operational implementation of policies and procedures to modify perceptions of a client’s global safety priorities over time.

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# SHIELDING WORKERS FROM HEAT STRESS: RECONCILING THE PARADOXES OF PROTECTION AND PRODUCTION LOGICS

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Safety and productivity are often perceived as competing demands in a construction project organisation and the strategies of achieving them as a dilemma for project decision-making. We explore the safety-productivity paradox through an institutional logics lens. Through an in-depth single case study of climatic heat stress management in a subcontractor's project organisation under a mega-project in north Australia, the manifestations, consequences and interrelations of three institutional logics of processing safety in production are explored: the protection logic, the production logic and the reconciling logic. The results illustrate the paradoxical effects of the protection logic and the production logic and the emergence of a reconciling logic leading to innovation that improves both safety and productivity. However the reconciling logic is missing at senior and middle management levels of the production side of the organisation, and overwhelmed by the strong production logic. It is concluded that the reconciling logic can be further established and endorsed through adjusting the structure and modification of the production and human resource management system.

Keywords: Australia, climatic heat stress, construction safety, productivity, institutional logics

## INTRODUCTION

Safety and productivity are often perceived as competing demands in a construction project organisation and the strategies of achieving them as a management paradox (Lewis and Smith, 2014) which is to be solved through conscious balance in senior management decisions (Smith and Lewis, 2011). However, questions as why members of an organisation are collectively blinded to one issue or another, why efforts of balancing goals do not necessarily lead to effective mitigation of risks, why actors in the system are bounded to an either-or repertoire of coping strategies, and what leads to reconciliation of safety and productivity in construction, remain unanswered. We seek to explain these issues through an institutional logics perspective and identify the manifestation of a reconciliation logic through the investigation of managing climatic heat stress risks on an Australian construction site.

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Climatic heat stress risk is a challenge to both safety and productivity on construction projects for its physiological effect on declining physical capacity and mental alertness (Parsons, 2014), leading to declining productivity or heat illness or accidents on site. Recent research reported an annual labour productivity loss of AU\$6 billion in Australia due to climatic heat stress (Zander *et al.*, 2015). However, despite readily available guidelines to manage it (e.g., AIOH, 2013), the Australian construction industry is surprisingly ignorant to this issue and there has been very little research in this area to inform project management strategies. We address this gap and, through investigation of its management on site, identify factors constituting a logic that reconciles safety and productivity in a project organisation.

Institutional logic is the underlined reasoning schemas that provide meaning, connection, justification and consistency to the practice and discourse of organisational and individual actions (Thornton *et al.*, 2013, Thornton and Ocasio, 2008). It focuses actors' attention around some problems (and therefore blinds them from the rest), determines how the actors collectively define the problems that are worth attention, and pre-defines a repertoire of solutions (Thornton, 2001, Thornton, 2004). Concerning how safety is processed in the production system of construction projects, Jia *et al.*, (2015) explicated two organisational level institutional logics that underpin actors' cognitions and actions: a protection logic and a production logic. The protection logic assumes safety and work are mutually exclusive and workers' welfare is to be achieved through sacrificing productivity. Such logic was seen in developing countries where construction sites have not yet established a safety management infrastructure. In the developed countries such as the Australian context, this logic remains underpinning the discourses and actions of certain stakeholder's groups, such as the workers' unions.

The production logic assumes production is the business of a construction project while safety is an institutional burden that needs to be cleared up with minimum attention. Such logic was seen in societies where formal institutions and regulators actively control the OHS responsibility of employers while employers strive for production to survive the market. Both logics assume a dialectic between safety and productivity, bounding project teams in an 'either-or' dilemma that demands actors' decision of selection or prioritisation, yielding paradoxical outcomes. Solution to such paradoxes involve a shift from 'either-or' to 'both-and' cognitive frame and a strategic focus on innovation (Smith and Tushman, 2005) that draws inspiration from the redefined problem 'how to do the work safely and productively', seeing safety as an attribute of the production system that indicates its fitness-to-operate (Griffin *et al.*, 2014). We define such an institution-making logic that assumes an integrated safety-productivity premise in an organisation as a reconciliation logic. An organisation accommodates multiple logics (Besharov and Smith, 2014). The three institutional logics coexist and compete in a construction project organisation and their manifestation. One can prevail at certain stage of a project (e.g., the production logic often prevails when the project is behind schedule) or upheld by certain groups of stakeholders in the project.

An institutional logic is to be differentiated from a strategic decision made by an organisational leader (Smith, 2014) in that institutional logic is socially and collectively constructed by all levels of actors and the structures of organising them, thus has a more effective influence on the outcome, while the latter is one of the factors that constitute the former and can be distorted when the middle management and frontline personnel are exercising a different logic (Durand *et al.*, 2013).

Different from an organisational strategy in the form of organisational policy or senior management decisions, institutional logic is constituted by policies, regulations, management infrastructures, rules, norms, and established practices in the institutional environment throughout a project organisation. Recently, paradox theorists shift their search of solutions from senior management decisions to the multiplicity of institutional logics within an organisation (Besharov and Smith, 2014). The aim of this study is to explore the manifestation and consequences of the multiple institutional logics of processing safety in production and, in particular, the presence and absence of the reconciliation logic at different levels of a construction project organisation that helps to solve the safety-productivity paradox.

## **METHODOLOGY**

The empirical research was conducted with a single case study approach using a triangulated data collection strategy from three major data sources: on-site ethnographic data, documents, meteorological data and off-site interviews.

### **Data collection**

The selected case was a subcontractor's project organisation in a mega-project. The project was the construction of oil and gas on-shore processing facilities, located in North Territory of Australia, a climate zone of hot and humid weather. The project started in 2009, valued AU\$34 billion, and is expected to complete in 2020. In total there were around 8,000 workers working on site every day.

The sub-contractor's company had around 22,000 staff and an annual avenue of 1.4 billion Euro in 2015. In this specific project, the subcontractor was working on the scaffolding work with a main workforce of 120 scaffolders. Four supervisors rotated to maintain the presence of three on site. Each of the three teams was divided into four groups of ten, headed by a Leading Hand (workers' leader). In the site office was the project management team, including senior management team (Project Director, Project Manager, HSES Manager, Construction Manager, Commercial Manager, HR Manager, Estimation Manager, Engineering Manager, etc.), HSE advisors, engineers, supervisors and administration staff.

The main data source was ethnographic data collected on site over a working week in late September 2015. One of the research team members was the Health, Safety, Environment and Security (HSES) Manager of the subcontractor's organisation. He acted as a gatekeeper and an informant for another academic researcher to come on site for a rapid ethnography (Pink *et al.*, 2013, Loosemore *et al.*, 2015). The rapid ethnography was guided by a central interest of understanding the organisational structure, safety, procurement and human resource management system, production work flow as the institutional context of heat stress management practice. The collected data included field notes of participant observation (Goffman, 1989), informal focus groups with three scaffolders' groups and one riggers group working in material storage yard, and 22 informal interviews (interviewees included a quality manager, a commercial manager, HSES manager, two safety advisors, a safety and environment advisor, senior safety advisor, HR administrator, engineer, two site supervisors, a procurement administrator, a lean construction advisor, a safety campaign coordinator, and eight scaffolders). In addition, documents related to this project were collected, including project meeting minutes and policy statements, project Enterprise Bargaining Agreements (EBA), heat stress policy by Construction Forestry Mining and Energy Union (CFMEU), company and project profiles. Finally,

heat stress data including temperature, humidity, wind speed and solar radiant heat were recorded at one-minute interval; meteorological data were obtained from the nearest observatory station.

### **Measurement of heat stress**

Climatic heat stress is composed of four factors: temperature, humidity, radiant heat and wind speed. These four factors can be synthesized into one single index, the Wet Bulb Globe Temperature (WBGT), to give a realistic measurement of the ‘hotness’ of the environment (Rowlinson *et al.*, 2014, Parsons, 2006). Air temperature is often taken for granted by the general public as a single indicator of heat stress, and is used in many empirical guidelines that are lack of a research base, such as the CFMEU heat stress policy analysed in this study (CFMEU QLD NT, 2015). The problem with single-indicator measurement is that they do not necessarily reflect the heat stress level of workplace, thus lead to either unnecessary productivity loss or unmitigated risks. Apart from the climatic heat, the metabolic heat generated by physical activities contributes a significant amount of heat stress on human body. In the construction work setting, metabolic heat is determined by workload, work pace and continuous working time (Rowlinson *et al.*, 2014), which are linked to both formal and informal aspects of management and supervision. Moreover, whether or not heat illness occurs to a person in a hot environment is contingent on many individual factors such as hydration status, fatigue and psychological stress (Jia *et al.*, 2016).

