CONFERENCE PROCEEDINGS
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Joint CIB W099 and TG59 International Safety, Health, and People in Construction Conference
Towards better Safety, Health, Wellbeing, and Life in Construction
Cape Town, South Africa, 11-13 June 2017

Editors
Fidelis Emuze – CIB Task Group on People in Construction
Mike Behm – CIB Working Commission on Safety and Health in Construction
FOREWORD

The organizing team of the Joint CIB W099 (Safety and Health in Construction) and TG59 (People in Construction) International Safety, Health, and People in Construction Conference is delighted to welcome you to Cape Town, South Africa.

The meeting provides an international forum for researchers and practitioners to put forward discourses on how to improve safety, health, wellbeing, and the life of people in construction. The forum is a platform where recognized best practices are shared between researchers and practitioners. The conference seeks responses to critical questions, which include:

- **W099 Conference Outcomes:**
  - How well do education, training, and professional development prepare design professionals in the provision of inherently safe(r) and healthier designs?
  - How can research into safety and health deliver improvements in workers’ conditions and their quality of life?
  - What progress towards achieving vision zero is likely to be brought about from current safety and health research across all jurisdictions?
  - What are the opportunities for creativity and innovation in the delivery of safer and healthier design?
  - How can gender equality, cultural diversity and inclusivity be promoted in the design of safe(r) and healthier workplaces?
  - Are the ethical and moral challenges understood around the globe and addressed appropriately in safety and health research projects?
  - Are we impacting research that is highlighted in the W099 Research Roadmap?

- **TG59 Conference Outcomes:**
  - How can information technology contribute to improvement?
  - How can both employment and industrial problems be addressed?
  - How can gender and work-life balance issues be addressed?
  - How can skills better be developed and transferred?
  - How can health and wellbeing issues be better recognised, understood, and avoided?
  - How can diversity and inclusivity be promoted?

The peer-reviewed papers and edited conference proceedings is aimed at contributing to theory and practice in favour of zero tolerance for harm in the construction industry through learning, research and practice.

Fidelis Emuze
International Coordinator: CIB TG59
Bloemfontein, South Africa
May, 2017
ACKNOWLEDGEMENTS

The planning and execution of the Joint CIB W099 & TG59 International Safety, Health, and People in Construction Conference is based on the goodwill of East Carolina University (ECU), the Nelson Mandela Metropolitan University (NMMU), the Central University of Technology, Free State (CUT), and other helpful individuals. The organising team is grateful to Michelle Turner, Patrick Manu, Ciaran McAleenan, Craig Goldswain, Emmanuel Aboagye-Nimo, Clinton Aigbavboa, Ayodeji Aiyetan, David Oloke, Sam Zulu, and Fred Sherratt for serving as a Session Chair in the conference.

The effort of the International Scientific Committee (ISC), who diligently reviewed both abstracts and papers that were afterward edited by Fidelis Emuze and Mike Behm is warmly appreciated. The contributions of the expertise of the ISC led to published proceedings that satisfy the subsidy criteria of the Department of Higher Education and Training (DHET) in South Africa. In South Africa, the support of Winston Shakantu (NMMU), Alfred Ngowi (CUT), and Yali Woyessa (CUT) are notable. Through voluntary supports, Mariana Botes, Brink Botha, Chris Allen, and Katharina Crafford in Port Elizabeth; and Dillip Das, Bankole Awuzie, Zanelle Matsane, Thabiso Monyane, George Mollo, Rasheed Isa, Adefemi Aka, Portia Atoro and Chikerizim Okorafor in Bloemfontein are much-appreciated. It is also important to mention the web support from Ciaran McAleenan, Leandra Jordaan, and the CIB (International Council for Research and Innovation in Building and Construction) secretariat.
ORGANISING COMMITTEE

Mike Behm (International Coordinator: CIB W099)
John Smallwood (Technical Programme Chair)
Fidelis Emuze (International Coordinator: CIB TG59)
Mariana Botes (Administration – NMMU)
Portia Atoro (Administration – CUT)

DECLARATION

The papers in this conference proceedings were double-blind reviewed at abstract and full paper stages by members of the International Scientific Committee. This process entailed detailed reading of the abstracts and papers, reporting of comments to authors, modification of articles by authors whose papers were not rejected by the reviewers, and re-evaluation of revised papers to ensure the quality of content. The conference proceedings are therefore made up of papers that have been reviewed by experts in specific fields of construction research. It is declared that multiple institutions contributed more than 75% of the papers in the proceedings.
THE PEER REVIEW PROCESS

To promote and guarantee the quality of the conference proceedings and therefore comply with the criteria for the Department of Higher Education and Training (DHET) subsidy in South Africa, a rigorous two-stage peer review process by no less than two recognized experts was followed. The process was executed by ensuring that each abstract was twice blind reviewed with particular reference to relevance to themes and questions, scientific rigor, originality of research and extent of contributions to knowledge. Authors, whose abstracts were accepted, after the stage one review process was completed, were provided with anonymous reviewers’ reports and requested to submit their full papers that complied with the references of the reviewers. The review of the full papers followed the two-tier blind review process again. Authors whose papers were accepted after this second review were provided with second anonymous reviewers’ comments and requested to submit their revised full papers. These final papers were included in the conference programme and the conference proceedings after evidence was provided that all comments were appropriately addressed by the concerned authors. The Easy Chair online system was fully utilized for the peer review of all submissions for the conference.

The submissions were made to:
https://easychair.org/conferences/submission_show_all.cgi?a=12600014

The conference was also hosted on the web through:
http://www.cibw099.com/2017capetown.html

The statistics shown below indicate that full papers originated from 16 countries:

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<th>Country</th>
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Furthermore, the members of the International Scientific Committee were not involved in the review related to their own authored or co-authored papers. The role of the editors was to ensure that the final papers incorporated the reviewers’ comments and position the papers into the final order as captured on the Table of Contents. Of the 80 submissions initially received, only 57 papers were accepted for inclusion in the proceedings. This statistic results in an acceptance rate of 71% / rejection rate of 29%. The total reviews conducted by experts at the paper review stage stand at 126. To be eligible for inclusion these papers were required to receive a minimum score of 3 out of 5 allocated by the peer reviewers during the final review process.

Best wishes,

Fidelis Emuze
International Coordinator: CIB TG59
Bloemfontein, South Africa
May, 2017
The peer review exercise for the 2017 Joint CIB W099 & TG59 International Safety, Health, and People in Construction Conference was expedited through the voluntary contributions of experts from various countries. The editors sincerely grateful to:

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<td>Zulu, Sam</td>
<td>Leeds Beckett University, United Kingdom</td>
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HOSTS

Department of Construction Management

Nelson Mandela Metropolitan University

for tomorrow

Department of Built Environment

Central University of Technology, Free State

ENDORSEMENT (CPD)

South African Council for the Project and Construction Management Professions (SACPCMP)

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TG59 is about the People in Construction. The theme for this conference is ‘Towards better Safety, Health, Wellbeing, and Life in Construction’, and for TG59 specifically areas of focus include employment, the labour market, diversity issues, and respect for people. With that very much in mind, what I hope to do today is to hold a mirror up to us, the academics affiliated with TG59, to encourage us to ask ourselves whether we are the fairest of them all? To question what are we really doing for the people in construction, and perhaps more importantly, to reflect on how are we going about doing it?

This is an unashamedly critical mirror: there are some awkward questions to come, and some strong critique, and I certainly do not see myself as standing outside of its gaze. It is my intention to stimulate discussion, debate and even argument. I think these are questions that should be asked and, given the atmosphere of change that is growing in the world, the time to ask them might well be now.

Firstly, let us determine who we are. We are academics: we think, we reflect, we ask questions and we seek answers in our research. We are intellectuals. For some this is just a job, one that happily also involves getting to travel to lovely places and meet interesting people, although we often also have to teach a few students on the side. But for others, and perhaps most of us here given our CIB affiliation, we do this, our research, because we want to make a difference. Many of us are long past the heroic ambitions that motivated us towards our PhDs (and if you are not yet there, I apologise for what comes next) and the ridiculously optimistic belief that we could change the world with just one thesis. Instead, we remain satisfied with making little tweaks here and there, but we do still want to make changes, and these changes are always for the better.

But what we should therefore ask, the first rule of any critical reflection, is of course ‘what is better?’ and this in turn raises the first of our awkward questions: Who decides what better looks like? The People in Construction? Governments? Industry? Us?

We may like to think that morality or ethics or simple human decency will readily make this decision for us, that there can be no real debate about what better looks like; surely better is just better for everyone?

Take the People in Construction. Perhaps the easiest of the questions to answer is: what does better look like for them? There are some fundamental basics we can consider here. Maslow arguably had a point. But the question quickly becomes one of increments as we ascend up that slippery-sided pyramid, given the imbalances and inequalities found today on our planet. For some, standards of living come to the fore – work-life balance, stress, equality – but for others even having a work-life balance to consider would be a luxury, when sufficient food, clean water, health, safety, and even freedom are everyday uncertainties. Indeed, the informal and peripatetic nature of construction arguably supports worker poverty at the global level, with low wages, poor working conditions and short-term, temporary contracts simply characterising life for many People in Construction, particularly those who physically work on sites, and particularly migrant workers (Buckley et al 2016). One high-profile example is that of Qatar, where Amnesty International (2016) continue to take risks in order to reveal the exploitation and abuse of migrant construction workers on the FIFA 2022 World Cup Sites. But we must be mindful that there are many more similar sites, happily keeping a much lower profile across the world, and that
the construction companies operating them are not small, local contractors, but large multinationals with prominent industry profiles (Buckley et al 2016).

But whilst this may appear to be a developed/developing world conundrum, it is certainly not the avocation of what Sidney Dekker called a Western Salvationist Narrative (2016), indeed as Noam Chomsky (1967) pointed out, the Western model of development is hardly one that we can point to with any pride. The ratification of the Modern Slavery Act in 2015 was put forward as evidence of the United Kingdom’s leadership on the world stage for human rights, including those for People in Construction (Chartered Institute of Building 2015). Yet this is the same country in which a company was able to hold and manage a ‘blacklist’ of construction workers since the 1970s, actively preventing skilled tradespeople from working because of their union activities, because they raised health and safety concerns, because they were seen as ‘trouble’. Information held on workers even included confidential police reports (RT 2012), and since the exposure of the list in 2009, over £75m has been paid out in compensation to affected workers. Again, some big company names were involved here, yet it took the UK courts to make them admit any guilt at all.

For the People in Construction, wherever they may be in the world, deciding what better looks like is perhaps not all that difficult. But we now come to a rather fundamental, even embarrassing truth: the People in Construction don’t pay us. They can’t. Some of them, the ones where better would be as simple as not dying on site today, often don’t even get paid themselves. But the simple logistics of academe tells us we do need to get paid somehow. We need to eat too (although perhaps not as well as some of us do). And as academics, one of our key funding streams comes from governments. So now, perhaps we should ask what does better look like to governments, to those elected to represent these voices of the People. Surely there can’t be that much difference between the two?

Well, it would be nice to think so. But we now live in a world where politics has become so firmly entrenched in neoliberalism that the reaction of the markets is the first thought for political decisions, not the reaction of the people such decisions are supposedly made to benefit. Take for example the emergence of PFI or DBFO, in which the public sector takes the risks whilst private capital takes the profits, and which remains a prominent procurement method within our industry. This is a method which continues to be evaluated and researched by academics on a global stage, with a focus on ‘…what makes for a successful partnership and [how to] bring this result about’ (Grimsey and Lewis 2004:2), rather than any reflection on the more fundamental questions of whether we, as academics, should even be supporting and facilitating the creation of such imbalanced relationships at all. Indeed, the story of the UK’s National Health Service and its 100+ PFI hospital projects does not make for pleasant reading, and the need to reassure investors that the UK government will pick up any defaults in payments, debts in the billions of pounds (Plimmer 2016), seems to markedly miss the point that UK taxpayers money could perhaps be better spent on keeping the UK general public fit and well, rather paying money to a select few international organisations, who never really had it to lend in the first place.

Yet the dominance of the neoliberal discourse is now such that for governments, better is always more closely associated with the health of the economic markets and its investors, not the health of the everyday people. This is a version of better which translates to increases in productivity, reductions in costs, and booming share prices. Indeed, in an incredibly short space of time this system has resulted in the creation of a world in which just eight people are as rich as the 3.6bn who make up the poorest half. Worse, those who point this out are immediately lambasted by economic ‘experts’ for their focus on the rich, and directed to instead focus their energies on encouraging economic growth (BBC 2017), which, yes, could perhaps make the poor a little less poor, but would certainly also make the rich even richer still.

By its very nature, this version of better put forward by governments is essentially the same as that of industry: improvements in production and profit and shareholder satisfaction seen as better all round. Yet we should exercise caution here. As a vocational field, construction academics are often
encouraged to *engage with industry*, able as it is to provide us with data, case studies, funding, creditability and impact, all of which are also not unhelpful to our own academic existence.

Yet in doing so we have to accept the industry version of *better* without question. We are asked to research and provide answers as to, for example; how industry can improve technologies, without pointing out that many improvements also need investment for worker training in new methods; how industry can increase automation, without pointing out that people might need the work more than machines; how industry can better manage its supply chains, without pointing out that the ‘hollowing out’ of construction firms has only increased problems for the workforce; how industry can improve health and safety, without pointing out that time and cost pressures are the fundamental cause of most of the problems; or how industry can better deliver on Corporate Social Responsibility, without pointing out that you really have to *mean* it for it to work – I refer you back to Qatar and the UK Blacklisting scandal.

Academia has, perhaps inevitably, become sympathetic, not to the People in Construction, but to the agendas of governments and industry. We research to improve productivity and profit, often unquestionably aligning our ideology to theirs, even though such agendas frequently do not reflect *better* for People in Construction at all.

One obvious challenge to this would be that we are *academics*, we have academic *rigour* as established through the methodologies used in our research. We can use the tools of research to defend us – working from the dominant positivist perspectives we can point to the scientific values of validity, reliability, generalisability to excuse and even negate these influences. We use them to proclaim our objectivity, to ensure the lack of any bias in our work. Yet as our mirror shows us, bias is far bigger than academic methodology and method: everything is political, agendas are inherent in all we do. Even within positivistic parameters there is no such thing as a disassociation from this economic and political context, there is no way to ever claim true objectivity – there is *always* bias.

This is not a call for alternative methodological research; that has been done by many others elsewhere (Seymour et al. 1997; Dainty 2008; Zou et al. 2014 to name but a few) but rather a call for more careful consideration as to *whose* version of better we are using, and how we are asking what better looks like. Even from within the scientific, positivist paradigm we need to be *reflective*, we need to look in our mirror and admit to ourselves what the ideological position for our research actually is. For a discipline where industry engagement is key, it is all too easy to fall into the trap of simply accepting the dominant discourses of ‘progress’ and ‘production’ and ‘growth’ as societal norms, and aligning our research to fit. Yet our role as academics is arguably to be more thoughtful than this, to be much more critical (Chomsky 1967), to look beyond such unspoken assumptions and ensure they are challenged where appropriate, or at the very least even acknowledged.