### **Productivity analysis**

Productivity can be measured by labour productivity, capital productivity, multi-factor productivity or total-factor productivity (Loosemore, 2014). In this study we analysed labour productivity against two threshold-based heat stress guidelines, the temperature-based CFMEU heat stress policy as a manifestation of the protection logic, and the WBGT-based, scientifically developed guidelines by American Conference of Governmental and Industrial Hygienists (ACGIH, 2014) as a benchmark of the actual effect of heat stress. The quantified productivity analyses results were used as triangulation to the interview and observation data, the former used under the protection logic and the latter under a reconciling logic.

The CFMEU policy specifies a set of thresholds linked with actions of reducing daily working hours or increasing breaks. This formal institution was used as a materialisation of the protection logic, examined against the 2015 meteorological data to estimate the annual productivity loss assuming a situation if it was literally implemented. The WBGT-based thresholds for moderate level of physical work specified by ACGIH (2014: 215) were used for estimating the productivity effect of a safety initiative of shading the workplace: The direct effect of a shade is to block the solar radiant heat, thus reducing the overall heat stress. We used our on-site heat stress data recorded at one-minute interval in the material storage yard on 30 September 2015 as a sample to calculate the productivity levels with and without the radiant heat. The threshold systems specified in the two guidelines can be seen in Table 1.

### **Synthesis and validation**

The different data sources were triangulated to construct an authentic case of site practices in relation to the management of heat stress. The factual data were then crosschecked with the HSES Manager in the research team. The authenticated case was then coded with the Six-C coding scheme, i.e., cause, consequence, condition,

covariance, context, and contingent (Glaser, 1978: 74), centred on the three institutional logics.

Table 1. Work-rest regimens in two heat stress guidelines for productivity analysis

Daily maximum temperature	CFMEU heat stress policy		ACGIH heat stress guidelines	
	Suggested rest period	Hourly average	Suggested workload	
Over 30°C	Keep an 8-hour working day	28°C-WBGT	75-100% work	
30 to 32°C	10 Minutes/Hour	29°C-WBGT	50-75% work	
32 to 35°C	15 Minutes/Hour	30°C-WBGT	25-50% work	
More than 35°C	At least 30 Minutes/Hour	31.5°C-WBGT	0-25% work	

The coding results were clustered and organised into episodes to illustrate the institutional logics. The results of the study were validated by referring back to the actors, including a follow-up interview with two union leaders off-site and written and verbal communication with the project management team.

## FINDINGS

### The paradoxical effects of the protection and production logics

- *Paradox 1: A strong protection logic leads to exposure to risks*

Underpinned by a logic of protecting workers' financial interests, the enterprise bargaining agreement (EBA), negotiated between the unions and the employer specified a 58 hour working week, which demanded 10 hours' work on a weekday and 8 hours' work on Saturday. The long working hours did secure workers a higher daily wage than the industry average, however, taking into account of three hours' daily travelling time, workers were inevitably exposed to a major risk of fatigue, a precursor of heat illness and other accidents.

In the same protection logic, the CFMEU heat stress policy suggesting a work-rest regimen based on daily maximum temperature. Table 1 presents the analysis results of its productivity impact using Darwin's 2015 meteorological data. If this policy had been enforced, the foreseeable productivity reduction would be 24.6%. With the workforce of 120 scaffolders, subcontractor's project organisation would expect 102,160 working hours' loss a year. This foreseeable productivity loss is obviously unaffordable for a project organisation. Moreover, in the Australian social context, a specific worry of the employer was that workers might take advantage of the rest period duration, leading to even greater loss in productivity (M01, M03). As a matter of fact, the policy was ignored in practice. The climatic heat remained a risk on site.

Table 2. Estimated 2015 labour productivity loss according to CFMEU heat stress policy

Daily maximum temperature	Suggested rest period	Affected work days	Foreseeable lost working hours (per worker)
Over 30°C	Keep an 8-hour working day	212	424
30 to 32°C	10 Minutes/Hour	127	169
32 to 35°C	15 Minutes/Hour	127	254
More than 35°C	At least 30 Minutes/Hour	1	4
Total lost work hours (120 scaffolders)			102,160
Estimated productivity loss			24.7%

- *Paradox 2: A strong production logic leads to productivity loss*

Driven by a production logic, project planning and supervision were blinded to the risk of heat stress in hot weather. By the physiological law, there is a natural

declination in the maximum physical capacity in heat. Such a phenomenon was mentioned by a workers' leader,

- In such a hot weather, even we don't get heat illness, there is a plateau in our physical capacity. We certainly get physical exhaustion.

Such a phenomenon, however, did not come to supervisors' attention. After all, his accountability was to deliver the project! When asked if there were any heat stress risk among his workers, a supervisor answered,

- No. We don't have such issue. Some can become grumpy in hot weather, but it's just a matter of personality. That's the nature of the work. You got to work with the environment.

However, a heat exhaustion incident was observed in his team five minutes after his statement: A sleepy worker tried to improve his concentration by drinking a strong coffee, which further dehydrated him. His limbs were out of coordination at 11.30 am. He had to take a long break for recovery. The team suffered from a low morale which further lowered the productivity. Supervisor's ignorance to the heat risk was manifested in the unchanged productivity expectation, leading to progress pressure on workers. When asked why they were relatively safe in the other working days but had a heat illness case on this day, a worker mentioned the impact of a progress pressure on the work pace,

- We normally can work slowly to be safe. But today's work is very important. Everybody worked very fast.

Supervisors' ignorance of heat stress and pushing for production triggered workers' cynicism. This was heard from a worker's summary of the incident,

- Supervisors don't care unless they work someone into serious illness.

In another interview, a worker compared his current job with his previous ones, "In the city you had to work very fast. Here you don't work hard." "Why?" He was twinkling his eyes, "Because you DON'T." The results show that managers chose to ignore the heat risks on site for worries of productivity losses and employee exploitation of rest period duration, which, ironically, resulted in heat illness cases which cost productivity. Moreover, the occurrence of such incidents triggered workers' cynicism and low morale, and activated the protection logic, leading to further productivity losses.

### **Emergence and absence of a reconciling logic**

Actions indicating a reconciling logic between safety and productivity were identified in the bottom-up efforts of a safety programme. Initiated by the principal contractor and funded by the client, all subcontractors of the project were required to participate in a behavioural safety programme named Incident Injury Free (IIF). The IIF programme aimed at promoting safety behaviours through training, coaching, visible safety leadership, facilities improvement and social support. The subcontractor set up a committee for IIF, led by the Secretary to the Project Manager, attended by members from all levels of the project team. The safety initiatives can be either top-down, from the principal contractor, or bottom-up, proposed by the subcontractor's IIF action team and funded by the client. In observation, the bottom-up initiatives were more effective. Related to heat stress, ice-making machines were provided in the office area and in an on-site crew area. Each worker was provided a thermo-insulated water jar to make it easier for working at different locations of the site. Once a month, the Action Team made a walk around the site to search out their workers from every

corner of the site to distribute ice cream (hydration icy poles). The ice-cream walk was more symbolic than problem solving, but effectively created a sense of community and a culture of caring among the workers. The action thus brought an effect of breaking the protection logic.

Another safety initiative by the IIF team was to build a canopy in the material storage yard. We compared the heat-affected productivity between working in an open yard exposing to radiant heat and in a shaded yard without extra radiant heat, using the WBGT-based thresholds in the ACGIH guidelines as a benchmark. As can be seen in Table 3, by shading the workplace, the overall labour productivity can be improved by 30%.

Table 3. Productivity result of a canopy in the yard

Time (hour)	Heat stress in the open yard (with radiation)	Heat stress in shaded yard (without extra radiation)	Productivity in open yard (hour)	Productivity in shaded yard (hour)
0900	27.1 °C-WBGT	25.9 °C-WBGT	1.00	1.00
1000	29.6 °C-WBGT	27.4 °C-WBGT	0.70	1.00
1100	30.7 °C-WBGT	28.4 °C-WBGT	0.40	0.50
1200	31.8 °C-WBGT	29.1 °C-WBGT	0.25	0.75
1300	31.5 °C-WBGT	29.1 °C-WBGT	0.25	0.75
1400	32.1 °C-WBGT	29.5 °C-WBGT	0.15	0.50
Total effective productivity (hours/percentage)			2.8 (60%)	4.5 (90%)
Productivity improvement by shading the yard				30%

The emerging logic constituted by the bottom-up initiatives was found to be incomplete and handicapped when examining the actions at multi-levels of the project organisation. The organisational chart of the IIF team indicated a lack of involvement from the production side of the organisation. Departments such as human resource management, engineering, project scheduling, or procurement department, were absent from the team. Managers of these important departments were treated as individuals looking after their personal safety at work, rather than as designers and controllers of the management systems that could have contributed to the improvement of workers' safety on site. An example was seen in the commercial manager's personal safety commitment statement, who promised that he would "*get up from my desk stretch/walk about to manage posture*" and "*tidy my desk at least once a week to promote housekeeping*".

Whilst such a safety commitment did fit into the IIF advocacy of 'safety leadership' where leaders were encouraged to demonstrate safety behaviour to the workers, the kind of behavioural safety is however irrelevant to his job role. An important factor that led to fluctuated workload among the scaffolders was the errors in material procurement and provision, which resulted in a pattern that workers were either idling to wait for the right gears or rushing to meet the deadlines when they finally arrived. Had the project procurement procedure been set up to be responsive to site safety, the commercial manager would have seen the opportunity of making strategic adjustment that could lead to improvement in both safety and efficiency at work. The reconciling logic was missing at this part of the organisation, and is inconsistent to the actions of the IIF team.

## DISCUSSION

Findings of this study demonstrate the paradoxical consequences of the protection and production logics of processing safety in production, and identify an emerging but incomplete reconciling logic. The propositions of safety and productivity of the three logics can be summarised in Table 4. The protection logic underpinning the rules and policies for protection of workers' interests, manifested in the long working hours specified by the EBA and the unrealistic heat stress policy by the union, paradoxically led to a consequence of more safety risks to the workers. On the other hand, contractors were stuck in the production logic, tried to push productivity by an exclusive focus on production, ignoring the heat risks, which paradoxically led to incidents and low morale, leading to productivity loss. The bottom-up safety initiatives under the IIF programme, as interpreted in action by a devoted action team, worked as a seed of the growing reconciliation logic. However, the strong protection and production logics were enhancing and activating each other thus downplaying the emerging reconciliation logic. In the absence of such efforts at the senior management level and the production side of the organisation, the reconciliation logic is incomplete and handicapped.

Table 4. Safety and productivity in different logics

		Protection logic	Production logic	Reconciliation logic
Safety	What is it	Workers' welfare; Fight against employer	Clearing trouble from union and regulators	Safe work
	Whose responsibility	Employer	Workers	Myself
	How to achieve	Stop work	Safety behaviour	Effort by all levels
Productivity	What is it	Employer's worry	Core interest	Smart work
	Whose responsibility	Employer	Workers	Both
	How to achieve	None of our business	Make workers work	Innovate

## CONCLUSIONS

The aim of this paper was to explore the manifestation and consequences of the multiple institutional logics of processing safety in production and, in particular, the presence and absence of the reconciliation logic at different levels of a construction project organisation. Through an in-depth case study of heat stress management in a project organisation in Australia, we explored the paradoxical effects out of the protection logic and the production logic. Meanwhile, the emergence of a reconciling logic was identified in the bottom-up safety initiatives, but found to be incomplete due to the lack of involvement at senior and middle management levels on the production side of the project. The findings highlight the need of involvement from actors on the production side of construction projects for building up the reconciling logic to solve the safety-productivity paradox. Theoretically, the study contributes to the understanding of logics multiplicity in addressing organizational paradoxes.

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# INTERNALISED STIGMA, DISCRIMINATION, DEPRESSION, SOCIAL SUPPORT AND DISCLOSURE EXPERIENCES OF HIV+ WORKERS IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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HIV/AIDS-related stigmas can be internalised by HIV+ persons, leading them to avoid treatment or care, engage in unsafe sex practices, feel emotional distress, isolation and self-loathing and perceive diminished social support. Using a self-administered questionnaire, internalised stigma was investigated in 34 HIV+ respondents from a sample of 512 construction workers in the Western Cape of South Africa, with statistical analysis of the quantitative data. Particular emphasis was placed on lifestyle-related risk factors such as the condom use (lack of), numbers of sex partners, and failure to take anti-retroviral medication. The HIV+ workers were found to have lower AIDS-related knowledge than non-infected co-workers, and their internalised stigma was significantly associated with level of education. Improving knowledge, eradicating discrimination in the workplace and society, and recasting HIV/AIDS as a chronic but manageable disease could potentially help to address the problems presented by such stigma, but construction organisations will have to apply nuanced and sensitive approaches in their intervention management.

Keywords: construction workers, HIV/AIDS, internalised stigma, discrimination, South Africa

## INTRODUCTION

HIV/AIDS is perhaps the most stigmatized medical condition in history (Parker and Aggleton, 2003). Stigma should more precisely be regarded as ‘stigmatising behaviour’ since stigma may be defined as the outward mark of disgrace and it is the stigmatising action that is at issue. It is *‘the phenomenon whereby an individual with an attribute is deeply discredited by his/her society and is rejected as a result of the attribute’*; as *‘a process by which the reaction of others spoils normal identity’* (Goffman, 1963: 3); and as a *‘powerful discrediting and tainting social label that radically changes the way individuals view themselves and are viewed as persons’* (Alonzo and Reynolds, 1995: 304). HIV/AIDS stigmatisation is thus a social process

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rooted in social power relations (Deacon, 2006). Prejudice towards, and discrimination against, HIV+ persons is a serious impediment to addressing the HIV/AIDS pandemic (Klein *et al.* 2002; Deacon *et al.*, 2009).

Few studies exist of AIDS stigmas experienced by HIV+ persons and none have focussed on construction workers. Simbayi *et al.* (2007) assert that socially-constructed views of AIDS can be assimilated and internalised by HIV infected persons, leading them to avoid seeking treatment or care; to engage in unsafe sex practices; and to experience feelings of emotional distress, isolation, and self-loathing. Internalised stigma is also associated with the development of depressive symptoms (Tucker *et al.*, 2013). Lee *et al.* (2002) report that HIV+ persons are embarrassed by their positive status; that it is difficult for them to disclose it to others; and that a link can be established between internalised stigma and depression. Smith *et al.* (2008) report a positive correlation between disclosure and social support, a negative correlation between stigma and social support, and a negative correlation between stigma and disclosure. These findings suggest that internalised AIDS-related stigmas potentially play a pivotal role in the distress and emotional reactions of many people living with HIV/AIDS (Restall, 2014).

Stigma issues are important for the South African construction industry in two respects. First, the industry has been identified as one of the economic sectors most adversely affected by HIV/AIDS, and also as one of the least responsive to the pandemic (Bowen *et al.*, 2013). Bowen *et al.* (2008) report that HIV prevalence amongst construction workers exceeds that of the national statistic. Second, the sheer scale of the disease in South Africa has overwhelmed the capacity of the government to respond through public resources alone; the private sector is thus called upon to share the burden through corporate intervention management among the workforce. The aim of the study, therefore, was to better understand the internalised stigma, experienced discrimination, depression, social support and aversion to disclosure experienced by HIV+ construction workers in South Africa; as these factors are an impediment to testing behaviour, which has considerable implications for rates of prevalence and incidence as a result of new infections and re-infections of existing HIV+ workers. The objective was not to compare this sector to other sectors, but rather to understand the dynamics of these characteristics and their impact on testing behaviour specifically for this sector. This would better inform construction organisations in their approaches to intervention management and thus contribute to the wider long-term aims of the research: to first assist the formal industry in its responsibility towards worker health and well-being; and then to use this knowledge to reach out to and help the informal construction industry.