For example, my own field of health and safety research certainly suffers from this. Safety often finds itself closely aligned to productivity, often positioned as a harmonious partnership despite the inherent conflicts from the way construction work is fundamentally structured and how this then manifests in practice on our sites (Sherratt 2016), the ‘business case’ for safety remaining an ethical hope rather than any proven ‘fact’. Indeed, what does the wider industrial context tell us? Companies exist for profit and shareholders, not workers, so how can this relationship truly exist in harmony. Moreover, with the growth of Corporate Social Responsibility, what company will say they don’t care about the health and safety of the workers? What company will say they prioritise profit over worker wellbeing? Well, that would be none. Yet we continue to ask safety managers their opinions of worker safety, without any consideration of such bias. And is it therefore so very surprising that we then reveal findings that blame the workers for their errors, errors that harm productivity, and for which more training must be the solution, because the company is (of course) already doing all it can? And although this may well have been treated to some application of inferential statistics, it is a clear example of the misuse of method, implemented without any acceptance of the bigger picture. What of systemic safety (Dekker 2006)
failures? What of examining how the safety managers are actually managing safety? What of challenging the fundamental relationship between production and people? What of asking the workers themselves? We are vulnerable to the risk that research simply becomes reporting, rather than any real academic process, where industry is able to present the ‘facts’ and ‘truths’ about worker safety, very much skewed to their own ideas of better as placed within their own wider agendas. But the People in Construction? Well, we didn’t even ask them.

Although this is perhaps a rather melodramatic example, it is unfortunately not all that distant from published reality. And it raises just a few more awkward questions. We should reflect in our mirror and perhaps think a little harder about just what we are asking and, just as importantly, how we are asking it. As academics, we get paid by industry and governments, but should we be so readily sold? Should we simply accept what better looks like to them, and make it our vision too? Should we unquestionably accept what this means for our research? Although what better means to the People in Construction can be easily taken into consideration, their voice all too frequently remains mute, the unfortunate consequence of the golden rule: he who has the gold makes the rules. But that is, of course, unless we speak for them. To make their voice heard as we stop helping companies enhance productivity at the expense of people, stop helping companies’ structure construction work in ways that create some of the most maltreated workers in the world, stop helping companies perpetuate working methods and practices that are unfair, unequal, and even downright dangerous. Why don’t we do things a bit differently?

As Noam Chomsky (1967) said of academics, ‘responsible, non-ideological experts will give advice on tactical questions; irresponsible ‘ideological types’ will ‘harangue’ about principle and trouble themselves over moral issues and human rights.

So I leave you with several further questions. Should we not become more irresponsible? Should we not take up more ideological positions? Should we not use our methodological cunning a little more? Should we not start to raise our voices and indeed harangue? Should we not be the very research group that really does trouble itself over issues of morals and people? Is that not what TG59 is all about, after all?

Thank you very much for listening 😊
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Program Committee

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EXPANDING PREVENTION THROUGH DESIGN (PTD) IN PRACTICE: INNOVATION, CHANGE, AND A PATH FORWARD

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Prevention through design (PtD) is an attractive occupational safety and health intervention because it complements the motivation to eliminate hazards on jobsites before work commences. Implementation of PtD with respect to construction safety and health, however, is not present or widespread in some countries and efforts continue to increase its dissemination. This paper presents results of a research study aimed at determining the impacts of PtD on project team roles and professional practice with the goal of identifying a path forward for further diffusion of PtD in the United States (US) construction industry. The researchers conducted fourteen structured focus group interviews of six different professional communities in the United Kingdom (UK), where PtD is integrated in practice through regulation. Widespread and sustained implementation of PtD in practice reveals changes in attitudes towards worker safety, especially with regard to who can have a positive impact and should play a role, along with improvements in communication, team integration, knowledge transfer, and design innovation. The findings point to a path forward for expanding PtD in the construction community that includes four essential attributes: knowledge, desire (motivation), ability, and execution. Each attribute addresses a fundamental need for affecting positive change and enabling successful PtD diffusion to take place.

Keywords: safety, prevention, design, construction, architecture

INTRODUCTION

Implementation of the Prevention through Design (PtD) concept with respect to construction worker occupational safety and health (OSH) is currently limited in some countries, including the United States (US) (Tymvios et al. 2012). While potential benefits of PtD to construction worker OSH have been identified (Lam et al. 2006; Gambatese et al. 2005; Christensen 2011) and examples of successful and continued PtD implementation exist in practice (Weinstein et al. 2005; Zou et al. 2008), further diffusion of PtD throughout the construction industry is needed. This paper describes a study designed to explore the adaptations that take place as a result of implementing PtD and to understand how the PtD concept can be further diffused throughout the construction industry in the US and other countries. Formal application of the PtD concept, while not extensive in the US, is common practice in some other countries and regions around the world (Aires et al. 2010, Toole et al. 2012). In the United Kingdom (UK), the Construction (Design and Management) Regulations were put in

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place in 1994 to fulfill the European Union’s Temporary or Mobile Construction Sites Directive (Directive 92/57/EEC) (CDM 1994). The CDM Regulations place a duty on design professionals and others involved in the projects to ensure that foreseeable hazards and risks to construction workers are mitigated (MacKenzie et al. 2000).

The many years of PtD experience among UK architects, engineers, owners, constructors, and health and safety professionals present a valuable opportunity to learn how an industry adapts to PtD regulations and sustained implementation. While full understanding and implementation of PtD in the UK may still be forthcoming, and educational institutions have yet to fully integrate PtD into design curricula, practical experience gained so far can provide useful insights for those countries that have yet to experience as high a rate of implementation. The present research study captures the salient perspectives and knowledge from UK companies in the construction sector regarding changes in design and construction practice and project team member roles and attitudes since the adoption of the CDM Regulations. For newly adopted interventions such as PtD, anticipating the potential changes can affect implementation success. Recognizing and planning for direct and ancillary impacts beforehand can facilitate and accelerate dissemination of the intervention.

**CURRENT KNOWLEDGE AND PRACTICE**

When the PtD concept is implemented, the construction industry recognizes beneficial impacts. In their investigation of a PtD process implemented on a project, Weinstein et al. (2005) found that, in 14 of the 26 (54%) changes made to the design of a facility that were studied, trade contractors specifically mentioned that the changes improved safety. Levitt and Samelson (1993) and Hinze (2006) contend that improvement in OSH also positively influences productivity, quality, time, and activity costs. Öney-Yazici and Dulaimi (2014) found that designers in the United Arab Emirates believe that PtD does not limit their creativity. Implementation of PtD has been found to positively impact project aesthetics and ease of structure maintenance (Behm and Poh 2012), and lead to a reduction in construction duration (Behm and Culvenor 2011). A reduction of the time needed from project conception to completion is expected because there is less retrofit required (Christensen 2011). PtD also increases the constructability of a project (Lam et al. 2006). Better designs, reduced workers’ compensation premiums, and reduced environmental damages are some other outcomes associated with PtD that have been observed (ISTD 2003, as cited in Gambatese et al. 2005). Perhaps one of the biggest impacts comes from the efforts within PtD programs to provide construction knowledge and expertise early on in the project timeline (Hecker et al. 2005). Lingard et al. (2014) provide evidence of the potential OSH benefits of ensuring that constructors’ knowledge about construction methods, materials, OSH risks, and means of risk control are integrated into pre-construction decision-making.

As the PtD concept is diffused throughout the construction industry, it is expected that the industry will react and change. Toole (2001) showed how the characteristics of a task, process, and industry have caused innovative building products to follow one or more trajectories. Similarly, Toole and Gambatese (2007) identified four specific trajectories that PtD is likely to cause: (1) increased prefabrication; (2) increased use of less hazardous materials and systems; (3) increased application of construction engineering; and (4) increased spatial investigation and consideration. Morrow et al. (2014) recommend that designers embed PtD into their work and highlight the
importance of dispelling the view that OSH is a lone activity, reserved primarily for
the experts to advise upon and direct when required.

Research has identified reasons for minimal diffusion of PtD in some countries. Barriers to PtD implementation in construction exist (Gambatese et al. 2005; Toole 2005), yet none are insurmountable. Questions remain, however, about how to overcome the barriers to diffusion. Further research is needed to identify a path forward that will be acceptable to industry and lead to the diffusion of PtD. The present study differs from prior research in that it utilizes experiential knowledge from a population where PtD is already practiced and has taken hold. The knowledge gained from diffusion within one country provide an example of what to expect when PtD becomes part of standard practice in another country. Additionally, prior research has mainly targeted direct and quantifiable impacts at the project level (e.g., project cost and quality). For the present study, it is hypothesized that there are additional subtle and latent changes that occur within and amongst project team members and the industry that are important and beneficial as well.

RESEARCH OBJECTIVES AND METHODS

The strategy chosen for conducting the research study was to gather and analyze experiences and perspectives from within the UK construction industry that have been gained from the regulatory mandated application of the CDM Regulations. To do so, the researchers utilized focus group interviews as the mechanism to collect data. While they do not provide a cause and effect relationship, focus groups are particularly applicable when exploring a topic that is difficult to observe and does not lend itself to observational techniques, e.g., attitudes and decision-making (Cohen and Crabtree 2006). Focus groups also provide access to comparisons that participants make between their experiences; a benefit that can be very valuable and provide access to consensus/diversity of experiences on a topic (Cohen and Crabtree 2006), such as PtD.

The focus group interviews were directed at those in the UK who have been impacted by the CDM regulations including architects, design engineers, facility owners and developers, constructors (general contractors and trade contractors), manufacturers and suppliers, and health and safety (H&S) consultants. Selection of the UK as the focus of the study is based on the UK’s experience with PtD in the construction industry. Efforts to mandate that designers consider the safety of those who construct or manufacture their designs dates back to the UK’s Health and Safety (H&S) at Work Act of 1974 (Legislation 2011a). This act obligates designers to ensure that their designs will be safe and without risks to health at all times when the design is being set (installed and/or constructed), used, cleaned, and maintained.

In response to the 1992 EU Directive, the UK passed into law the Construction (Design and Management) Regulations (CDM), which became effective in March 1995 (Legislation 2011b). The objective of the Regulations is to reduce the total amount of risk which is introduced into the construction process by effective management of OSH upstream of the construction activity. The crux of the Regulations affecting the design profession is that the regulations place a duty on the designer to ensure that any design which they create avoids unnecessary risk to construction workers (MacKenzie et al. 2000). The CDM Regulations were revised in 2007, aiming to reduce paperwork burdens and streamline the process. In April 2015, revised CDM Regulations were approved that more closely follow the requirements of the EU Directive (HSE 2015). The fundamentals of PtD remain but the details, such as
how the roles are allocated, have changed. The present research was conducted while the 2007 CDM Regulations were in force. The findings from the study do not take into account changes made to the Regulations in 2015. It is expected that there will be changes in practice as a result of the 2015 revisions, which include the requirement of appointing a principal designer. While design professionals may initially not feel comfortable taking a lead or co-leadership role in safety, this appointment is likely to further engage the design community in PtD and promote collaboration between design and construction disciplines on a project.

The targeted participants of the focus group interviews were representatives of six different professional “communities” within the UK construction industry: (1) architects, (2) design engineers, (3) facility owners/developers, (4) constructors (general contractors and trade contractors), (5) manufacturers/suppliers, and (6) H&S consultants. A total of 12 focus group interviews were initially targeted, two for each professional community in order to have repeated groups (Krueger 2002), and to provide multiple data collection opportunities for each community within the resources allotted for the study.

Guidance on conducting focus groups indicates selecting similar types of people to participate in the focus group interviews (Krueger 2002). The sample of focus group participants was taken from individuals who are members of, or whose employers are members of, one or more of the following construction industry professional organizations in the UK: Chartered Institute of Building (www.ciob.org.uk), Royal Institute of British Architects (www.riba.org), Institution of Civil Engineers (www.ice.org.uk), British Safety Council (www.britishsafetycouncil.co.uk), and Association for Project Safety (www.associationforprojectsafety.co.uk). There may be some overlap in membership across the organizations.

Consistent with recommendations for conducting focus groups (Krueger 2002), convenience samples were used to ensure diversity within each professional community. Additionally, the targeted size of each focus group, as recommended for focus groups (Krueger 2002), was 6-9 participants. The researchers developed a series of questions exploring the PtD concept and its application for use as a guide in the focus group interviews. In addition to general demographic information about the participants (position, years and type of experience, education, employer type and size, experience with CDM Regulations, etc.), the focus group questions addressed each of the research questions posed above. The first focus group session was used as a pilot to ensure the applicability and clarity of the questions.

The focus group sessions were scheduled over several weekly periods for approximately two hours per focus group at times that were convenient for participants. Each individual who responded with interest in participating was contacted via e-mail and/or telephone to confirm their voluntary participation. Interested participants then self-selected a scheduled focus group session in which to participate. As a result, the number of participants varied between focus groups. Due to some focus group sessions containing only a few participants, additional group sessions were set up to ensure participation by members of all of the targeted communities. The researchers ultimately conducted 14 focus groups with a total of 110 participants.

RESULTS AND ANALYSIS

At the conclusion of each focus group session, the researchers asked the participants to submit the completed demographic forms. In some cases, demographic forms were
not completed and submitted by participants. A total of 62 demographic forms were received (56% of participants). The following is a summary of the participant demographics:

- **Type of firm for which the participant works (multiple selections allowed):**
  - H&S consultant (25% of responses), engineering (19.3%), architect (18.2%), contractor (9.1%), facility owner (8.0%), subcontractor (6.8%), manufacturer (4.5%), and other (9.1%).

- **Services provided by the participant’s firm (multiple selections allowed):**
  - H&S consultant (25.6% of responses), project management (21.6%), construction (19.9%), engineering (17.0%), and architecture (15.9%).

- **Firm size (number of employees):**
  - Greater than 1,000 employees (42.6% of participants), 500-1,000 employees (11.5%), 250-499 employees (6.6%), 100-249 employees (13.1%), 50-99 employees (1.6%), 10-49 employees (8.2%), and 1-9 employees (16.4%).

- **Years of experience:**
  - Mean of 23.0 years of experience working in the industry, and 11.3 years working with the CDM Regulations.

A large portion of the focus group participants work for H&S consultancy firms. The roles that these individuals carry out can vary significantly with respect to the type of work actually performed and the project phase in which the work is performed. Nevertheless, their perspective is especially of interest to the study because of their involvement in PtD and understanding of safety management practices. With regard to design professionals, 25 of the 62 participants are either an architect or design engineer. Contractors and owners make up even smaller percentages of participants. The number of participants in each role may impact the overall nature of the responses. In addition, the participant selection process was not random. The distribution of participants based on expertise, along with the selection process, limit the generalizability of the results to the population at large. Further research based on a larger, randomly-selected sample size and different sample distribution will provide greater confidence in the results.

During the focus group interviews, participant responses and discussion were recorded (hand-written and tape-recorded) for later analysis. Analyses consisted of basic descriptive statistics and text analysis to understand the participants’ collective perspectives. Using the transcription files, the researchers organized the participant responses according to each question posed during the focus group session. The researchers then conducted content analyses of the responses to identify words, phrases, and comments associated with each research question posed. Those that were stated with high frequency were noted in order to answer the research questions posed, to identify key concepts, themes, and terms, and to develop an understanding of the similarities and dissimilarities between different parties and projects. The analyses were conducted using multi-level keyword searches of the transcribed focus group discussions to target and confirm trends in the response data. The findings of these analyses are provided below for each research question posed.

1. **How has the CDM legislation affected project design, construction, and safety?**

   For design, the most often cited changes were: increased modularization and constructability; earlier incorporation of construction knowledge; inclusion of more engineering controls in the design; greater use of less hazardous materials; and slight increases in design cost and design duration. Constructors have experienced: increased
prefabrication; reduced material handling and less use of scaffolding; and more use of specialized equipment to remove the worker from hazardous conditions and eliminate hazardous operations. There was no clear trend in the responses regarding impacts on construction cost and duration. In addition, the participants recognized improvements in construction quality, worker productivity, and end-user H&S.

2. How has involvement in PtD affected perceptions of safety, roles on the project, and organizational and professional culture?

Changes have, to a great extent, been greater collaboration and communication amongst project teams and specifically between designers and constructors. A different perspective on safety, and the role which each individual can and should play in regard to safety, have also been positively affected. OSH is now viewed as important to the overall success of a project and designers now generally view construction OSH as an imperative. There is a changed perspective on responsibility for, and designer’s ability to affect, OSH. Construction OSH now immediately comes into conversations during planning and design. In terms of roles on projects, there is greater recognition that, as part of the project team, designers have a role and responsibility with regard to OSH. Project management efforts now include active assessments and management of OSH risks; OSH is included in project feasibility assessments. Other parties besides the architect/engineer, such as the quantity surveyor and owner/client, are playing a bigger role in project safety leadership. Organizational and professional culture impacts have been: closer relationships between disciplines (working more as collaborators); greater consideration of the needs and priorities of the other disciplines; more thorough design approach (better professional design practice); and OSH now spread to a greater extent throughout the disciplines.

3. To what extent have innovative processes and products been developed in response to the directive to address safety in design?

The focus group participants provided examples of changes to the physical features of designs, the design process and tools, communication of safety hazards, and safety organizations. Most are project-specific; the intent and application was to solve a problem on a project. Diffusion beyond the project to other projects or to other companies has been limited. In regard to the physical features of designs, most of the changes have been revised designs to eliminate hazards and facilitate safe construction operations. That is, rather than creating some new design or product, it is more common for existing designs to be slightly revised. Examples of this type of change are: including anchorage points for fall protection in the design; modifying the size, location, shape, or materials of a design; and designing such that the systems can be prefabricated. In addition, much of the change has occurred in the structural, mechanical, and electrical systems within a facility. When new designs are created, the examples provided by the focus group participants were most often targeted at modularizing the designs and at designs of features used in the maintenance of structures (e.g., window washing systems).

4. What is done differently now compared to practice prior to the CDM Regulations?

Much of the difference since the implementation of the CDM Regulations is related to how information is developed and shared, and how communication occurs. The differences noted ranged from general project team interactions to specific details on project documents. The project development process now includes more off-site construction and modularization, greater collaboration between design and
construction personnel, and heightened focus on safety throughout the project lifecycle. Related specifically to differences in the project documents, some designers are now placing symbols on drawings to alert constructors of potential hazards (e.g., a picture of a person tripping where a tripping hazard exists). Notes describing potential safety hazards and needed personal protection are also being added to design documents. Within design firms, on-line networks and databases have been developed to collect and share OSH knowledge. These systems are often tied to a firm’s lessons-learned resources. Lastly, many different variations of risk assessment tools have been created to help identify, evaluate, and mitigate the risks present in a design, as well as provide a formal record of conducting a risk assessment.

5. **How has management of projects changed under the CDM Regulations?**

Overall, the greatest change has been the additional efforts to formally manage OSH risk. This effort includes ensuring that the appropriate parties and roles are in place, the required documentation is created, and OSH risks are recorded and addressed. Whereas construction worker OSH was previously limited to the management within the constructor’s organization, it is now expanded to the entire project team.

6. **What can the US and other countries learn from the UK’s experience and what should be included in a path forward to enhance diffusion of PtD?**

The focus group responses provide an indication of the needs and best practices for expanding PtD in the US and other countries in the absence of legislation similar to the CDM Regulations. The needed practices and resources are summarized as follows:

- Involvement of the owner/client.
- Designers knowledgeable about: how their designs influence construction means and methods; OSH hazards commonly present on construction sites; and designs which mitigate the hazards.
- Contractor involvement to ensure inclusion of construction knowledge.
- Supporting design tools and resources, including a design risk assessment process.
- A means to motivate implementation of PtD.
- Engaging designers to convince and show them that they play a key role.
- Responsibility for implementing PtD.
- Expanding involvement in PtD beyond the main project team members.

In addition to the open-ended discussion related to the research questions described above, the focus group participants brought up, or the conversations led to, other issues important to PtD. Below are some additional issues and experiences that arose from the focus group interviews which are of interest to PtD implementation and diffusion:

- Much of the focus remains on end-user safety, not construction worker OSH.
- The true benefit comes from working together and communicating; the CDM Regulations were simply the catalyst to enhance project team member communication and integration that ultimately lead to improved safety.
- Changing designer culture in a way that respectfully engages designers recognizes that the burden should not solely be placed on the designer and design culture; placing blame in such a way is not beneficial to the industry and to worker OSH.
• There remains an unclear extent of responsibility for mitigating OSH risks in the design (i.e., how far should a designer should go to design out hazards).
• There is an unclear understanding of, and lack of confidence in, the ability for designers to positively impact construction safety as part of their design role.
• It is common to have a misdirected focus on meeting the CDM Regulations instead of implementing PtD.
• The PtD message needs to be expanded beyond the main project team members.

CONCLUSIONS
As an OSH intervention, PtD is an attractive concept. PtD provides an opportunity to eliminate and reduce OSH hazards from the workplace and, therefore, greatly lower OSH risk. Fewer jobsite hazards means a safer place to work; there is less of a chance of getting injured. When employees feel safer on the job and are not distracted by unsafe conditions, improvements in worker morale, work quality, productivity, and organizational culture follow. Consequently, PtD is also an appealing proposition for employers, especially construction employers. PtD helps to fulfill moral and regulatory obligations in regard to employee safety, health, and welfare, and can also lead to enhanced financial gains and recognition for a firm. The potential benefits from implementing PtD processes and practices in a workplace are clearly recognized.

When PtD is implemented, the design impacts are typically expressed in increased modularization of the design, and in modified designs to accommodate and promote safer construction methods. When a safety hazard is identified, and alternative construction methods are desired to more safely conduct the work, the design is changed to accommodate the alternative methods. The alternative methods may be implemented on the jobsite, although much emphasis is put on prefabrication. PtD promotes and leads to prefabrication away from the jobsite to eliminate safety hazards on the jobsite.

To implement PtD, design for safety checklists are now commonly used along with risk assessment pro forma. These tools are applied as part of PtD processes which commonly consist of multiple design and constructability reviews throughout the planning and design stages. Utilizing constructor, H&S consultant, and end-user input, “safety constructability” reviews are conducted to identify hazards and manage the risk. The result is modified designs along with additional hazard communication information placed on the design drawings to alert constructors of hazards and communicate safety measures to be taken or regulations to follow. Caution is given, however, as not to create complicated, crowded, and overly extensive drawings by adding too many notes, especially notes that indicate an obvious hazard and are likely superfluous. Competency in understanding drawings and fulfilling project team roles should be addressed. A suitable contractor should be able to address the OSH hazards associated with typical designs. Designers do not have to inform constructors of “obvious” hazards; only hazards that are unusual or derive from some unique aspect of the design.

Perhaps the most important impact of implementing PtD is the change in the project team. There has been a transformation in how project team members interact, communicate, regard construction worker OSH, and conduct their work. These changes include: more and improved communication, greater project team integration, increased interest in safety, and better overall professional practice. These changes are
the success of PtD, and what ultimately have led to safer construction sites and improved worker OSH.

The changes to the project team, professional practice, and industry culture are important results and one of the successes attributable in part to the CDM Regulations. The traditional model for construction worker OSH risk management in the US has been to rely solely on the constructor to implement primarily downstream, lower-level safety controls. PtD is an effective intervention that can be part of a new model to address and improve construction worker OSH. Much like the current trend towards integrated project delivery and building information modeling, PtD is a model which involves integration of design and construction, collaboration between all project team members, and all parties playing a role. It is also a model in which a choice is made to design out the hazards before construction begins rather than protecting against them during construction.

Changing an industry such that it adopts a new model for managing worker OSH risk is a difficult prospect. Making the change requires recognition that the current model, identified and held onto tightly as being standard practice, is not the best model. It must be accepted that standard practice is not necessarily synonymous with best practice. This point is highlighted in the T.J. Hooper legal case in the US (Eastern Transportation Co. v. Northern Barge Corp., 60 F.2d 737). This 1932 case centered on oceangoing barges lost in a storm, including one named T.J. Hooper that, consistent with standard practice at the time, were not equipped with radio receiving sets to receive storm warnings. Billings Learned Hand, US Court of Appeals Second Circuit Judge, responded with the Court’s opinion regarding whether the barges should have had receiving sets onboard as follows: “Is it then a final answer that the business had not yet generally adopted receiving sets? There are, no doubt, cases where courts seem to make the general practice of the calling the standard of proper diligence; we have indeed given some currency to the notion ourselves. Indeed in most cases reasonable prudence is in fact common prudence; but strictly it is never its measure; a whole calling may have unduly lagged in the adoption of new and available devices. It never may set its own tests, however persuasive be its usages. Courts must in the end say what is required; there are precautions so imperative that even their universal disregard will not excuse their omission.”

PtD as a construction safety intervention is currently being employed, not only in the UK and countries possessing similar legislation, but also by some companies in the US and other countries. An environment of acceptance is needed for PtD to diffuse throughout the industry. Those in architecture, engineering, and construction who are involved in its implementation must accept that current practice is insufficient and should be augmented with the inclusion of PtD. Causing this change, a change that requires internal reflection by the design community on its own practices, has so far been slow to occur and spurned by many in the US. Continued reflection and consideration by the design community, and diligence by industry organizations in PtD promotion, are needed.

RECOMMENDATIONS

Actions undertaken to expand PtD must be selected and implemented with consideration given to the structure and nature of both the construction industry and the PtD concept. Doing so increases the likelihood of PtD acceptance and diffusion, and ultimately its effectiveness and impact. Prior research suggests that diffusion and implementation of a construction worker OSH intervention such as PtD requires
attention to four key attributes: knowledge, desire (motivation), ability, and execution (Behm and Culvenor 2011; Gambatese et al. 2005; Hecker et al. 2005; MacKenzie et al. 2000; Toole 2005; Toole et al. 2012). Each attribute addresses a fundamental need for affecting positive change and enabling desired outcomes. The research findings reveal that each of the attributes needs to be fulfilled in some way to realize PtD success. Evaluation of the focus group results shows that, for each attribute, a variety of components can be identified that exist to address and accentuate the attribute within the context of PtD in construction. Selection and pursuit of each component depends on the resources available and industry environment. Accordingly, the combination of prior research results combined with the results of the present study highlight the key attributes and related components shown in Figure 1 (Gambatese 2013).

Figure 1: Attributes and components for PtD diffusion and implementation (with permission Gambatese 2013)

Careful consideration should be given to the selection, pursuit, and timing of components included in a PtD action plan. The availability of resources, industry culture, political environment, and timing of implementation (i.e., the right information at the right time) must be considered. While a component may support a given attribute, its implementation may not be desired, or may be delayed, based on the current nature of the industry and expected impacts.

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REFERENCES


Assignment of expatriate construction professionals (CPs) is a common strategy for construction organizations to manage their construction projects outside their home country/district. The expatriate assignment is very expensive in terms of its cost for compensating expatriated CPs and the significance of their performance to the project success. However, expatriated CPs used to suffer from underperformance, while rare study has investigated this problem through the stress management perspective. Given that stress is prominent among expatriated CPs, current study set out to fill in this research gap. Through purposive sampling technique in accordance with certain criteria, a questionnaire survey was adopted to collect data from expatriated Hong Kong CPs who are working in Mainland China. A total of 126 data were collected and are subjected to a series of statistical analyses, including correlation and regression analysis. The results show that there is both negative linear relationship and inverted U-shaped relationship between same pair of stress and performance for expatriated CPs, namely frustration decreases their intention to stay. This indicates that the excessive stress level has been harming the expatriated CPs’ intention to stay. In addition, unhappiness negatively reduces belongingness, but it affects trust among colleagues in an inverted U-shaped manner. To manage the expatriated CPs’ stress and improve their performance, the construction organizations are recommended to provide counselling, therapy and other stress management program like mindfulness-based stress management program.

Keywords: Construction professionals; Expatriate; Performance; Stress

INTRODUCTION

Due to the demanding nature of construction industry, majority of construction professionals (CPs) have been suffering from high level of stress (Chartered Institute of Building 2006). Excessive high stress is detrimental and often lead negative consequences to individual CPs (e.g., depletion of work ability, morality and suicide; Finney et al. 2013) and construction organizations (e.g., high turnover, absenteeism and low moral; Brockman 2013).

It has been very common for Hong Kong (HK) CPs assigned to outside of their hometown for working, especially to Mainland China (MC; Wong et al. 2004).
statistics show that around 30% of HK CPs are working in MC (Census and Statistics Department 2011). The expatriate assignment is generally expensive and very important for any companies (Chen et al. 2002), while expatriate failure and expatriates' underperformance are not uncommon (Insch and Daniels 2002). In fact, the expatriated CPs needs to adapt themselves to the differences in both work and private life aspects between home and hosting country/district (e.g., language – Cantonese in HK vs Mandarin in MC; working practices – Contract & regulations in HK vs Relationship in MC; isolation from family; Brown 2008), which may further exacerbate their stress level during the expatriate assignment.

Although studies have attributed the expatriated employees’ poor performance to factors, rare study has investigated the root causes of expatriated CPs’ poor performance from the stress management perspective. Therefore, the aim of current study is to fill in the research gap through the investigation of the complicated relationship between stress and performance for expatriated HK CPs who are working in MC through a scientific and objective research design.

**STRESS**

Stress has been defined as the individuals' nonspecific responses to unmanageable demanding (Selye 1956). It is common that the stress manifests as frustration, unhappiness, anxiety and loss temper, which can be regarded as emotional stress (Baba et al. 2009). Unmanageable stress is problematic, because it can result in significant loss to both individual and organization, such as various health problems, high absenteeism, and accidents (Finney et al. 2013).