## **RESEARCH METHOD**

### **Participants and setting**

A survey questionnaire, self-administered in a supervised field setting on construction sites, was used to collect data. The questionnaire was based on instruments previously employed in South Africa (Simbayi *et al.*, 2007; Kalichman *et al.*, 2009). Convenience sampling was used for the selection of construction firms and sites, as well as the workers interviewed. The sample frame consisted of all employees present when researchers visited the sites by prior arrangement. Ethical clearance was obtained from the University of Cape Town.

Participants ( $n=512$ ) comprised site-based unskilled and skilled workers and site office-based staff drawn from 6 firms on 18 construction sites in the Western Cape. Questionnaires were available in English, Afrikaans and *isiXhosa* (an indigenous African language), the most commonly spoken languages in the Western Cape. Participants were told about the nature of the study, assured that their participation was entirely voluntary and anonymous, and informed that they could withdraw from participation at any time. Participants who provided informed consent then completed the questionnaires. Between them, the supervisors were proficient in all three languages. Time to complete the questionnaires ranged from 30 minutes to 1-hour, depending on participant literacy.

## Measures

*Demographic characteristics:* Age was measured in five discrete categories: 20 or under; 21-30; 31-40; 41-50; and over 50 years. Ethnicity data used four response options: 'Black' African; 'Coloured' (mixed race); 'Indian'; and 'White', but the data for the latter three classes were later combined as 'Others' for the statistical analysis. Level of education was categorised as 'primary or less', 'secondary', or 'tertiary or higher'. Nature of employment was classified as 'permanent', 'temporary / contract', or 'casual'. Marital status was categorised as either 'married or in a long-term relationship', or 'single'. Participants were asked if they had children ('Yes'; 'No'). Participants also reported their lifestyle risk behaviours, with catalogue items for alcohol consumption and cannabis ('dagga') use, sexual intercourse with multiple partners in the preceding three months, and use of and attitudes towards condoms. HIV+ participants were also asked to self-identify (anonymously) and describe their current health status ('excellent' to 'very poor'); whether or not they were currently taking ARV medication ('Yes'; 'No'); and the number of AIDS-related overnight hospitalizations ('never' to 'four or more times').

*AIDS-related factors:* Table 1 provides details of the seven AIDS-related factor *scales* used in this study. A 6-item test was used to assess HIV/AIDS-related internalised stigma (see Table 1) with 'Agree' or 'Disagree' response options. Example items include: 'It is difficult to tell people about my HIV infection'; 'Being HIV+ makes me feel dirty'; 'I am ashamed that I am HIV+'; and 'I sometimes feel worthless because I am HIV+'. Internal consistency was excellent,  $\alpha=0.90$ . Responses to each of the 6 items were first examined as individual indicators of internalised stigma. Thereafter, an *AIDS-related internalised stigma scale* was developed and scored for the number of 'Agree' responses (score range 0 to 6; higher score = higher levels of internalised stigma). Similarly composite scales were also computed for the other six AIDS-related variables, namely: AIDS-related medical conditions (health); AIDS-related knowledge; personal experiences of discrimination; anxiety and depression; social support and connectedness; and aversion to disclosure ('openness').

*Statistical analysis:* The data were analysed using IBM SPSS Ver. 23.0 for Macintosh (IBM Corporation, 2013). Descriptive statistics and non-parametric tests (see Pett, 1997) were used to examine bivariate relationships between the demographic characteristics of the HIV+ ( $n=34$ ) sub-sample and the remaining HIV- ( $n=478$ ) participants (total sample:  $n=512$ ). The Kruskal-Wallis Test and Mann-Whitney Test were used to explore bivariate relationships between composite variables and demographic characteristics of HIV+ workers (see Table 2). Finally, Spearman's rank correlation coefficients were computed to examine the bivariate relationships between

the various composite variables (see Table 3). Additionally, the mean, standard deviation and standard error for each scale are given.

*Table 1. Scale items and Cronbach's alpha reliability coefficients for HIV/AIDS factors (HIV+ n=34)*

Scale	Items	( $\alpha$ )
<b>Health</b> Yes=1; No=0 Scale Range: 0-14	H3. Symptoms (fourteen): Incidence of any of the listed medical conditions over the past 3 months: persistent shortness of breath; persistent cough; oral sores; recurring fever; persistent or severe diarrhoea; difficult or painful swallowing; nausea, stomach cramps or vomiting; persistent or severe headaches; seizures and lack of coordination; mental symptoms such as confusion and forgetfulness; loss of vision; excessive or sudden weight loss; extreme fatigue; coma	0.930
<b>AIDS knowledge</b> Correct response=1 Incorrect response=0 Don't know=0 Scale Range: 0-9	K1. Is AIDS spread by kissing? (No) K2. Can a person get AIDS by sharing kitchens and bathrooms with someone who has AIDS? (No) K3. Can you get AIDS by touching someone with AIDS? (No) K4. Can men give AIDS to women? (Yes) K5. Does washing after sex help protect you against getting AIDS? (No) K6. Can a pregnant woman give AIDS to her baby? (Yes) K7. Can a person get rid of AIDS by having sex with a virgin? (No) K8. Is HIV the virus that causes AIDS? (Yes) K9. Is there a cure for AIDS? (No)	0.789
<b>Internalised stigma</b> Agree=1 Disagree=0 Scale Range: 0-6	IS1. It is difficult to tell people about my HIV infection IS2. Being HIV+ makes me feel dirty IS3. I feel guilty that I am HIV+ IS4. I am ashamed that I am HIV+ IS5. I sometimes feel worthless because I am HIV+ IS6. I hide my HIV+ status from other people	0.898
<b>Personal experiences of discrimination</b> Yes=1 No=0 Scale Range: 0-6	PD1. I have been treated differently since I disclosed my HIV+ status to friends / family PD2. Friends and family stopped visiting after learning that I am HIV+ PD3. My HIV+ status has caused me to lose a job or housing PD4. I believe my family has experienced discrimination since my HIV+ status became known PD5. I believe my friends have experienced discrimination since my HIV+ status became known PD6. There are people I have not told I am HIV+ for fear of negative consequences	0.836
<b>Anxiety and depression</b> No Days=0 1-2 Days=1 3-4 Days=2 5-7 Days=3 Scale Range: 0-21	Number of days in the past week (including today) which best describe your feelings. AD1. I thought my life had been a failure AD2. I felt fearful AD3. I talked less than usual AD4. I felt lonely AD5. I had crying spells AD6. I felt sad AD7. I felt that people disliked me	0.805
<b>Social support and connectedness</b> Completely true=1 Mostly true=2 Mostly false=3 Completely false=4 Scale Range: 0-24	SS1. There are several people that I trust to help me solve problems SS2. If I needed a place to stay for a week because of an emergency I could easily find someone who would put me up SS3. If I were sick, I could easily find someone to help me with my daily chores SS4. I feel a strong emotional bond with at least one other person SS5. When I need help to deal with a personal problem, I know someone I can turn to SS6. If I needed an emergency loan of R100, there is someone I could get it from	0.622
<b>Aversion to disclosure ('Openness')</b> Completely true=1 Mostly true=2 Mostly false=3 Completely false=4 Scale Range: 0-16	AD1. If I did not know a person's HIV status I am certain I could decide about telling them my HIV+ status before having sex AD2. I'm certain that I could discuss being HIV+ with a new sex partner AD3. I feel confident that I could tell someone I am dating that I am HIV+ AD4. I would rather not have sex than deal with decisions to disclose my HIV+ status	0.853

*Note: Correct responses indicated in parentheses against each knowledge question.*

Percentages reported refer to the percentage of the number of participants answering that particular question.