**PERFORMANCE**

The expatriated CPs’ performance is critical to the success of the construction project and the expatriate assignment. The performance should not only include the job-specific task proficiency, but also the support and facilitation to the team and organization (Campbell 1993). The construction tasks are also often very complicated, and it is impossible for individual CPs to finish the tasks alone. This necessitates the cooperation between expatriated CPs and their local colleagues. Hence, in current study, three performances were taken into consideration, including the task performance, interpersonal performance and organizational performance. The task performance concerns about the expatriated CPs’ productivity, critical thinking and the correction of decision making; the interpersonal performance focus on the interactions between expatriated CPs and their local colleagues, which can be manifested as satisfaction of relationship, goodness of relationship, and trust among colleagues; and the expatriated CPs’ organizational performance is mainly reflected by their commitment to their company (Leung et al. 2008, 2011).

The negative effect of stress on employees’ performance has also been widely documented, including reduction of productivity, harms of group cohesion and cooperation, and increases in turnover intention (e.g., Brockman 2013; Lei et al. 2004). However, it has also been claimed that for neither high stress nor low stress leads to the improvement of the performance on complex tasks, while only moderate
stress is optimal (Yerkes and Dodson 1908; Jex 1998). In fact, some studies have also reported the possible curvilinear relationship between stress and performance for construction employees (e.g., previous findings show that stress can affect CPs’ organizational performance in a U-shaped manner and interpersonal performance in inverted U-shaped manner; Leung et al. 2008).

CONCEPTUAL MODEL
In accordance with the extensive literature, a conceptual model for explaining the hypothesized relationships between stress and performance for expatriated HK CPs is proposed (see Figure 1). The conceptual model shows that the emotional stress should affect the expatriated HK CPs’ three performance, including task, interpersonal and organizational in linear and/or curvilinear manners.

Figure 1  A Conceptual Stress–Performance Model for Expatriated HK CPs in MC

RESEARCH METHOD
Measurement
To test the hypothesized linear and curvilinear relationships between stress and performance for the expatriated CPs who have been assigning to MC by their HK-based company, a questionnaire survey was administered among them through many manners, including fax, email or mail to individual expatriated CPs. In addition to ask the respondents’ demographic information, the questionnaire includes the scales for measuring stress (Maslach et al. 1996; Leung et al. 2012, 2015); and performance (i.e., task, interpersonal, and organizational performance (Leung et al. 2005, 2006, 2008). All the scale measurements in the questionnaire are adapted from previous validated studies with some modification for expatriated CPs. Respondents are requested to use a 7-point Likert scale from 1 (strongly disagree/rarely true) to 7 (strongly agree/totally true) to rate their agreement with statements about their stress and performance.

In order to control the quality of the data collection, purposive sampling technique was applied (Patton 1990). Participants were selected based on several criteria (1) they are permanent HK residents; (2) they are CPs working for developers, consultants, main contractors, subcontractors and other stakeholders in the construction industry; and (3) they were required to work in MC at the time when the survey was distributed.

Statistical Analyses and Results
Out of 500 questionnaires that were distributed out to expatriate CPs, a total of 126 acceptable questionnaires were returned, representing a response rate of 25.2%.
Among the 126 expatriated CPs, 46.4% are aged between 40-49, 30.4% are aged between 30-39, 16% are aged over 50, and only 7.2% are aged between 20-29. As for gender, around 90% of respondents are male, which reflects the male-dominating nature of the construction industry. The statistic of their demographic information also shows that around 75% of respondents got married, and remaining 25% are single; and over 70% of respondents have at least one child.

Current study aims to investigate the relationship between stress and performance for expatriated CPs, and correlation analysis and regression modelling were used to fulfil this research purpose. Correlation analysis can identify both the strength and direction of the relationships between two variables (i.e., stress and performance in current study). The results of correlation analysis are shown in the following Table 1. Only the relationships confirmed with statistical significance (at 0.05 and 0.01 level) will be considered.

<table>
<thead>
<tr>
<th>Stress</th>
<th>Task Perf.</th>
<th>Interpersonal Perf.</th>
<th>Organizational Perf.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TP1</td>
<td>TP2</td>
<td>TP3</td>
</tr>
<tr>
<td>Linear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES1</td>
<td>-.109</td>
<td>.089</td>
<td>.005</td>
</tr>
<tr>
<td>ES2</td>
<td>-.189*</td>
<td>.030</td>
<td>.017</td>
</tr>
<tr>
<td>ES3</td>
<td>-.182*</td>
<td>.000</td>
<td>.014</td>
</tr>
<tr>
<td>Curvilinear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES12</td>
<td>-.087</td>
<td>.131</td>
<td>.038</td>
</tr>
<tr>
<td>ES22</td>
<td>-.224*</td>
<td>.042</td>
<td>.042</td>
</tr>
<tr>
<td>ES32</td>
<td>-.204*</td>
<td>.030</td>
<td>.044</td>
</tr>
</tbody>
</table>

**Note:** ES1 = Frustration; ES2 = Unhappiness; ES3 = Anger; TP1 = Productivity; TP2 = Critical thinking; TP3 = Decisions making; IP1 = Satisfaction with relationship; IP2 = Goodness of relationship; IP3 = Trust among colleagues; OP1 = Intention to stay; OP2 = Belongingness; OP3 = Commitment to organization

**Correlation significant at the 0.01 level (2-tailed).**

*Correlation significant at the 0.05 level (2-tailed).

The results show that there are linear relationships between stress and performance. For task performance and stress, productivity is negatively related to unhappiness (ES2: -0.189) and anger (ES2: -0.182). For interpersonal performance and stress, trust among colleagues has negative relationship with unhappiness (ES2: -0.212). For organizational performance and stress, intention to stay is negatively correlated with frustration (ES1: -0.262) and unhappiness (ES2: -0.199); and belongingness is negatively related to unhappiness (ES2: -0.199). No linear relationship was found between critical thinking and stress, decision making and stress, satisfaction with
relationship and stress, goodness of relationship and stress, and commitment to organization and stress.

The results of the correlation analysis also show the curvilinear relationships between stress and performance. For task performance and stress, productivity has an inverted U-shape relationship with unhappiness (ES2: -0.224), and anger (ES2: -0.204). For interpersonal performance and stress, satisfaction with relationship has an inverted U-shape relationship with unhappiness (ES2: -0.183); and trust among colleagues has an inverted U-shape relationship with unhappiness (ES2: -0.206). For organizational performance and stress, intention to stay has an inverted U-shape relationship with frustration (ES1: -0.287) and unhappiness (ES2: -0.218). No other curvilinear relationship was found between stress and performance.

To investigate the prediction of each performance from a set of stress, regression analysis with stepwise method has been used in current study (Hair et al. 2010). It was applied to investigate both the linear and curvilinear relationships between stress and performance. Based on the significance of the p-value, a total of 4 regression models were developed for explaining both linear (2) and curvilinear (2) relationships between stress and performance. For the linear relationships, the results of regression analysis show that: intention to stay is negatively influenced by frustration (see Model 1); and belongingness is reduced by unhappiness (see Model 2). Two regression models were also established to explain the curvilinear relationships between stress and performance: trust among colleagues has an inverted U-shape relationships with unhappiness (see Model 3); and intention to stay has an inverted U-shape relationship with frustration (see Model 4).

<table>
<thead>
<tr>
<th>No.</th>
<th>Dependent Variables</th>
<th>Independent Variables</th>
<th>Beta</th>
<th>Sig.</th>
<th>VIF</th>
<th>R</th>
<th>R square</th>
<th>F(A)</th>
<th>Sig.</th>
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</thead>
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<tr>
<td>1</td>
<td>OP1</td>
<td>Constant</td>
<td>.000</td>
<td>.262</td>
<td>.069</td>
<td>8.387</td>
<td>.005</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>ES1</td>
<td>-.262</td>
<td>.005</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>OP2</td>
<td>Constant</td>
<td>.000</td>
<td>.199</td>
<td>.040</td>
<td>4.707</td>
<td>.032</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>ES2</td>
<td>-.199</td>
<td>.032</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>IP3</td>
<td>Constant</td>
<td>.000</td>
<td>.300</td>
<td>.090</td>
<td>5.606</td>
<td>.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES22</td>
<td>-.180</td>
<td>.049</td>
<td>1.014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>OP1</td>
<td>Constant</td>
<td>.000</td>
<td>.287</td>
<td>.082</td>
<td>10.222</td>
<td>.002</td>
<td></td>
<td></td>
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<td>.002</td>
<td>1.000</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note: ES1 = Frustration; ES2 = Unhappiness; ES3 = Anger; PS1 = Headache; PS2 = Lose appetite; PS3 = Skin problem; TP1 = Productivity; TP2 = Critical thinking; IP1 = Satisfaction with relationship; IP3 = Trust among colleagues; OP1 = Intention to stay; OP2 = Belongingness.
DISCUSSION

To ensure the reliability of the current study in accordance with the research triangulation, only the results confirmed by both correlation analysis and the regression models were used to develop the Stress–Performance model for expatriated CPs (see Figure 2). The Stress–Performance model shows that all the linear relationships between stress and performance are negative, e.g., frustration reduces expatriated HK CPs’ intention to stay; and unhappiness harms their belongingness to the company. The results of current study also confirm that an inverted U-shaped relationship exist between stress and performance, including frustration and intention to stay; and unhappiness and trust among colleagues.

![Figure 2: A Stress–Performance Model for Expatriated HK CPs in MC](image)

Note: —— significant negative relationship confirmed by correlation analysis; ——— significant inverted U-shaped relationship confirmed by correlation analysis.

**Stress and Performance**

The association between frustration and employees’ turnover behaviors has been claimed (O'Connor 1984). However, current study found that there are both negative linear relationship and inverted U-shaped relationships between frustration and expatriated HK CPs’ intention to stay in MC. Combination of the negative linear relationship and inverted U-shaped relationship indicates that the expatriated HK CPs generally suffer from a high level of frustration and frustration has already been imposing negative influence on their intention to stay in MC (i.e., negative linear relationship and right hand sight of the inverted U-shaped relationship). Perhaps, the expatriated HK CPs may attribute their severe frustration to their organization’s expatriate assignment, and thought that their company may not be a good one for them to work. Therefore, it is reasonable to infer that they want to leave their company to release themselves from the frustration.

Unhappiness, as another emotional stress, negatively predicted the expatriated CPs’ belongingness and has an inverted U-shaped relationship with trust among colleagues. Belongingness concerns about whether expatriated HK CPs are proud of being a part of their company. It is reasonable to infer that if the expatriated CPs attribute their unhappiness to their company’s expatriate assignment, their belongingness to their company will be reduced.
It has been claimed that trust can affect individuals’ happiness (Kuroki 2011), while current study found that there is actual an inverted U-shaped relationship between trust and unhappiness. Perhaps, when the expatriated HK CPs are unhappy because of encountering new problems in MC, and they got help and support from their local colleagues. Under such a circumstance, their trust for their colleagues increases along with the increase in unhappiness (left hand side of an inverted U-shaped relationship). However, once they become very unhappy (right hand side of an inverted U-shaped relationship), it is likely for them to have negative perception of their local colleagues, and thus, trust for their local colleagues will be reduced.

**RECOMMENDATIONS**

This study confirmed that expatriated HK CPs have been generally suffering from high stress (i.e., negative liner and right hand side of inverted U-shaped relationship) and stress is a critical contributor to the expatriated CPs’ poor performance (e.g., frustration harms intention to stay and unhappiness reduces belongingness). Given that the performance of expatriated CPs directly affects the project success, construction companies are strongly recommended to take actions properly for their expatriated CPs well managing their stress. For example, the cognitive therapy has been regarded as useful for releasing various stress symptoms; the 24-hours counselling services (e.g., 24 hours hot-line) can support stressed CPs properly understanding and managing their stress, which can prevent the further development of stress; and the mindfulness-based stress management reduction program can psychologically reduce individuals’ emotion stress in terms of frustration and unhappiness (e.g., Kabat-Zinn et al. 1992; Zhang and Wu 2014). These stress management practices have wide applicability to people with different professions and culture and, are expected to improve the employees’ performance if they can be adopted by the MC in the industry for our expatriated HK CPs.

**Future Study**

Although bias may be existing in the questionnaire survey, several remedial actions have been made: 1) scales used in current study have been empirically validated; 2) selection criteria were adopted for the selection of appropriate participants; and 3) only the relationships confirmed by both correlation and regression analyses were used to develop the final model and make conclusion (i.e., within-method triangulation). It is recommended to conduct future research involving the adoption of qualitative research methods (e.g., case study) and the investigation of mediating and moderating effects.

**CONCLUSIONS**

Because of the close distance and high frequent interactions between HK and MC, it is common for construction organizations to assign HK CPs to work in MC. However, it is very common for expatriated CPs to suffer from underperformance and high stress, because of the conflicting differences in both private life and work aspects between them and their local colleagues. Based on the results confirmed by both statistical analyses, a Stress–Performance model was established for expatriated HK CPs which
contains both linear and curvilinear relationships. It shows that both negative linear relationship and inverted U-shape relationship exist between same pair of stress and performance, namely frustration and intention to stay. This finding indicates that stress is relative high and has already been harming expatriated CPs’ performance. This study also found that unhappiness reduces the expatriated CPs’ belongingness to their organization, and it also affects the trust between expatriated CPs and their local colleagues in an inverted U-shaped manner. In order to improve expatriated CPs’ performance, stress management is urgently needed. The construction companies are suggested to provide various methods to manage their expatriated employees’ stress, including provision of counselling, therapy, and stress management program like MBSR training.

ACKNOWLEDGEMENT

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REFERENCES


THE ROLE OF AFTER-HOURS, WORK-RELATED CONTACT IN WORK-TO-FAMILY CONFLICT AND PSYCHOLOGICAL DISTRESS EXPERIENCED BY CONSTRUCTION PROFESSIONALS

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The boundaries between work and family/social life are becoming increasingly blurred for construction professionals, largely as a result of the convenience of modern communications technology for after-hours, work-related contact. When the work/family/social life balance is disturbed, conflict arises and some level of psychological distress is likely to occur. A conceptual integrated model of work-to-family conflict and psychological distress is proposed. Demographic characteristics, job pressures, job autonomy and control, and after-hours, work-related contact are posited to explain work-to-family conflict and psychological distress. Regression analysis and structural equation modelling are used to test the model, using survey questionnaire data gathered from 630 construction professionals in South Africa. The findings show that years of work experience, job pressure, and work-to-family conflict are direct determinants of psychological distress. Construction organisations owe a duty of care towards their employees and intervention strategies should directly address the need for, and level of, after-hours, work-related communication. Employers should also enhance employees’ job autonomy and control as much as possible. Employees need to be more assertive in setting boundaries between their work and family/social lives and the amount of after-hours, work-related contact they are prepared to tolerate.