## ANALYSIS OF THE DATA

*Participant characteristics:* Most participants in the full dataset ( $n=512$ ) were male (91%;  $n=461$ ) and 7% ( $n=34$ ) reported themselves to be HIV+. Participant ages ranged from 18 to 69 years (mean = 36, SD = 10.86), with most in the 21-30 year age group (34%;  $n=168$ ). Almost two-thirds (62%;  $n=313$ ) of participants were 'Black' African. Over a quarter (29%;  $n=144$ ) had at most primary level education, whilst 52% ( $n=260$ ) had secondary level education. Sixty-two per cent ( $n=304$ ) were permanent employees, as distinct from contract (employed on a project basis: 34%;  $n=167$ ) and occasional (casually hired: 4%;  $n=22$ ) workers. Sixty-five per cent ( $n=320$ ) were either married or in long-term relationships, and 76% ( $n=380$ ) reported having children. In comparing the characteristics of the sub-samples of HIV+ and HIV- participants, the only significant demographic difference between the two groups was in respect to age ( $p=0.004$ ) with proportionately-more older workers in the HIV+ group than in the HIV- group. For AIDS knowledge, the HIV- group demonstrates a significantly higher level of AIDS knowledge than does the HIV+ group (HIV+: mean score=5.72; HIV-: mean score=6.83;  $p=0.011$ ). Depression scale scores between the two groups are not significantly different.

*Health:* Of the HIV+ group, 79% ( $n=27$ ) reported 'very good' or 'excellent' health, 42% ( $n=10$ ) stated that they were not currently compliant with an anti-retroviral (ARV) medication regime (CD4 count unknown), and 81% ( $n=22$ ) claimed to have never been hospitalised overnight for an AIDS-related medical condition. Considering current lifestyle risk behaviour, 24% ( $n=8$ ) of HIV+ workers reported having had two or more sex partners in the preceding 3 months; 44% ( $n=15$ ) had not used a condom at their last coital act; and 35% ( $n=12$ ) stated that they did not like using a condom. Regarding substance usage, 62% ( $n=21$ ) of HIV+ workers had consumed alcohol at least once in the past 3 months (50% indicated twice or more), and 15% ( $n=5$ ) had smoked cannabis at least once in the same period. Alcohol and drug use is contra-indicated for ARV medication.

*AIDS-related medical conditions:* Half ( $n=17$ ) of the HIV+ participants did not suffer from any of the symptoms listed in the questionnaire. Of those who did, the most frequently reported symptoms included persistent shortness of breath (24%;  $n=8$ ), a persistent cough (21%;  $n=7$ ), persistent headaches (21%;  $n=7$ ), excessive or sudden weight loss (21%;  $n=7$ ), and mental confusion (21%;  $n=7$ ). The medical symptom scale scores are not significantly related to any of the demographic factors (see Table 2), nor are they related to depression scale scores (see Table 3).

*Internalised stigma of HIV+ workers:* A majority (54%;  $n=15$ ) of this group believed that it was their own fault that they are HIV+. Nearly half stated that it was difficult to tell people about their infection (48%;  $n=14$ ), and that they tried to hide it from other people (48%;  $n=13$ ). They reported that being HIV+ made them feel dirty (30%;  $n=9$ ), guilty (47%;  $n=14$ ), ashamed (41%;  $n=11$ ), and sometimes worthless (28%;  $n=8$ ). Only level of education is significantly related to internalised stigma ( $p=0.017$ ), with the more highly-educated participants feeling *more* stigmatisation compared to less educated respondents (see Table 2). Two of the variables within the stigma scale were found to be significantly related to demographic characteristics. Firstly, ethnicity was significantly associated with knowing whether or not HIV is the virus that causes AIDS (Table 1, Item K8;  $p=0.002$ ). Proportionately more 'Black' African participants did not

answer this question correctly compared to those from the 'Other' ethnic groups. Secondly, being a parent or not was significantly associated with whether or not washing after sex is believed to help protect someone from getting AIDS (Table 1, Item K5;  $p=0.029$ ). Proportionately more participants who were parents did not answer this question correctly compared to the childless respondents.

*Discrimination experienced by HIV+ workers:* Whilst many HIV+ participants reported having spoken about AIDS with a family member (77%;  $n=20$ ) or friend (82%;  $n=23$ ), 54% ( $n=15$ ) stated that they had not disclosed their status to some people for fear of negative consequences and those that had disclosed reported that they had been treated differently since disclosing their status to family and friends (36%;  $n=10$ ); they had lost a job or housing (14%;  $n=4$ ); they had experienced discrimination (35%;  $n=9$ ); they had experienced cessation of visits from family and friends (21%;  $n=6$ ); and that their *family* members (36%;  $n=10$ ) and *friends* (30%;  $n=8$ ) had experienced discrimination. The discrimination *scale* scores are not significantly related to any of the demographic factors (see Table 2). Responses to individual questions within this discrimination scale reveal a significant relationship between education level and having lost a job or housing (Table 1, Item PD3;  $p=0.022$ ). Specifically, the less educated respondents had experienced the loss of a job or housing more than better-educated respondents.

*Anxiety and depression:* The scale results for anxiety and depression were not significantly related to any of the demographic variables (Table 2). Within the depression scale results (not shown here), a significant difference was found in the relationship between marital status and feelings of sadness (Table 1, Item AD6;  $p=0.019$ ); with single persons reporting significantly more frequent occasions of feeling sad. A significant relationship also exists between being a parent and feeling disliked by people (Table 1, Item AD7;  $p=0.012$ ); where parent respondents less frequently experienced feelings of being disliked, compared to non-parents. It is also noteworthy that 64% ( $n=21$ ) of HIV+ participants had experienced feelings of inadequacy at some point during the preceding week. Similarly, 27% ( $n=9$ ) claimed to have felt sad during that week.

*Social support and connectedness:* None of the demographic variables were significantly related to the social support *scale* (see Table 2). For individual questions within the scale, significant relationships were found between gender and having access to assistance with problem-solving (Table 1, Item SS1;  $p=0.001$ ), and between employment type and having easy access to a place to stay in case of emergencies (Table 1, Item SS2;  $p=0.024$ ). Male respondents, more than females, reported greater levels of support in respect of help with problem solving. Contract/temporary employees reported having easier access to emergency accommodation than did colleagues in permanent employment.

*Disclosure of HIV+ status to new sexual partners ('openness'):* The 'openness' *scale* result was not significantly related to any of the demographic variables (see Table 2). Within the scale (not shown here), only disclosure of a HIV+ status to a dating partner was significantly associated with gender (Table 1, Item AD3;  $p=0.008$ ), whereby male respondents expressed significantly greater willingness to disclose their positive status to their dating partners than did female workers.

*Bivariate correlation analysis of factor scales:* The Spearman's rank correlation coefficients for all composite scales are shown in Table 3. A significant relationship was found between the internalised stigma scale and the experienced discrimination scale ( $\rho=0.525$ ;  $p=0.018$ ).

This positive relationship indicates that higher levels of internalised stigma are associated with higher levels of experienced discrimination. No other significant relationships between composite scales were evident. Education level and AIDS knowledge were *not* significantly correlated (not depicted in Table 3). In contrast, for the HIV- group, the relationship (also not depicted here) between education level and AIDS knowledge was highly significant ( $r=0.371$ ;  $p<0.001$ ).

Table 2. Degrees of significance between factor scales and demographic variables ( $n=34$ )

Factor scale	Age ( $p$ -value)	Gender ( $p$ -value)	Ethnicity ( $p$ -value)	Education level ( $p$ -value)	Employment type ( $p$ -value)	Marital status ( $p$ -value)	Children ( $p$ -value)
AIDS-related medical symptoms	0.285 <sup>3</sup>	0.659 <sup>4</sup>	0.051 <sup>4</sup>	0.200 <sup>3</sup>	0.210 <sup>3</sup>	0.737 <sup>4</sup>	0.439 <sup>4</sup>
AIDS-related knowledge	0.387 <sup>3</sup>	0.753 <sup>4</sup>	0.305 <sup>4</sup>	0.464 <sup>3</sup>	0.969 <sup>3</sup>	1.000 <sup>4</sup>	0.101 <sup>4</sup>
Internalised stigma	0.537 <sup>3</sup>	0.270 <sup>4</sup>	0.683 <sup>4</sup>	0.017 <sup>3</sup>	0.610 <sup>3</sup>	0.533 <sup>4</sup>	0.783 <sup>4</sup>
Experienced discrimination	0.843 <sup>3</sup>	0.909 <sup>4</sup>	0.877 <sup>4</sup>	0.149 <sup>3</sup>	0.331 <sup>3</sup>	0.686 <sup>4</sup>	0.688 <sup>4</sup>
Anxiety and depression	0.554 <sup>3</sup>	0.774 <sup>4</sup>	0.580 <sup>4</sup>	0.438 <sup>3</sup>	0.485 <sup>3</sup>	0.564 <sup>4</sup>	0.178 <sup>4</sup>
Social support and connectedness	0.135 <sup>3</sup>	0.240 <sup>4</sup>	0.134 <sup>4</sup>	0.388 <sup>3</sup>	0.054 <sup>3</sup>	0.301 <sup>4</sup>	0.158 <sup>4</sup>
Aversion to disclosure (Openness)	0.317 <sup>3</sup>	0.958 <sup>4</sup>	0.260 <sup>4</sup>	0.267 <sup>3</sup>	0.651 <sup>3</sup>	0.101 <sup>4</sup>	0.623 <sup>4</sup>