Keywords: work contact, work-to-family conflict, psychological distress, construction professionals, South Africa

INTRODUCTION

Few workers enjoy lives where their work and family/social environments can be maintained as entirely separate domains and where neither intrudes temporally upon the other. The boundaries between these environments are becoming increasingly blurred, largely due to the development of communications technology and the easy availability of personal devices such as smart phones, notepads and notebook/laptop computers, each with comprehensive connectivity. Madden and Jones (2008) found that 45% of survey respondents reported using such technology in the evenings or at weekends to engage in work contact. According to Schieman and Young (2013: 244), ‘work contact’ is the “frequency with which workers receive and send work-related communications

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(e.g., emails, phone calls, text messages) outside of regular working hours.” Importantly, such contact may involve a variety of devices that are not mutually exclusive. Nor are the contexts in which contact occurs. The affected worker is not necessarily at home or in a social environment, such as a restaurant, but may be travelling or visiting another office.

Lingard and Francis (2009) claim that work-related contact, at least in the family domain, gives rise to ‘work-to-family conflict’ in the construction industry. Such conflict is associated with higher levels of family and personal distress (Lingard and Sublet, 2002).

Work-to-family conflict (WFC) arises from incompatibility between the demands and pressures associated with work and those arising in the worker’s family or social environment (Greenhaus and Beutell, 1985). This may have adverse psychological consequences (Kinnunen et al., 2006), including depression and anxiety (Frone et al., 1996). These consequences can be given an umbrella label of “psychological distress” (Facey et al., 2015: 995) and are regarded as mental illnesses, attributable to work-related stress, by the Australian Safety and Compensation Council (2006). People vary in the extent to which they segment or integrate work and family roles (Nippert-Eng, 1996) and the ways in which the boundaries between them are crossed (Ashforth et al., 2000) in attempting to achieve a balance (Allen et al., 2014). Boundary control strategies need to be two-way: employer-directed and family/worker-directed.

The job-demands–resources (JD-R) model of workplace stress (Bakker and Demerouti, 2007) provides a useful perspective for exploring such conflicts and imbalances in terms of the characteristics of work, the nature of the expectations imposed upon workers, and the extent and type of resource needed and available to meet those demands. The JD-R model proposes that work that is high in demands from the worker, but inadequate in resources will lead to a higher likelihood of work-related stress occurring. The factors driving the JD-R model thus provide a useful underpinning for hypothesising the relationship between work contact, work-to-family-conflict, and psychological distress among construction professionals in South Africa. These factors can then be incorporated as variables in an explanatory model that then form the basis for specific item catalogues in a data collection instrument design. The research question to be addressed is: What are the strengths and directions of relationships between after-hours, work-related contact (and other work-related factors including job autonomy and control, and job pressure); work-to-family-conflict; and psychological distress as experienced by construction professionals? The aim of the research is to gain a fuller understand those relationships so that strategies and interventions to prevent, mitigate and alleviate work-related stress and psychological distress can be better framed and targeted.

**RESEARCH DESIGN & METHOD**

**Conceptual explanatory model**

The variables in a conceptual explanatory model of work contact and work-to-family conflict and psychological distress are based upon the JD-R theory of workplace stress and are shown in Fig. 1.

Work experience, gender, domestic situation (relationship status and number of children), and employment position level (hereinafter termed ‘employment status’) may be regarded as exogenous variables as they are deemed as given conditions for the
respondent. These exogenous variables are hypothesized to explain work-related aspects such as job autonomy and control, job pressure, and work contact. Job-characteristics (job autonomy and control and job pressure) and work contact are assumed to co-vary and each is hypothesized to predict work-to-family conflict. Finally, work-to-family conflict is hypothesized to explain psychological distress.

![Diagram showing hypothesized relationships for demographic factors, job factors and work contact, and work-to-family conflict and psychological distress]

**Primary data collection**
Since mathematical modelling was intended to test the explanatory model, it was necessary to collect primary data from the professional disciplines involved in the construction industry in South Africa. This led to the adoption of an on-line questionnaire survey with a sampling strategy that would allow the national populations of construction professionals in various disciplines to be reached.

**Survey instrument design**
The item catalogues in the questionnaire used for data collection (see Table 1) drew substantially on the work of earlier researchers. Gender and domestic situation were included in the questionnaire given the dynamics of work and parenting, and the roles most often played by women in childcare and homemaking (Lingard and Francis 2009). Data on work experience and employment status were gathered to examine the influence of seniority and exposure to the industry on work contact, work-to-family conflict, and psychological distress (Bowen et al., 2014).

Job autonomy and control questions (JAC 1-3) and job pressure items (JP 1-3) were derived from Galinsky et al. (2011). Work contact items (WC 1-3) were adapted from the ‘Toronto Study’ of the Canadian labour force undertaken telephonically by Schieman and Young (2013). Work-to-family conflict questions (WFC 1-4) were based upon Schieman and Young (2010) and Lingard and Francis (2002). The personal distress
catalogue was based upon the work of Kessler (2002). This approach, using items previously tested for validity and reliability, facilitated comparison of findings. Grouping of the questionnaire items according to the factors in the conceptual explanatory model permitted the development of scale measures to represent those factors in the modelling process. The scale measures are shown in Table 1 together with their alpha scores for internal consistency.

Table 1. Questionnaire items, scale measures and Cronbach’s alpha scores (n=630)

<table>
<thead>
<tr>
<th>1. Demographic variables</th>
<th>Metrics applied</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male=1; Female=2</td>
<td></td>
</tr>
<tr>
<td>Relationship status</td>
<td>Divorced, separated, widowed or never married=1; Married or living with a partner=2</td>
<td></td>
</tr>
<tr>
<td>Children under 18 years residing at home</td>
<td>None=1; 1 Child=2; 2 Children=3; 3 Children=4; 4 Children=5; 5 Children=6; 6 Children=7; 7 Children=8; Exceeding 7 Children=9</td>
<td></td>
</tr>
<tr>
<td>Experience in the construction industry</td>
<td>1-5 years=1; 6-10 yrs=2; 11-15 yrs=3; 16-20 yrs=4; Exc. 20 yrs=5</td>
<td></td>
</tr>
<tr>
<td>Employment position</td>
<td>Salaried employee=1; Associate=2; Director or Partner=3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Interaction variable (Scale score range: 1-18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic situation (DS)=Relationship status x Number of children under 18 years residing at home</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Job Autonomy and Control (JAC) (Scale score range: 3-12)</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAC1. You have the freedom to decide what you do on your job?</td>
<td>Strongly disagree=1; Somewhat disagree=2; Somewhat agree=3; Strongly agree=4</td>
</tr>
<tr>
<td>JAC2. It is your own responsibility to decide how your job gets done?</td>
<td></td>
</tr>
<tr>
<td>JAC3. You have a lot to say about what happens on your job?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Job pressure (JP) (Scale score range: 3-15)</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the last 3 months, how often did (were):</td>
<td></td>
</tr>
<tr>
<td>JP1. You feel overwhelmed by how much you had to do at work?</td>
<td>Never=1; Rarely=2; Sometimes=3; Often=4; Very often=5</td>
</tr>
<tr>
<td>JP2. You have to work on too many tasks at the same time?</td>
<td></td>
</tr>
<tr>
<td>JP3. The demands of your work exceed the time you have to do the work?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Work contact (WC) (Scale score range: 3-15)</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the past 3 months:</td>
<td></td>
</tr>
<tr>
<td>WC1. How often were you called about work matters outside of normal office hours?</td>
<td>Never=1; Rarely=2; Sometimes=3; Often=4; Very often=5</td>
</tr>
<tr>
<td>WC2. How often did you receive job-related emails or text messages out of normal office hours?</td>
<td></td>
</tr>
<tr>
<td>WC3. How often did you contact people about work matters outside of normal office hours?</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Work-to-family conflict (WFC) (Scale score range: 4-20)</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the past 3 months:</td>
<td></td>
</tr>
<tr>
<td>WFC1. How often did you not have sufficient time for important people in your life because of your job?</td>
<td>Never=1; Rarely=2; Sometimes=3; Often=4; Very often=5</td>
</tr>
<tr>
<td>WFC2. How often did you not have sufficient energy to do things with important people in your life because of your job?</td>
<td></td>
</tr>
</tbody>
</table>
WFC3. How often did your work keep you from doing as good a job at home as you could?

WFC4. How often did your job keep you from concentrating on important things in your family or personal life?

7. Psychological distress (PD) (Scale score range: 7-35)

In the past month, how often did you (feel):

PD1. Anxious or tense?
None of the time=1; A little of the time=2; Some of the time=3; Most of the time=4; All of the time=5

PD2. Nervous?

PD3.orry a lot about things?

PD4. Have you had trouble keeping your mind on what you were doing?

PD5. Feel restless or fidgety?

PD6. Sad or depressed?

PD7. Hopeless?

Survey administration and response sample
Architects, engineers, quantity surveyors, and project and construction managers in South Africa have to be registered with relevant statutory councils, and the relevant registration lists thus stand proxy for the discipline populations. Professional associations serve a similar purpose. With the co-operation of these bodies, construction professionals were notified by e-mail, asked to participate in the survey, and given a URL to access the online questionnaire. After removing responses with missing values the final dataset totalled 630. This still constitutes an acceptable total from which results can be generalized to at least the South African population (approximately 7000) of construction professionals as it exceeds the 400 minimum recommended by Leedy and Ormrod (2009). The distribution of demographic characteristics in the final dataset is close to the total population of construction professionals in South Africa and constitutes a 9% response rate. Within the response sample, female respondents account for 18% and are slightly over-represented in all discipline groups. Ethnicity is also skewed compared to national demographics but not to the construction industry, reflecting a legacy of the pre-1994 apartheid regime in South Africa.

Data analysis
The survey data were first subjected to descriptive analysis. Confirmatory factor analysis (CFA) using structural equation modelling (SEM) was then conducted to assess the initial factorial model, and four critical fit indices applied to determine the degree of fit of the CFA and path models, using the following threshold values: $\chi^2$/df ratio (less than 4); Comparative Fit Index (CFI of $\geq 0.95$); Root Mean Square Error of Approximation (RMSEA $\leq 0.06$); and Hoelter critical N (CN index $\geq 200$). The Chi-Square Difference Test tested model improvements; and Cronbach’s alpha tested the scale measures for internal consistency (see Table 1). Multiple linear regression analysis identified significant predictors of job autonomy and control, job pressure, work contact, work-to-family conflict and psychological distress, and was undertaken to facilitate the path analysis. A path model explored the direct and indirect determinants of psychological distress.

RESULTS
The demographic profile of respondents was: male (82%); ‘White’ (89%); married or living with a partner (88%); and children under 18 years at home (35%). Over 60%
were 45 years or older, 57% had more than 20 years construction experience, and 58% were director/partners in professional practices. In terms of after-hours work contact, 28.4% of survey respondents reported that they often or very often received work-related telephone calls out of office hours; while 37% reported that this sometimes happened. For text messages and emails, the often/very often frequency of contact was reported by 56% of respondents, and 27.5% reported that this sometimes happened. It should be noted that 25.6% of participants reported that they themselves often, or very often, initiated after-hours work contact with others; and that 34% sometimes did so.

Survey respondents showed concern about the effect of job pressure and after-hours work-related contact upon their family and social lives. For this work-to-family conflict factor, 34.6% reported that they often or very often did not have time for the important people in their lives, and 37.8% indicated that this happened at least sometimes.

In terms of psychological distress, 69.4% of respondents felt tense at least some of the time. Similar frequency levels for nervousness were reported by 43.5%, worry (60%), inability to concentrate (54.9%), restless or fidgety (48.3%), actual sadness or depression (37.9%), and feelings of hopelessness (24.6%).

For the explanatory modelling, the initial CFA model showed an adequate fit to the data. Correlated errors (possibility due to similar question wording) were found between WFC1 with WFC2; PD4 with PD5; and PD6 with PD7. However, none of these threatened the overall integrity of the measurement model and, with these paths specified, the final model showed an excellent fit to the data ($\chi^2/df$ ratio=2.157; CFI=0.977; RMSEA=0.043; and Hoelter (95%)=348) with all factor loadings significant ($p<0.001$) and >0.50.

The Cronbach’s alpha values for the scale measures were all between 0.75 and 0.91, suggesting good to excellent internal consistency (see Table 1). No residual errors were revealed in the SEM, nor any data problems with the measurement model.

The path diagram (Fig.2) and associated significance levels for the antecedents of psychological distress showed an excellent fit to the data ($\chi^2/df$ ratio=1.730, $p=0.039$, CFI=0.991, RMSEA=0.034, and Hoelter (95%) =606), with all paths significant ($p<0.01$).
Figure 2. Path diagram for predictors of psychological distress

Job pressure and work-to-family conflict had the most influence on psychological distress, with higher levels of each leading to greater distress. Generally, higher levels of job pressure were associated with higher levels of work contact, although females reported higher levels of job pressure than males but lower levels of work contact. Construction professionals with higher levels of work experience were more likely to enjoy greater levels of job autonomy and control, but also reported more extensive work contact. Professionals having a partner and children at home were more likely to experience higher levels of job pressure. Employment position was significant in predicting job autonomy and control and work contact: those with greater seniority were more likely to enjoy greater levels of job autonomy and control but also experienced more extensive work contact. Construction professionals with higher levels of job autonomy and control reported significantly lower levels of work-to-family conflict, and were likely to suffer lower levels of psychological distress.

DISCUSSION

The aim of this study was to examine the association between work contact and work-to-family conflict and psychological distress experienced by construction professionals. The findings, based on the path model, show the antecedents of psychological distress.
After-hours work-related contact contributes to psychological distress through increased work-to-family conflict. Our cross-sectional study does not show the effect of time, but recent research, conducted by Dettmers (2017) over a four-month period, suggests that extended work availability (work contact) is associated with increases in emotional exhaustion.

The frequency after-hours work contact found among construction professionals in South Africa is substantially greater than that recorded by Madden and Jones (2008) in the general population. However, we cannot infer that construction professionals thus have more propensity for such communication. Given the rapid development and uptake of digital technology, the time lapse between the surveys is probably a better explanation.

Female construction professionals reported greater levels of job pressure than males, but lower levels of after-hours work contact. It may be that female professionals with more direct family responsibilities are able to exert better boundary control over such communication. The finding lends some support to Tausig et al. (2005) who reported inconclusive findings with regard to job pressure, but found that males tended to work longer hours. Support is also given to the claim of Lingard and Francis (2009) that job pressure for females in the construction industry correlates positively with roles they undertake as working mothers, as domestic situation was positively associated with job pressure. However, the results show no association between gender and job autonomy, and thus this aspect of the research requires more nuanced investigation.

There is a relationship between job status and work contact for construction professionals: the more senior the status the higher the amount of work contact. This confirms the findings of Bellavia and Frone (2005).

Work experience was found to be negatively associated with psychological distress: the greater the experience, the less the distress likely to be felt; but the survey data does not allow any investigation of the effects of conditioning, stress counter-measures and coping mechanisms. Here too, more subtle longitudinal investigation is needed.

LIMITATIONS

Using similar methods, instruments and item catalogues to replicate the work of earlier researchers in a different context inevitably results in some limitations.

The response sample, although representative of construction professionals in South Africa, is self-selecting by virtue of the on-line access option afforded to potential respondents. This participation bias is not considered to be a major issue here.

The questionnaire assumes that the work environment of respondent construction professionals is primarily office or site based, and any subtleties arising from different environments are not captured. Future research will need to consider alternative ways of working.

The nature and context of the reported work contact in the survey item catalogues is limited to frequency, and distinguished only between emails/text messages and telephone calls. However, there may well be different work-to-family conflicts and psychological distress outcomes, depending upon the circumstances of each contact event.
Finally, the after-hours work contact explored in our survey was uni-directional: from work to family or social environment (albeit also including contact initiated from home by the professional); whereas such contact can be bi-directional (family-to-work) whereby family or friends make contact with the worker during working hours. Addressing these limitations by gathering ‘richer’ data is likely to require case-based semi-structured interview methods (and hence inevitably smaller response samples). Notwithstanding these limitations, the explanatory model has provided a useful platform for future deeper and more nuanced investigation.

CONCLUSIONS

The substantially high levels of after-hours, work-related contact and the reported frequency of factors associated with psychological distress, found among professionals in the South African construction industry, gives rise to concern. The modelled path diagram supports the hypothesis that higher levels of job pressure lead to higher frequency of work-related contact, greater work-to-family conflict, and increased symptoms of psychological distress. The conceptual explanatory model is therefore supported.

The construction industry cannot afford to ignore issues relating to psychological distress, since they have obvious implications for professionals’ well-being and productivity. Enhancing job autonomy and control for professional employees would be a positive mitigating strategy for employer organisations. Establishing policy guidelines about after-hours work contact would also help, but might be difficult to sustain in practice. Sensitivity towards the psychological state and needs of individual workers is essential, and future research should explore this, together with the effectiveness of appropriate preventative/mitigating counter-measures and coping mechanisms for psychological distress. Such research should also consider the bi-directionality of work contact and family conflict.

Professional associations in the construction industry could also help to inform members about acceptable limits of work contact, and offer in-service short course training opportunities for managing it in a balanced way.

For their part, construction professionals, regardless of their employment status, should be assertive in setting acceptable boundaries between their work and family/social roles, particularly with respect to after-hours, work-related contact.

This research contributes to current knowledge about the antecedents of work-related stress and its outcomes, in a construction professional context, by considering the nature and strength of factor relationships, particularly with respect to after-hours work contact.

REFERENCES


MITIGATING CONSTRUCTION ACCIDENTS THROUGH ENHANCED ARCHITECTURAL EDUCATION AND TRAINING

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Research findings indicate that architectural designers in South Africa inadequately address construction health and safety (H&S), including ergonomics, during the design process despite ethical and moral expectancies, and those of the Construction Regulations. It is proffered that up to 50% of construction accidents could be mitigated through alternative design approaches. While this paper reflects a model developed through a PhD (Construction Management) study to assist architectural designers to engage the process, the real focus is on the ‘design knowledge window’ located within the model. While four provisional studies involving quantitative and qualitative techniques were undertaken, the main study adopted a focus group (FG) methodology located within the action research (AR) paradigm. The research was undertaken in the Eastern Cape Province and rich data was gathered from voluntary architectural designers registered with the South African Council for the Architectural Profession (SACAP). Relevant literature and the data from the provisional studies and the FGs was synthesised, enabling the development of the model including the ‘design knowledge window’, which more specifically proposes construction processes, construction programming, contextual H&S, causes of accidents, hazard identification and risk assessments (HIRAs), project type and complexity, design recommendations, and lifecycles of buildings as requisite knowledge topics. Integration of these into architectural education and continuous professional development (CPD) training programmes, with simultaneous consideration of the model, will empower architectural designers to consider construction H&S, including ergonomics, during the design process, ultimately for the benefit of the reputation of the construction industry and the wellbeing of constructors, their families and the greater community.

Keywords: architectural designers; education; health and safety; knowledge; training.

INTRODUCTION

The construction industry in South Africa is a major stakeholder in the local economy, however it remains one of the most dangerous of the 24 listed industries. It ranks ninth in terms of accident frequency rate, fifth in terms of accident severity rate, and third in terms of accident fatality rates (cidb 2009). Not only do construction accidents lead to illness, injury and death, but also result in environmental destruction, loss of productivity, reduced quality, time overruns, and ultimately an increase in construction costs. The question is posed as to whether construction accidents can be mitigated through design, or alternative design approaches? In analysing 450

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construction accident reports, Behm (2006) suggests that 151 of the incidents could have been mitigated through the design process. The Health and Safety Executive (HSE) (2003) undertook a detailed construction accident study, and concluded that 50 of 100 incidents could have been mitigated through alternative design. Despite the Construction Regulations of 2003 (Republic of South Africa 2003) and the amendment thereof in 2014 (Republic of South Africa 2014), which expects architectural designers, among others, to engage construction H&S, research indicates that they are not committed to the process (Goldswain & Smallwood 2009). Ethical and moral expectancies are also questionable. The Architectural Professions Act, No. 44 of 2000 (Republic of South Africa 2000) expects all architectural designers to be registered with SACAP, which in return expects them to carry out their duties with integrity (SACAP 2008), surely inferring ethical and moral 'behaviour'. International models include the United Kingdom's Gateway model (HSE 2004a) and Australia's Construction Hazard Assessment Implication Review (CHAIR) model (WorkCover NSW 2001). These are not elaborated upon within the paper, but much can be drawn from them. The PhD (Construction Management) study upon which this paper is based, sought to develop a model suitable for the South African architectural profession. Due to the constraints of this paper only the 'design knowledge window' is addressed.

**CONTEXT**

**Construction hazards, risks, and causes of accidents**

Accidents do not simply occur. Haslam et al. (2005), drawing on others, propose accidents to be multi-causal in nature. Proximal factors occur within the site environment, while distal factors refer to issues surrounding design, choice of materials and equipment, and the specific design usage. The hazards and risks are created through poor design and planning, and arise from client requirements, economic ambit, and the education of those involved (HSE 2003; Gibb et al. 2006). Construction health hazards and risks include exposure to hazardous chemical substances (HCSs). Inhalation of dusts, fumes, mists and gasses can lead to eye problems, respiratory problems, lung disease, organ damage, and central nervous system damage. Absorption of HCSs through the skin can cause dermatitis. Handling cements and concrete can lead to allergic contact dermatitis, and working with bitumen and similar products can cause dermatitis and acne related disease. Ingestion of HCSs through swallowing, often accidentally, has similar outcomes and can be avoided by washing hands before eating. (cidb 2009; Deacon 2003; Smallwood 2001; Occupational Safety and Health Council 2004; Bureau of Labour Statistics – US Department of Labour 2008; Weitz and Luxenberg 2010). Construction safety hazards and risks include motor vehicle accidents (MVAs), falls onto different levels, falls from and collapse of scaffolds and support work, falls from ladders, hoists and platforms, demolition and excavation related falls, and falling off of structures and through openings. Struck by accidents are caused by falling materials, plant and structures, among other, and collision with plant or vehicles. Other hazards and risks include electricity, contact with moving parts of machinery, fire and explosion, excavation collapse, and working in confined spaces (Behm 2006; cidb 2009; HSE 2003; Bureau of Labour Statistics – US Department of Labour 2008; Innes 2009; Deacon and Smallwood 2010; Weitz and Luxenberg 2010; HSE 2010). Ergonomic issues include repetitive movements, handling heavy or inconveniently sized equipment and materials, bending and twisting, working in awkward positions, reaching, vibration, repetitive strain injuries (RSIs), exposure to noise, use of force,
staying in the same position for too long, working in adverse weather conditions, and working while injured (WorkCover NSW 2001; Smallwood 2006; Smallwood 2007; cidb 2009; Deacon and Smallwood 2010; Safe Work Australia 2010; HSE 2010).

**Designing for construction health, safety, and ergonomics**

While various definitions relating to designing for H&S exist, Behm (2006) proposes it to be the “consideration of construction site safety in the preparation of plans and specifications for construction projects”, while Toole and Gambatese (2006) contend that “… design is reviewed to ensure it can be constructed safe(l)y, as well as meet cost, schedule and quality goals”. There is a vast range of technologies, processes and programming options related to construction. Choices made by designers influence construction performance (Chang and Lee 2004). It is essential to recognise the design and construction relationship as an integrated system, with the necessity being “… the implementation of a design envisioned by architects and engineers … performed with a variety of precedence and other relationships among different tasks.” (Hendrickson, 2008) The method of construction must be integrated into design and technology, and the ideal method and sequence of should be considered during the design process and not left to the contractor's decision (Hendrickson 2008). The HSE (2004b) promotes enhanced planning and construction assessment in order to enhance construction H&S by incorporating influence networks to better understand organisational and human factors, which serves to expose hazards and risks. It highlights changes in operations, which exacerbates hazards and risks. WorkSafe Victoria (2005) propose ‘hazard identification’ as the identification of situations where people may be exposed to harm, and ‘risk assessment’ involves the likelihood of harm occurring through exposure, while risk control involves the means of mitigating hazards and risks. Simply put – ‘find it’, ‘assess it’, and ‘fix it’. Carter and Smith (2006) consider HIRAs and contend that accident causation models focus on how hazards lead to accidents. They insist that the problem lies in hazards which are not identified as this means that control measures cannot be implemented and that method statements are a means of assessing risk, and propose them to include work sequences descriptions, locations, resources, and risk assessments. Despite method statements, hazard identification levels are lean (Carter and Smith 2006).

**Design recommendations**

Behm (2006) advocates a range of design recommendations made by Gambatese and Weinstein, such as disconnect, reduce voltage, or re-route power lines around the project before it begins, and design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails. Behm (2006) also includes a range of new design recommendations such as: when design features such as ventilation systems, trash chutes, chimneys, and elevators, cause floor openings to occur during construction, provide a warning in the plans and specifications for construction, and design in permanent guardrail systems and sequence them in early in the construction process for use by all contractors, and consider the existing site and its potential hazards in relation to the heavy equipment required to perform the scope of work. Mroszczyk (2005) also draws on existing recommendations, but follows each with the ‘purpose’ alongside, for example: specify primers, sealers, and other coatings that do not emit noxious fumes – reduce noxious fumes.

**Project type and complexity and lifecycles of buildings**

Hendrickson (2008) suggests that: structures are custom designed and constructed, and take a long time to complete; the design and construction of a structure is site
specific; each is influenced by natural, social and other locational conditions such as weather, labor supply, and local building codes; the service life of a facility is long and anticipation of the future is difficult, and technological complexity, market demands and changes of design during construction are frequent. These are further impacted on by construction technologies, processes and programming.

**RESEARCH METHOD**

van Teijlingen and Hundly (2001) propose provisional studies to provide valuable insight toward the success of the main study. Four provisional studies were undertaken in the Eastern Cape Province as representative of South Africa and included quantitative and qualitative methods. Architectural designers registered with the SACAP formed the target population and sample stratum. The first (Goldswain & Smallwood 2009) focused on the perceptions of architectural designers relative to mitigating construction hazards and risks. The questionnaires included 15 statements and an open ended question, and were distributed to 102 architectural designers. 18 responses were received equating to a 17.5% response rate. The second (Goldswain & Smallwood 2011) probed what would encourage architectural designers to mitigate construction hazards and risks during the design process. Semi-structured interview questions were relayed to 10 participants out of 60 contacted, equating to a response rate of 16.7%. The third (Goldswain & Smallwood 2012) pursued an architectural design model framework toward improved construction H&S in South Africa. It included a range of statements in a matrix format, as well as open ended opportunities. The survey was conducted among 76 participants and 12 responses were received equating to 15.8%. The fourth (Goldswain & Smallwood 2013) sought to identify key inputs which could be integrated into the architectural design model framework. 20 statements, three structured questions, and an open ended option was included and distributed to 73 designers. 15 responses were received equating to 20.5%. Ultimately, valuable insights led to the development of nine structured questions for use in the main study. FG methodology within the AR paradigm was used in order to obtain rich qualitative data from the SACAP registered participants. The process involved: setting up the population and the random sample; suitable venues; invitations, and the agenda. Eight participants for the Buffalo City Metropolitan Municipality region FG were available, but only four participants were available for the Nelson Mandela Metropolitan Municipality region FG. Anonymity was guaranteed, consent forms were signed, and the nine structured questions were relayed to both FGs. The activities were audio-video recorded for transcription. Overall demographics included seven Professional Architects (58.3%), two Professional Senior Architectural Technologists (16.7%), and three Professional Architectural Technologists (25%). The average age was 45 years with an average of 20.75 years of experience. In terms of gender, there was only one female (8.3%) participant despite efforts to create a balance. Synthesis of the data with literature and the provisional studies enabled the development of a provisional model. Carter and Smith (2006) propose that validation is a crucial aspect of model development. A qualitative and quantitative survey was developed and distributed to the FG participants. It engaged the range of model components and the full provisional model. A ‘Likert’ type scale of 1 (totally disagree) to 5 (totally agree) was applied and open-ended questions were included. The responses were positive in terms of validating the model.
FINDINGS, ANALYSIS AND DISCUSSION

The 'knowledge' topics required by architectural designers in order to embrace designing for construction H&S, including ergonomics, is embedded in the design knowledge window. A FG participant stated: “If the designer can refine the design and say there might be better processes … to achieve the goal, one needs the knowledge.”

Construction processes and construction programming

Selected FG data includes: “I think everyone needs to understand the construction process … You can’t design and design safely if you don’t understand the construction process,” and " … this comes (in) the form of project plan or project process and that becomes more important than the architectural design, because it is a process of how do you do it safely …" Relative to programming " … you say that according to specifications you are not allowed to lay the carpet with that ‘thing’ until such time as the whole building has been evacuated …". This talks to the importance of technology and the integrated system whereby technology, programming and method is advocated by Hendrickson (2008). Similarly, data from the fourth provisional study stated that “… architectural practitioners should be actively exposed to the physical construction process …” The included triangulation renders construction processes and construction programming relevant to the design knowledge window.

Contextual H&S and causes of accidents

Selected FG data relative to contextual H&S includes: “They need to have a basic design for health and safety - construction health and safety …", and "… I would say that the average designer does not have the knowledge." Furthermore, "… you need the context as in the need for it", and "… maybe a little about the background for it and the impact it’s got on society …" There is a vast amount of contextual literature, which has not been included here. While the provisional studies did not interrogate contextual H&S, they all used contextual H&S as a backdrop. Selected FG data relative to causes of accidents discusses risk such which can lead to accidents: “I did a house once where I specified a large pane of glass. I didn’t consider how the hell they’d get it to the first floor. So yes, the next time I design a house I’ll consider how and chat to the contractor …", and " … because they would get like ‘speed bonuses’ they wouldn’t wait … what we would see today is horrendous – and the boss back in the office said go faster, faster". Haslam et al. (2005) advocates Kletz (2001) promoting the multi-causal range of proximal and distal factors, which lead to accidents or ‘active failures’ (Gibb et al. 2006), and accidents include falls onto different levels, MVAs, struck by, inhalation, absorption and ingestion, and body stressing, among others as causes of accidents (Haslam et al. 2005; Penny 2007; Bureau of Labour Statistics – US Department of Labour 2008; cidb 2009; Innes 2009; Safe Work Australia 2010; HSE 2010). The fourth provisional study included the statement of ‘Architectural designers would need to understand the causes of construction accidents in order to design for construction health, safety, and ergonomics’. This resulted in a MS of 4.07, which is well above the midpoint score of 3.00. The inferred and the included triangulation renders contextual H&S and causes of accidents relevant to the design knowledge window.