Notes: See Table 1 for an explanation of the scales. <sup>3</sup>Kruskal-Wallis Test; <sup>4</sup>Mann-Whitney Test

Table 3. Spearman's rank correlation coefficients between factor scales for HIV+ persons ( $n=34$ )

Scale	AIDS-related knowledge ( $r$ )	Internalised stigma ( $r$ )	Experienced discrimination ( $r$ )	Depression ( $r$ )	Social support and connectedness ( $r$ )	Aversion to disclosure (Openness) ( $r$ )	Symptoms ( $r$ )
AIDS-related knowledge	1.000	0.023	0.188	-0.175	0.056	0.148	-0.008
Internalised stigma	0.023	1.000	0.525*	0.245	-0.159	-0.390	0.135
Experienced discrimination	0.188	0.525*	1.000	-0.085	-0.109	-0.389	0.205
Anxiety and depression	-0.175	0.245	-0.085	1.000	-0.142	-0.221	0.201
Social support and connectedness	0.056	-0.159	-0.109	-0.142	1.000	0.101	0.223
Aversion to disclosure (Openness)	0.148	-0.390	0.389	-0.221	0.101	1.000	0.021
Symptoms	-0.008	0.135	0.205	0.201	0.223	0.021	1.000
Scale range	0-9	0-6	0-6	0-21	0-24	0-16	0-14
Scale mean	5.72	2.57	1.83	3.11	10.19	7.52	2.18
Scale SD	2.65	2.44	1.99	4.27	3.60	3.75	3.69
Standard error	0.47	0.53	0.41	0.81	0.64	0.75	0.63
Scale $\alpha$	0.79	0.90	0.84	0.81	0.62	0.85	0.93

Notes: See Table 1 for an explanation of the scales. \* $p<0.050$ .

## DISCUSSION

The AIDS-related knowledge scores of HIV+ respondents are significantly lower than those of HIV- participants. This supports the findings of Kalichman and Rompa (2000) concerning functional health literacy of persons with HIV/AIDS, and could be partly explained by the significantly higher proportion of older workers in the HIV+ sub-sample, a factor which is problematic as media and communication knowledge is generally directed more at younger age groups. The reported lifestyles of many respondents in the HIV+ group present an obstacle to prevention and mitigation of the disease, as almost one in four of the sub-sample claimed to have had two or more sex partners in the preceding 3 months; 44% reported not using a condom at last coital act; and 52% indicated that they would be inclined to abstain from sex rather than deal with

decisions regarding disclosure. Nearly half of the HIV+ sub-sample (42%) reported not taking (or not remaining compliant with) ARV medication. Possible reasons for this include poor family support, depression, and internalised stigma (see Nsimba *et al.*, 2010).

Internalised stigmas are evident in the HIV+ group. Many report feeling guilty, ashamed, worthless and dirty. Nearly half try to hide their condition from others. These results align with Simbayi *et al.* (2007), who found that HIV+ persons have internalised stigmas to a greater extent than the broader community. Internalised stigmas may account for at least some of the psychological distress reported by persons living with HIV/AIDS (WHO, 2008), which reported higher rates of depression in HIV+ people compared with HIV- control groups. The level of distress also seems to be related to the severity of symptoms of HIV infection. The current study has identified feelings of inadequacy in nearly two out of three HIV+ participants, and feelings of unhappiness in just over a quarter of them. On the other hand, in contrast to the WHO (2008) findings, AIDS-related medical symptoms and depression were not found to be significantly related. Whilst elevated, the depression scale scores of the HIV+ workers reported here were not significantly higher than those of the HIV- workers. Unlike Lee *et al.*'s (2002) finding, the relationship between depression scores and internalised stigma was not found to be significant.

Many HIV+ workers reported incidents of discrimination. Over a third had been treated differently by family and friends since disclosing their status and had experienced other acts of discrimination. Twenty per cent of this group were no longer visited by family and friends, and four respondents had lost a job or housing due to their condition. These findings align with those of Maughan-Brown (2010). At the same time, levels of perceived social support were found to be generally quite high, potentially providing a counter to stigma and depression (Li *et al.*, 2009).

## CONCLUSIONS

The internalised stigma, experienced discrimination, depression, social support and aversion to disclosure among HIV+ construction workers in the Western Cape are reported. The sub-sample was found to have significantly lower levels of AIDS-related knowledge than their HIV- counterparts. This also reflected in their lifestyles, where practices such as multiple sex partners, not using condoms and preference for maintaining their unsafe sexual practices rather than dealing with disclosure-related decisions, were reported. About half of the HIV+ respondents reported not taking ARV medication, with this potential lack of treatment compliance appearing to be associated with internalised stigma. Frequent feelings of inadequacy, unhappiness, guilt, shame, worthlessness and dirtiness were reported, and half of the respondents in this group tried to conceal their condition. Many felt discriminated against by family, friends or employers. On the other hand, levels of perceived social support among HIV+ workers were found to be generally good, with most reporting a high likelihood of obtaining help in an emergency, such as being able to getting a small loan or finding someone to help with daily chores; although fewer believed they could find someone to accommodate them for a week in an emergency.

The findings provide some guidance about work-based HIV/AIDS intervention management by construction firms. They suggest that if the problems resulting from internalised stigma are to be effectively addressed, they need to be dealt with through carefully structured nuanced and culturally-sensitive intervention. The conventional notion of HIV/AIDS as being a (rapidly) terminal medical condition needs to be

countered by the understanding that, although still chronic, it is a manageable disease that, with carefully monitored treatment, can yield a substantially extended lifespan.

The construction sector is a significant employer of labour in the South African economy in both the formal ( $\pm 7.5\%$ ) and informal ( $\pm 13\%$ ) sectors, and this underscores the importance of such understanding and intervention for economic as well as public health reasons. The construction industry, throughout sub-Saharan Africa, is largely unique compared to other industries in terms of its formal and informal sectors; its labour employment structures; its high utilisation of migrant workers; its fragmentation of firms; its diversity of project clients, project types and locations; and the long term nature of its products which often form the capital infrastructure assets of other industries and public services. The contribution of the research should be seen against this context. Employer organisations now have specific areas to target in the policy and programme development and implementation they undertake in terms of HIV/AIDS intervention management. Planned future research will explore exactly how these can be achieved.

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# **BOUNCING BACK TO MOVE FORWARD: RESILIENCE OF STUDENTS IN THE BUILT ENVIRONMENT**

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Development of resilience is considered a critical competency related to work readiness for students of the built environment, given that workers of the construction industry are known to experience high levels of stress, burnout, and work-life conflict. While resilience-based research has been undertaken in university settings, this has excluded students undertaking studies in the built environment. To address this gap, research was undertaken to: (1) develop and validate a measure of student resilience; (2) measure the resilience of students undertaking studies in the built environment; and (3) explore the relationship between resilience and wellbeing. Data was collected from undergraduate students based in Melbourne, Australia. Results identified a student profile of resilience and wellbeing-related measures of subjective happiness, depression, anxiety, and stress. Findings have practical implications for educators within the built environment. Universities can actively support student wellbeing by fostering resilience. It is possible that resilience can be developed by identifying initiatives which can be embedded within course structures, learning activities and assessment tasks. Building on these findings, further research is underway to explore the definition of resilience within an educational context; identify learning and teaching strategies which support development of student resilience; and explore resilience in the context of graduate work readiness.

Keywords: built environment, project management, resilience, students, wellbeing.