Hazard identification and risk assessments (HIRAs)

Selected FG data relative to HIRAs includes: “… so there is an inherent risk of digging down trenches 3, 4, 5m down and say people - it has to be hand dug for
whatever geomorphic reason and we have to have personnel down below ground level. I think the professional should identify risks …", and "… it also goes around your health and safety plan that you issue at tender stage. So you are identifying the risk. The problem comes in when you haven’t identified a risk". Carter and Smith (2006) also insisted that the problem lies in hazards, which are not identified as this means that control measures cannot be implemented. It is noted that the first provisional study realised a MS of 3.53, which is above the midpoint score of 3.00 relative to the statement of ‘architectural designers would need to identify hazards and undertake risk assessments in order to design for construction health, safety, and ergonomics’. The included triangulation renders HIRAs as relevant and important to the design knowledge window.

**Design recommendations**

Selected FG data relative to design recommendations was brief and included: “…just clarify that - when you say design recommendations?”, and "… if there are other researchers or other practices in other countries who have made recommendations for design practices … in other words recommendations to resolve health and safety issues and risks through the design process” then "probably yes - again one needs to look at what is the environment in which that design recommendation has been made against our environment. The extensive lists of design recommendations by Behm (2006), drawing on Gambatase and Weinstein, and the similar works with added ‘purpose’ provided by Mroszczyk (2005) are justified. The fourth provisional study offered the statement of ‘Consideration of existing design recommendations would prove beneficial to developing a guiding model suitable for use in the context of South Africa’ resulted in a MS of 3.79, which is above the midpoint score of 3.00, rendering the triangulation valid and relevant to the design knowledge window.

**Project type and complexity and lifecycles of buildings**

Selected FG data relative to project type and complexity and lifecycles of buildings is integrated and includes: “… should obviously be researched and amended as per project …" and "… overseas there are more complicated buildings being built in the first world countries - that is more available than here. I think the complexity high rise etc. has possibly got to do with the high mortality or injury here", and "… in terms of frameworks what particular projects need more spotlight placed on health and safety than others". It is also necessary "… to look at the life cycle of the building not just the design and construct phase", and "… from concept to final demolition. There a lot of buildings that go through three, four cycles in their lifespan, and it’s becoming more complex". Hendrickson (2008) promotes planning and design of any facility to consider the entire project life-cycle, and that designs should be reviewed to ensure constructability thus minimising negative impact (Toole and Gambatase 2006; Hendrickson 2008). Provisional study two reminds designers that "… building at 1m can be as dangerous as at 20m." It also insinuates project type and complexity with commentary such as "… the design may be challenging and unconventional …", and that "… there is always a way to carry out works safely, but it is costly for unconventional projects". Lifecycles of buildings unfortunately did not form part of the provisional studies, but through relevant literature and FG reaction it is deemed necessary as part of the design knowledge window.

**Presentation of the model, including the design knowledge window**

While the focus of the paper is on the topics included in the design knowledge window, the greater model is presented overleaf in order to demonstrate where and
how the 'window' fits into and interacts with the greater process model. It is suggested that without an understanding of the design knowledge window topics, architectural designers will find difficulty engaging the cyclic design opportunity window.

CONCLUSIONS

Extensive and appropriate literature provided a backdrop for the PhD (Construction Management) study. This paper is based on a portion of the study. The four provisional studies were undertaken to build an understanding of the topic within the South African context and ultimately derived the nine structured questions to extract rich qualitative data from the FG participants, which were all registered with SACAP. Synthesis of the data was used to develop the greater model, of which the design knowledge window formed the basis of this paper, and the included topics are considered key to assist architectural designers to engage in healthier, safer, more ergonomic design. It is proffered that construction processes, construction programming, contextual H&S, causes of accidents, HIRAs, project type and complexity, design recommendations, and lifecycles of buildings are key knowledge topics.
It is implored that architectural educators and architectural CPD trainers realise the importance of ‘designing for construction health, safety, and ergonomics’, and integrate the design knowledge window topics into architectural education and CPD training. A proactive move toward complying with ethical and moral expectancies, as well as the Construction Regulations is required. Preventing construction accidents through design requires a positivist attitude. Architectural designers can lead the way.
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SUICIDE IN THE CONSTRUCTION INDUSTRY: IT’S TIME TO TALK
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The construction industry is known as a male-dominated industry which is characterized by a “macho” culture. Site-based work is physically demanding and is associated with inherent risks. To mitigate these risks, occupational health and safety legislation is embedded within work practices to enable a safe and healthy working environment for workers. Despite this legislation, site-based construction workers suffer from a high prevalence of mental distress, and in many countries, levels of suicide are high when compared with other industries. High levels of psychosocial factors have been identified as antecedents of mental distress for site-based construction workers. Mental distress has also been associated with workers’ pain and injuries. This paper considers how Australia, the United States, and the United Kingdom are responding to suicide prevention in the construction industry. Findings suggest that a key gap in the response to suicide prevention is the education of future industry entrants. Graduates of built environment degree programs are emerging leaders of the industry who will be responsible for a large number of workers, and will have the capacity to effect change. However, the topic of worker mental health is largely absent from university curricula. Recommendations are made on the role university educators’ play in preparing future construction professionals and consideration is given on what it means to be work ready in the context of mental health and suicide.

Keywords: construction, mental health, suicide prevention, work readiness.

INTRODUCTION

Suicide
During 2012, 804 000 suicide deaths occurred worldwide, representing an annual global age-standardized suicide rate of 11.4 per 100 000 populations (World Health Organization, 2014). However, the World Health Organization (WHO) (2014) suggests that the actual rate may be higher as suicide may be misclassified as an accident or another cause of death. Suicidal ideation has been associated with depressive symptoms, and the link between suicide and mental disorders such as depression and disorders associated with substance abuse is well established (Aleman and Denys, 2014). However, suicidal ideation is a complex phenomenon which is influenced by several interacting factors – personal, social, psychological, cultural, biological and environmental. No single factor is sufficient to explain why a person died by suicide (WHO, 2014). Most commonly, several risk factors act cumulatively to increase an individual’s vulnerability to suicidal behaviour (Aleman and Denys, 2014; Oquendo et al., 2014; WHO, 2014).

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Suicide in the construction industry
The workplace has been recognised as an environment which may contribute to suicide intentions for some workers (Woo and Postolache, 2008; Oquendo et al., 2014; International Labour Organization, 2016). Psychosocial factors considered harmful have been identified as financial problems, interpersonal conflicts including bullying and harassment (Fridner et al., 2009; Nielsen, Nielsen, Notelaers and Einarsen, 2015), low control or low decision latitude, low social support, high psychological demands, and long working hours (Amagasa, Nakayama and Takahashi, 2005; Routley and Ozanne-Smith, 2012). These harmful psychosocial factors are consistent with the Social Determinants of Health framework which posits that poor quality work can contribute to health inequity (Marmot, 2005) through exposure to a higher risk of mental disorder (World Health Organization and Calouste Gulbenkian Foundation, 2014).

Suicide is more prevalent among males than females (WHO, 2014), which means that occupations and industries with male-dominated workforces are more susceptible to higher rates of death by suicide. The construction industry is a male-dominated industry in which a macho culture is evident (Ness, 2012; Leung, Chan and Cooper, 2015) which can create barriers to seeking help and acknowledging emotional problems for its workers (Spencer-Thomas and Beyer, 2015). Furthermore, workers of the construction industry are known to experience a high level of psychosocial hazards and risks, such as low levels of support at work, low decision latitude and job control, and insecure employment (Alavinia, Duivenbooden and Burdorf, 2007; Oude Hengel, Blatter, Geuskens, Koppes and Bongers, 2011; Turner and Lingard, 2016). Site-based construction work is physically demanding and is associated with inherent risks. To mitigate these risks, occupational health and safety legislation is embedded within work practices to enable a safe and healthy working environment for workers. Despite this legislation, site-based construction workers suffer from a high prevalence of mental distress, and in many countries levels of suicide are high when compared with the general population.

In the United States, the construction industry has the second-highest suicide rate when compared with other industries. It also has the highest actual number of suicides of all industries (McIntosh et al., 2016). Of concern is that rates are markedly higher than for the general male population. Using data from 2012, the construction and extraction occupational category had a suicide rate of 52.5 per 100,000 for males. In contrast, the suicide rate per 100,000 of the general male population for 2012 was 19.4 (WHO, 2016). It is understood that these excessive rates may be underreported because suicide may not be the primary cause of death documented due to the method of infliction, and/or due to the stigma associated with suicide (Peiffer, 2016). Suicide rates in the US are summarised in Table 1.

<table>
<thead>
<tr>
<th>Category</th>
<th>Overall</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>General population</td>
<td>12.1</td>
<td>19.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Construction and extraction</td>
<td>53.3</td>
<td>52.5</td>
<td>Not reported</td>
</tr>
</tbody>
</table>

Source: general population (WHO, 2016); occupational categories (McIntosh, et al., 2016).
In Australia, suicide rates according to industry are not routinely reported; therefore the ability to consider rates in the context of the general population is limited. Using data from one State in Australia from 1995 - 2001, Heller, Hawgood and Leo (2007) found that the commercial building construction industry had an estimated suicide rate of 40.4 per 100 000 for males, which is higher than the general Australian male population of 16.1 per 100 000 (WHO, 2016). Milner, Niven and LaMontagne (2014) found that suicide rates among unskilled construction workers such as machine operators and labourers was significantly greater than the suicide rate of skilled tradesmen between 2001 and 2010. For unskilled workers during this period, the lowest rate was 15.5 per 100 000 in 2003 and the highest rate was 21.1 per 100 000 in 2007, which are close to or higher than the general male population rate of 16.1 per 100 000. For skilled workers, the lowest rate was 9.9 per 100 000 in 2002 and the highest was 14.6 per 100 000 in 2001, both of which were lower than the general male population. These rates are summarised in Table 2.

Table 2: Suicide rates per 100 000 in the Australia

<table>
<thead>
<tr>
<th>Category</th>
<th>Overall</th>
<th>Female</th>
<th>Male</th>
<th>Highest rate- male (2001 – 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General population</td>
<td>10.6</td>
<td>5.2</td>
<td>16.1</td>
<td></td>
</tr>
<tr>
<td>Queensland construction industry</td>
<td></td>
<td></td>
<td>40.4</td>
<td></td>
</tr>
<tr>
<td>Unskilled construction workers</td>
<td></td>
<td></td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>Skilled construction workers</td>
<td></td>
<td></td>
<td>14.6</td>
<td></td>
</tr>
</tbody>
</table>

Source: general population (WHO, 2016); Queensland (Heller et al., 2007); skilled and unskilled workers (Milner et al., 2014)

Across the United Kingdom, suicides rates are higher in the construction industry when compared with other industries. Roberts, Jaremin and Lloyd (2013) outlined high-risk occupations for suicide based on data from England and Wales from 2001 to 2005. Similarly, Meltzer et al. (2008) report on patterns of suicide by occupation in England and Wales from 2001 to 2005. Labourers in building trades were identified as a high risk occupation for suicide, at 59.1 per 100 000 (Roberts et al., 2013). This is markedly higher than for the general male population in the United Kingdom reported to be 9.8 deaths per 100,000 population during 2012 (WHO, 2016). For 2014, the Office for National Statistics (2016) report that the male suicide rate was 16.8 deaths per 100,000. Meltzer et al. (2008) report that among males from 2001–2005, construction workers had the greatest number of suicides. In Ireland, suicide rates by industry are not routinely reported. However, construction workers have been identified as a high-risk group for suicide. Arensman et al. (2013) undertook research in the region of Cork between 2008 and 2012 and found that 41.6% of all suicides had construction or production backgrounds, which was more than triple the next highest sector (agriculture at 13.2%). In Scotland, suicides were most common in the skilled trades occupations (513 cases, 25%) (NHS Scotland, 2016).

Suicide prevention

Given the alarming statistics, ironically, suicide can be prevented (Schwartz-Lifshitz, Zalsman, Giner, and Oquendo, 2012; WHO, 2014; Wahlbeck, 2015). In recognition of the high prevalence of suicide, there have been calls to increase awareness of suicide and make suicide prevention a higher priority on the global public health agenda. In
response to high suicide rates, the WHO (2014) released its first report on suicide prevention, stating that the report “represents a significant resource for developing a comprehensive multisectoral strategy that can prevent suicide effectively” (p.2). More recently, the International Labour Organization (ILO) (2016) released its report on workplace stress, and identified that work-based psychosocial risk factors are a major source of stress which have been linked to suicide ideation. Like the WHO (2014), the ILO (2016) also emphasise the need for a collective approach to preventing and controlling the causes of work related stress. The collective approach includes an active effort of multiple stakeholders such as employer organisations, trade unions, professional associations and networks.

In its suicide prevention framework, the WHO (2014) outline various strategies which comprise a comprehensive approach. These include:
- Raising awareness about mental health, substance use disorders, and suicide.
- Gatekeeper training for supervisors and managers.
- Education about suicide and its prevention.
- Establish public information campaigns to support the understanding that suicides are preventable.
- Increase public and professional access to information about all aspects of preventing suicidal behaviour.

**AIM**

Given the elevated rates of suicide in the construction industry, there is a critical need for a collective approach (WHO, 2014; ILO, 2016) to suicide prevention by key industry stakeholders. Key stakeholders are defined as those groups who have the capacity to effect change through their position of influence, authority or power. Workers have not been included in the list of key stakeholders given their reported low level of control and low decision latitude. However, workers are at the centre of efforts to reduce suicide. The aim of the study is to review current approaches to suicide prevention in the construction industry and identify active stakeholders. The study focuses on Australia, the United Kingdom, and the United States which are categorised as industrialised countries/regions with elevated rates of suicide in the construction industry. It is intended that this paper will contribute to a Community of Practice (CoP) for suicide prevention in the construction industry. CoP is defined as “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis” (Wenger, McDermott and Snyder, 2002, p. 4). CoP has previously been applied to suicide prevention in various contexts such indigenous people (Wexler et al., 2016) and rural communities (Varia, Ebin and Stout, 2014).

**METHOD**

The research adopted a critical review of industry reports, websites, and the academic literature to explore current approaches to suicide prevention in the construction industry. The findings from the review were analysed using a multiple-stakeholder approach as suggested by WHO (2014) and ILO (2016). In this research, key stakeholders of the construction industry are defined as construction-based employers, professional and peak bodies, unions, government, and educational institutions.
Educational institutions are identified as a key stakeholder as they are responsible for preparing future leaders of the construction industry.

FINDINGS
In Australia, the United Kingdom, and the United States, key stakeholders are actively involved in suicide prevention efforts to varying degrees, as reported below. Key stakeholders include employers, professional and peak bodies, unions, and government.