## **INTRODUCTION**

### **Resilience**

Students transitioning from high school to university are faced with an unfamiliar environment which can induce stress and poor mental wellbeing (Bayram and Bilgel, 2008; Catterall, Davis and Yang, 2014; DeRosier, Frank, Schwartz and Leary, 2013; Morosanu, Handley and O'Donovan, 2010). Failure to adjust to the new environment can impact on students' academic success and persistence in post-secondary education (Andrews and Wilding, 2004). A major transition again takes place when students move from university into the workplace to commence their professional career. Resilience has been acknowledged as a critical capability that can assist students in their transition to university (DeRosier et al., 2013) and professional life (Candy and Crebert, 1991), as well as contribute to students' mental health and wellbeing (Dunn, Iglewicz and Moutier, 2008; Watson and Field, 2011). Resilience has also been positively linked to academic engagement and achievement (Martin et al., 2015). Resilience is considered as the ability to bounce back or recover from stressful

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circumstances in order to reach a whole adjustment to environment (Ahern, Kiehl, Sole and Byers, 2006; Smith *et al.*, 2008; Tusaie and Dyer, 2004). Windle (2011) offers a comprehensive definition which emphasises the centrality of assets and resources in responding to negative affect, recognising that resilience is contextual and will vary over the life course: "Resilience is the process of effectively negotiating, adapting to, or managing significant sources of stress or trauma. Assets and resources within the individual, their life and environment facilitate this capacity for adaptation and 'bouncing back' in the face of adversity. Across the life course, the experience of resilience will vary (p.163)". Importantly, resilience has been linked to maintaining physical and psychological health, and having the ability to recover more quickly from stressful events (Ryff and Singer, 2003). The ability to manage stress is critical for students, as academic stress is associated with lower course grades, coping and motivation (Struthers, Perry and Menec, 2000).

### **Student wellbeing**

Learners are faced with significant levels of on-going stress throughout the course of their university experience which impacts on their mental health (Martin and Marsh, 2009; Phair, 2014; Shuchman, 2007; Stallman, 2010). A study of United Kingdom undergraduate learners identified that stress and difficulties with mental health and wellbeing are widely experienced (Laidlaw, McLellan and Ozakinci, 2015). Further, the United Kingdom Royal College of Psychiatrists (2011) reported that 29% of students studying in higher education reported clinical levels of distress. In Australia, a study of 6,479 undergraduates from two Australian universities reported "preliminary evidence of very high levels of psychological distress" (Stallman, 2010, 254). Of the population surveyed, 83.9% experienced elevated levels of distress. This level was significant when compared to the general population of which only 29% felt heightened levels of psychological distress (Stallman, 2010).

Educators are tasked with the role of providing a supportive environment in which students can learn and prosper. There is growing recognition by educators that resilience development during university is an important capability that will increase the likelihood of positive academic and employment outcomes. This positions resilience as a key capability which can be developed through the university curriculum (Grant and Kinman, 2012; Stallman, 2011; Watson and Field, 2011) by the implementation of targeted strategies which build assets and resources critical for resilience.

### **Study and work in the built environment**

Workers of the construction industry are known to experience high levels of stress (Bowen, Govender and Edwards, 2014; Leung, Chan and Cooper, 2015), burnout (Lingard and Francis, 2009; Yip and Rowlinson, 2006), and work-life conflict (Lingard, Francis and Turner, 2010). Outcomes are detrimental for the worker, the worker's family, and the organization and include depression, substance abuse, chronic health problems, relationship breakdowns and intention to turnover. Research indicates that property and construction students have very high levels of burnout compared to professional samples due to the pressures exerted from combining both work and university (Lingard, 2007; Moore and Loosemore, 2014). Curtis and Williams (2002) write of the 'routinisation' of students combining paid work and study, suggesting that this is now the norm. Lingard (2005) found that hours spent in paid employment were at least as long and, in many cases, were in excess of hours spent at university for property and construction students.

Previous research has typically investigated students' resilience within a specific program, such as law (Sagone and De Caroli, 2014; Watson and Field, 2011), social work, nursing and midwifery (Grant and Kinman, 2013), medicine and engineering (Sagone and De Caroli, 2014). Despite an understanding of the built environment as highly pressured and stressful, together with an understanding that students who combine work and study experience a high level of burnout, little research has explored how resilience may mediate stress outcomes for students of the built environment.

## AIM

This study aims to address the identified gap through a program of research to: (1) develop and validate a measure of student resilience which enables results to be translated into practical curriculum-based initiatives which support resilience development; (2) measure the resilience of students undertaking studies in the built environment; (3) explore the relationship between resilience and wellbeing; (4) review the definition of resilience within an educational context; (5) identify learning and teaching strategies which support development of student resilience; and (6) explore the role of resilience in the context of work readiness for graduates. This paper focuses on aims one, two and three.

## METHOD

### Participants

Students studying in the property, construction and project management disciplines at RMIT University in Melbourne, Australia, were invited to participate in the research. Ethics approval for the research was received from the university ethics committee.

### Methods

A mixed methods approach is applied to the research. The research is being conducted over four interdependent stages. Table 1 outlines the four stages in the context of the six research aims.

Table 1: Stages of the research in relation to research aims

Research Aim	Stage 1: survey	Stage 2: interview	Stage 3: curriculum intervention	Stage 4: focus groups
1) Develop and validate a measure of student resilience	✓			
2) Measure the resilience of students undertaking studies in the built environment	✓			
3) Explore the relationship between resilience and wellbeing	✓			
4) Review the definition of resilience within an educational context		✓		
5) Identify learning and teaching strategies which support development of student resilience		✓	✓	✓
6) Explore resilience in the context of work readiness of graduates				✓

This paper reports on stage 1 of the research, which focuses on research aims one, two and three. Stages two, three and four are underway and will be reported elsewhere, following completion of data collection and analysis.

In stage one, a survey was administered to participants which comprised of four sections: demographic information; resilience measure; subjective happiness measure; and a depression, anxiety and stress measure.

**Resilience measure:** The Resilience at Work (RAW) measure (Winwood *et al.*, 2013) was adapted by the researchers for use in a university setting. In order to render the RAW scale applicable to the university context, the 20 items were adapted so that the word 'work' was substituted by 'university'. Examples of the items include 'The university work that I do fits well with my personal values and beliefs', and 'I have a strong and reliable network of supportive students at university'. The RAW scale has seven subscales: (1) living authentically (three items); (2) finding your calling (four items); (3) maintaining perspective (three items); (4) managing stress (four items); (5) interacting cooperatively (two items); (6) staying healthy (two items); and (7) building networks (two items). Instructions given to participants specified that the questions referred to their experience at university, including the time spent at university, as well as the time spent on studies outside of university. Participants were asked to indicate their agreement with the items on a seven-point Likert scale from 'strongly disagree'(0) to 'strongly agree' (6).

The adapted scale, Resilience at University (RAU), was initially piloted to assess the psychometric properties of the measure and to ascertain whether it had the potential to be a reliable and valid measure of resilience. The results of the pilot study were promising, and it was considered that further analysis of the RAU scale was warranted using a larger sample. Results of the pilot study are reported in Turner *et al.*, (2015).

**Depression, Anxiety and Stress Scale:** The Depression, Anxiety and Stress Scale (DASS) short version (Lovibond and Lovibond, 1995) is a 21-item self-report measure which yields three psychometrically separate factors (depression, anxiety, and stress) and has good internal reliability ( $\alpha = 0.93$ ). The response format is a 4-point Likert scale, with higher scores reflecting a higher level of depression, anxiety, and stress. Each factor has seven items that are summed to compute a score.

**Subjective Happiness Scale:** Following the pilot study, this scale was added to the questionnaire so that validation of the measure could be investigated along with a finer-grained analysis of resilience and its relationship to wellbeing. The Subjective Happiness Scale (SHS) is a four-item self-report measure developed to assess an individual's overall happiness (Lyubomirsky and Lepper, 1999). The response format is a 7-point Likert scale, with higher scores reflecting greater happiness. A single score is computed by averaging the responses to the four items following reverse coding of the fourth item. Scores range from 1 to 7, with higher scores reflecting greater happiness (Lyubomirsky and Lepper, 1999). The measure has demonstrated satisfactory internal consistency, with an alpha coefficient of 0.86.

## RESULTS

### *Participants*

Nine-hundred and fifty students undertaking a Bachelor of Applied Science in the built environment disciplines were invited to complete a survey. Four hundred and ten surveys were completed, representing a 43% response rate. The majority of participants were local (82.2%), with a smaller proportion being international (17.6%). Seventy-five percent of participants were male and 24.6% were female, which is reflective of the workforce in the built environment. The mean age of participants was 22.9 years (SD=4.05).

*Resilience at University (RAU) measure*

The first aim of the research was to develop and validate a measure of student resilience. Specifically, this stage of the research explored whether an adapted version of the RAW scale (Winwood *et al.*, 2013) may be valid in a university setting. The six-factor structure of the RAU closely replicated the seven-factor structure of the RAW (Winwood *et al.*, 2013), with the major difference being the grouping of the items from the interacting cooperatively and living authentically subscales onto one factor. Factor one had an eigenvalue of 4.76 and explained 25.08% of the variance, and included all items from the finding your calling subscale. Factor two had an eigenvalue of 2.04 and explained 10.75% of the variance, and included all items from both the interacting cooperatively and living authentically subscales. Factor three had an eigenvalue of 1.63 and explained 8.59% of the variance, and included three of the four items from managing stress subscale. One item from the managing stress subscale ('I am careful to ensure that my university work does not dominate my personal life') was excluded from analysis due to cross loading. Factor four had an eigenvalue of 1.34 and explained 7.07% of the variance, and included all items from the building networks subscale. Factor five had an eigenvalue of 1.24 and explained 6.75% of the variance, and included all items from the maintaining perspective subscale. Factor six had an eigenvalue of 1.06 and explained 5.62% of the variance, and represented all items from the staying healthy subscale. The factor structure and psychometric properties of the scale are outlined in Turner *et al.*, (2016). Results suggest that the RAU shows promise as a valid and reliable measure of student resilience.

*Student resilience*

The second aim of the research set out to measure the resilience of students undertaking studies in the built environment. Higher scores on the measure indicate a better level of resilience. The mean and standard deviation for each factor of the RAU is outlined in Table 2. Means ranged from 'slightly' (3) to 'neither agree nor disagree' (4). A finer grained analysis of the data will be undertaken to explore differences between groups according to gender, discipline (such as property, construction and project management), year of program, and local and international students.

*Table 2: Mean scores of the RAU factors*

	Mean	SD
Factor 1: Finding your calling	3.99	.947
Factor 2: Interacting cooperatively and living authentically	4.24	.778
Factor 3: Managing stress	4.03	1.08
Factor 4: Building networks	4.32	1.34
Factor 5: Maintaining perspective	3.74	1.16
Factor 6: Staying healthy	4.29	1.24

*Resilience and measures of wellbeing*

The third aim of the research sought to explore the relationship between resilience and wellbeing. A Pearson product-moment correlation coefficient was computed to assess the relationship between the Resilience at University (RAU) measure with the Subjective Happiness Scale (SHS) and the Depression, Anxiety and Stress Scale (DASS). Results showed a medium significant positive correlation between the RAU

measure and SHS ( $r=.440$ ,  $n=185$ ,  $p<.000$ , CI 95%:  $-0.32 - 0.55$ ), and a medium significant negative correlation with the depression measure ( $r=-.491$ ,  $n=366$ ,  $p<.000$ , CI 95%:  $-.56 - -.41$ ), and the stress scale ( $r=-.354$ ,  $n=380$ ,  $p<.000$ , CI 95%:  $-.44 - -.26$ ). The RAU and anxiety had a low significant negative correlation ( $r=-.294$ ,  $n=380$ ,  $p<.000$ , CI 95%:  $-.38 - -.20$ ).

## DISCUSSION

The first aim of the research sought to develop and validate a measure of student resilience which enables results to be translated into practical curriculum-based initiatives which support resilience development. Factor analysis of the adapted version of Winwood *et al.*'s (2013) RAW measure and subsequent cross-validation against other proven scales demonstrated that the new Resilience at University (RAU) measure shows promise as a valid and reliable measure of student resilience. The new RAU measure demonstrated its utility in unpacking the different categories of resilience enhancing behaviours.

The second aim of the research sought to measure the resilience of students undertaking studies in the built environment. This is an understudied cohort which limits the capacity to consider the results in the context of previous studies. Sagone and Caroli (2014) explored the dispositional resilience of student engineers, framing resilience according to Sinclair and Oliver's (2003) model of hardiness. In their study, the three factors underpinning hardiness (helplessness, alienation, and rigidity) represented the negative polarities of the three positive factors of dispositional resilience (control, commitment, and challenge). While Sagone and Caroli's (2014) study progresses our understanding of student resilience, findings cannot be compared with their study as they conceptualised resilience using a model of hardiness which is arguably a different construct to that of resilience. As far as the authors are aware, no other studies have explored student resilience specifically within the built environment.

Overall, students scored highest on building networks, staying healthy, interacting cooperatively and living authentically. The students' lowest scores were in maintaining perspective. Maintaining perspective is considered an important personal asset related to resilience (American Psychological Association, 2010), and is described as having the ability to reframe setbacks, maintain a solution-focus, and manage negativity (Winwood *et al.*, 2013). Given that workers of the construction industry are known to experience high levels of stress (Bowen *et al.*, 2014; Leung, *et al.*, 2015), the capacity to maintain perspective is considered important for good mental health in this high-demands industry.

The third aim of the research sought to explore the relationship between resilience and wellbeing. In this study, wellbeing was considered using measures of subjective happiness, depression, anxiety and stress. Resilience was shown to have a positive relationship with subjective happiness, and a negative relationship with depression, anxiety, and stress for participants. As far as the authors are aware, the wellbeing measures applied in this study have not been previously applied in other studies with students of the built environment. Initial comparison of the wellbeing of the current undergraduate sample with published findings found that the built environment students experienced greater wellbeing than either law or medical students. On the depression scale, 74.7% of the built environment undergraduates fell within the normal range compared to only 58% of students in law (Larcombe, Finch and Sore, 2015) and 48.7% in medicine (Iqbal, Gupta and Venkatarao, 2015). Higher levels of

wellbeing for built environment students were also found on the anxiety and stress scales. This is an important finding, as stress experienced throughout the course of their university experience can impact on students' mental health (Martin and Marsh, 2009; Phair, 2014; Shuchman, 2007; Stallman, 2010). It would appear that the mental health of participants from the built environment was better when compared with other disciplines, although further research is required to ascertain why this may have been the case.

## CONCLUSIONS

The development of resilience for students of the built environment is critical for two reasons. Firstly, resilience has been positively linked to academic persistence, engagement and achievement. Secondly, the construction industry is known as a high-stress environment in which its workers suffer from poor mental health. In order to be work-ready, built environment graduates require the capacity to bounce back and recover from stressful circumstances. One of the key contributions of this study is the development and validation of a new, university-focussed measure of resilience which can be used to advance the study of resilience in the tertiary context. The new measure provides a tool which can be practically applied in both the initiation of targeted interventions and in evaluating the impact of interventions.

Another key contribution is the identification of a resilience profile for built environment students. Prior to this study, little was known about the resilience of students from the built environment. The findings also contribute to our understanding of the health and wellbeing of students of the built environment, establishing that resilience is associated with higher levels of subjective happiness and lower levels of depression, anxiety and stress. The research has practical implications for educators within the built environment. Universities can actively support student wellbeing by fostering resilience. It is possible that resilience can be developed by identifying specific areas such as an ability to maintain perspective that can be embedded within course structures, learning activities and assessment tasks.

The research is limited in three important ways. Firstly, the new measure of resilience is in development and more research is required to ascertain whether it is a valid and reliable measure of student resilience. Secondly, the results cannot be generalised to other built environment programs as the study was undertaken in one university in Australia. Finally, a cross-sectional survey was administered and therefore causal relationships are unable to be identified.

Further research on student resilience in the built environment is underway. Research is focusing on stages two, three and four as described in Table 1. In order to address limitations of generalisability, it is anticipated that the study will be expanded to include multiple universities which offer programs in the built environment.

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