Australia
Key suicide education and prevention strategies according to stakeholders include:
- Mates in Construction (MIC) was established in 2008 to reduce the high level of suicide among Australian construction workers (MIC, 2016). MIC is a charity organization which is funded by unions, building and construction employers, and the Federal Government. It seeks to offer evidenced-based programs driven by the translation of research into practice. MIC provides suicide prevention through community development programs on construction sites, and supports workers to access help through case management (Gullestrup, Lequertier and Martin, 2011).
- A suicide prevention program targeted to young workers in the building and construction industry, particularly those who live in rural and regional areas, is offered by Incolink (Broadbent, Corney, du Plessis and Papadopoulos, 2013). Incolink is a redundancy payment central fund established by unions and employers in the Victorian building industry (Incolink, 2016).
- The Australian Institute of Building (AIB) is a professional body with a national presence which released a policy addressing mental health and suicide (AIB, 2013).

United Kingdom
Key suicide education and prevention strategies according to stakeholders include:
- Mates in Mind was announced in 2016 and expected to launch in 2017. It is a sector-wide program intended to help improve and promote positive mental health and decrease suicide across the construction industry. The program is led by the Health in Construction Leadership Group (HCLG) and supported by the British Safety Council. The HCLG has a broad membership comprising of contractors, clients, the Health and Safety Executive, professional bodies, trade associations and trade unions (HCLG, 2016).
- In Ireland, Mind Our Workers is a joint campaign organised by Pieta House, a charity organisation offering treatment for suicide ideation, and the Construction Industry Federation (Pieta House and the Construction Industry Federation, 2012). The campaign focuses on encouraging more communication about suicide and mental health on construction sites and amongst construction workers in Ireland. It has support from peak professional bodies of the construction industry.

United States
Key suicide education and prevention strategies according to stakeholders include:
- The Carson J Spencer Foundation is a charity organisation which released ‘A Construction Industry Blueprint: Suicide Prevention in the Workplace’ in 2015 (Carson J Spencer Foundation & National Action Alliance for Suicide Prevention, 2015). The Blueprint has a companion website specially targeted for suicide in the
construction workplace (http://www.constructionworkingminds.org/), which is supported by employers, industry associations, unions, and government bodies.

- The Construction Financial Management Association (CFMA) is a peak professional body which educates its members about the issues of mental health, and its largest chapter in Phoenix held a suicide prevention summit in 2016 as a test model for a potential nationwide initiative. Emerging from the 2016 summit was the establishment of the Construction Industry Alliance for Suicide Prevention which aims to provide and disseminate information and resources for suicide prevention and mental health promotion in construction (CFMA, 2016).

An internet search of university websites was applied to construction management bachelor programs delivered by universities in Australia, the United Kingdom, and the United States. A literature review was also conducted. The following key terms were used in the search: mental health, mental health education, suicide prevention, suicide prevention and education. The search did not reveal evidence that universities offering construction management programs include education about suicide and its prevention in their curricula. When safety content or courses appear, safety receives the most coverage, physical health receives a distant second in coverage, with mental health coverage non-existent. Furthermore, suicide prevention efforts conducted by industry appeared to have little to no links with construction management university programs.

DISCUSSION
The human and economic cost of suicide is vast and efforts to reduce suicide are critical. This is particularly pertinent for the construction industry given that it has elevated rates of death by suicide. This study aimed to review current approaches to suicide prevention in the construction industry and identify active stakeholders, with a specific focus on Australia, the United Kingdom, and the United States. All countries/regions have implemented suicide prevention strategies with active participation and support from key stakeholders including employers, professional and peak bodies, unions, and the government. The review identified that programs run in each of these countries/regions were led and supported by a range of key stakeholders. For example, the Mates in Mind program run in the United Kingdom was supported by contractors, clients, professional bodies, trade associations and trade unions. This is consistent with a collective approach to suicide prevention as outlined by the WHO (2014) and the ILO (2016).

In its suicide prevention framework, the WHO (2014) outlines various strategies which form part of a comprehensive approach. These include gatekeeper training for supervisors and managers, and education about suicide and its prevention. There is also an emphasis on developing a social culture where suicide is not taboo and dialogue is encouraged. University graduates of built environment programs are emerging leaders of the construction industry who will be responsible for a large number of workers, and will have the capacity to effect change. Educating future professionals will assist in normalising the dialogue about suicide and contribute to efforts to reduce the suicide rate. However, there was no evidence that worker mental health and information about suicide and its prevention are integrated into the university curricula.

University plays a critical role in ensuring that graduates develop lifelong learning skills and attributes that can carry them on to a long and fruitful career (Savage et al., 2010). In the context of the high incidence of mental health issues and suicide in the
construction industry, it can be argued that knowledge of these topics are an essential component of work-readiness for graduates of the built environment, and that universities are indeed key stakeholders in suicide prevention. The knowledge and skill set acquired will be necessary for self-leadership, as well as leading others. Furthermore, a critical aspect of preventing suicide in the construction industry is the alleviation of harmful workplace factors which contribute to suicide. Universities play a crucial role in preparing students to challenge the root causes of work-related factors linked to suicide. Equipping future leaders of the construction industry with this knowledge will assist them to proactively address the core of the issue and move the emphasis from addressing the problem to being part of the solution.

Research conducted on built environment higher education highlights the importance of establishing strong links between university and industry to ensure that graduates have the necessary technical and social skills to productively engage and contribute to their discipline during and after the critical transition-to-work phase of their careers (Savage, Davis and Miller, 2010). By applying a work-readiness lens, three key stakeholder groups are central to graduate work readiness: (1) the graduate; (2) the university; and (3) the industry. These key stakeholders comprise a work readiness stakeholder framework as outlined in Figure 1. The model is informed by the literature (for example: Davis and Savage, 2009; Forsythe, 2012; Harvey, 2001) and provides a basis from which suicide prevention and education can be approached. Implicit in the model is that suicide education and prevention is an outcome which assumes a coordinated approach between multiple stakeholders: (i) industry and university collaborate to ensure that graduates have the skills and knowledge required to successfully contribute to an industry which supports the mental health of its workers; (ii) the university facilitates the knowledge and experience required by the graduate to enter industry; (iii) the graduate uses this knowledge in industry to influence and lead change which supports workers mental health.

Figure 1. Work readiness stakeholder framework applicable to suicide prevention and education

CONCLUSIONS
The research has practical implications for educators within the built environment. Universities can actively support awareness and education of mental health, suicide and its prevention. It is possible that these subject areas can be incorporated into course structures, learning activities and assessment tasks. This may be achieved by taking a comprehensive approach to occupational health and safety education which includes both physical safety and health, and mental health. In this context, educators play a key role in preparing graduates of the built environment to be work ready by incorporating mental health into the curricula, along with awareness of the
psychosocial hazards and risks which contribute to suicide. By applying the work readiness stakeholder framework, educators can collaborate with industry to equip students with knowledge of suicide prevention. It is possible that universities can utilise suicide prevention resources already developed by the construction industry.

The research also has practical implications for key stakeholders of the construction industry through the contribution to a Community of Practice for suicide prevention. The CoP can provide a forum for stakeholders to make others aware of this largely hidden problem, and can work together to deepen their knowledge of suicide prevention strategies tailored for construction workers. Furthermore, this may be particularly useful for countries which have yet to implement suicide prevention strategies in the construction industry.

The study has three important limitations. It is known that rates vary by region of the world (e.g. Eastern Europe exhibits the highest rates) (Nock, et al., 2008). Therefore, the results cannot be generalised to other countries as it focused on three industrialised countries/regions with elevated rates of suicide in the construction industry. Furthermore, the study did not consider whether the identified programs and policies had been evaluated and whether they were effective in preventing suicide in the construction industry. While there has been some focus on evaluating work place suicide interventions (e.g. Milner, Page, Spencer-Thomas and Lamotagne, 2015), further research could usefully evaluate suicide prevention programs targeted for the construction industry. Finally, the results are based on secondary data obtained from a desktop search. It is possible that additional suicide prevention strategies are being implemented by key stakeholders of the construction industry which have not been explicitly reported and published on the internet.

Suicide is a complex phenomenon which is influenced by several interacting factors. At the work place, psychosocial hazards and risks have been identified as contributing to suicide intentions for some workers. Mitigating the work place factors which may contribute to suicide ideation will form a critical component of suicide prevention efforts into the future.

REFERENCES


INTEGRATING RFID AND BIM TO DESIGN A REAL-TIME POSITION TRACKING SYSTEM FOR SUBWAY PROJECTS LIFECYCLE SAFETY MANAGEMENT

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Position tracking technology is an effective method for improving safety management in job site. However, subway projects often involve working underground, which leads to the invalidation and inaccuracy of current technologies. To overcome the deficiency, an integration of RFID into BIM are proposed at design phase. In the system, BIM is used to simulate the construction process and finally visualize the subway; RFID tags are embedded in shield tunnel segments, the dimensions of the shield segments and the places where tags are embedded are recorded so that the relative location of the shield segments and tags can be calculated. Workforce, equipment and materials are all equipped with wearable or portable RFID readers which can read the information written in the nearby tags and the information would be sent to the system through wireless network. Through a simple algorithm, the system can get their accurate position which will help to improve subway projects lifecycle safety management.

Key words: BIM, design for safety, lifecycle, RFID, safety management.

INTRODUCTION

The subway provides a fast, economical and convenient way for people traveling in metropolis and it has become an outstanding symbol of a city. As a result, subways have been built around the world since last century and this can easily get evidence from China (Wan et al. 2015). Normally, one subway line consists of some subway stations connected by subway sections. Subway stations provide a platform where passengers get on/off the train. Subway sections are often in the form of underground tunnels providing tracks for subway trains. Therefore, the construction of subway projects can be divided into station construction and section construction. In most cases, station construction is conducted like other underground projects using open-cut method (Ding et al. 2011). Unlike subway station construction, section construction has to be done underground due to the

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restriction of land use in urban areas where open-cut method cannot be adopted. As a result, section construction and the following operation of subway operation as well as maintenance have to be done underground and within the constructing or completed tunnels. However, the geological and hydrological conditions are unpredictable underground (Ding et al. 2012), the space of job sites are narrow and the lightening conditions are poor. All these make the lifecycle of subway project more dangerous compared with other types of construction projects (Zou and Li 2010). In order to overcome the restrictions of poor construction conditions and improve safety performance of subway projects, the job sites should be well planned and workforce, resources, equipment etc. should be monitored timely.

With the rapid development of information and communication technologies (ICTs), sensors have been adopted to promote safety management in construction industry. Among them, the potential of position tracking technologies such as GPS, UWB RFID, BLUETOOTH etc. in promoting safety management in job sites has been discussed (Qi et al. 2011; Skibniewski 2014; Zhou et al. 2013). The location-based safety management has been applied in modification of construction site layout plan, reduction of the conflicts in the crowded jobsite and establishment of a real-time warning system which can track trajectories and the location of people, materials and equipment accurately (Ding and Zhou 2013; Irizarry and Karan 2012; Wu et al. 2010). However, most of current researches and applications of position tracking systems are used outdoors where these technologies are accurate. As for the subway projects, the position cannot be tracked accurately due to the underground circumstance. Another obstacle is that subway safety management is separated into different phases. The design, construction, operation and maintenance of subway projects are conducted by different companies, which makes subway safety management disperse and inefficient. In conclusion, a precise and integrated method is in high demand for subway lifecycle safety management.

This paper provides a systematic consideration for the lifecycle of subway projects. BIM is introduced to visualize the subway projects by establishing a digital model. Through the integration of RFID into BIM, an accurate real-time position tracking system is built to overcome the restriction of underground work. The structure of this paper is organized as follows: section 2 compares the current position tracking technologies. The architecture of the system is illustrated in section 3. Section 4 explains how to obtain the accurate position in the underground tunnels using the system. A summary of the contribution and limitation of this research and the discussion about further research follow before the list of acknowledgements and reference.

STATE OF THE ART
Overview of subway construction

With increasing urbanization and continuous development of the transport industry in China, the government invests a lot in infrastructure projects in metropolis. Subway is regarded as an effective way to solve traffic congestion in many cities (Wan et al. 2015). The functions of subway projects are mainly realized based on subway station and subway section to. For example, subway station is where the train picks up or drops off the passengers and the structure of subway station is normally a building with several floors above or below the ground. Subway sections are tunnels which provide tracks for the trains and help the subway lines spread in cities. As most subway trains run under the ground, subway sections are also below the ground. Meanwhile, section construction not only makes up a great proportion in the subway project, but also faces various challenges as it spreads in cities. Considering its importance and difficulty, we put more effort on subway section in this research.

Due to the characters of subway section and the restriction of land use in urban areas, the construction of tunnels always takes advantage of shield tunnel machine (STM). Shield tunnel machine is a modern shield construction equipment, characterized by safe construction, high efficiency and automation, and environment friendliness (Wang et al. 2012). With the help of STM, the tunnel is supported by a segmental lining that is continuously assembled by precast concrete lining segments inside the shield during the advance of the machine. Figure 1 shows main parts of subway tunnel construction. In figure 1, pic.a is a bird view of the shield tunnel machine just before it starts. Pic.b shows the shield tunnel segments in different shapes and sizes. Pic.c is the joint of different segments and tunnel rings. In pic.d, a part of the tunnel is completed and the track is paved for carts to transport soil and equipment during the construction phase.
RFID application in indoor projects

The information and communication technologies are developing at a remarkable speed and provide cutting-edge methods for construction industry. Among them, position tracking technologies help to perceive the precise location of resources like workforce, materials, equipment etc. on the job site, it is essential and fundamental for a real-time management system. While GPS can be applied outdoors to acquire adequate accuracy, it cannot be used to perceive items indoors like tunnels. Hence, other technologies must be utilized to achieve indoor position tracking and which are in large demand.

Radio frequency identification (RFID) tags are cheap but reliable and they are identified as one of the ten greatest contributory technologies of the 21st century. RFID use a memory storage device to store a certain amount of data such as the product identification number, price, cost, manufacture date, location, and inventory on hand (Chao et al. 2007). With this function, RFID has been employed with other technologies in many fields including indoor position tracking. Khoury and Kamat (2009) evaluated the position tracking technologies including Wireless Local Area Networks (WLAN), Ultra-Wide Band (UWB), and Indoor GPS positioning systems. Passive radio frequency identification (RFID) tags are employed for helping position tracking and finally achieve an accuracy between 10 to 50
centimeters in the laboratory environment. Tesoriero et al. (2010) took the advantage of RFID-based system to help locate the autonomous robot at low cost with high accuracy and precision. In summary, RFID can be used for indoor projects. Meanwhile, the advantages of RFID (low price, high accuracy, long duration) can meet the demand of position tracking in subway tunnels.

**BIM in subway projects**

Building information model (BIM) has brought great changes to the lifecycle of projects in architecture, construction, engineering and facility management industry (Eastman et al. 2011), and subway project is not an exception. Marzouk and Abdelaty (2014a; 2014b) proposed a BIM-based framework for managing performance of subway station and realized the monitor of thermal comfort by integrating wireless sensor network (WSN) with BIM. BIM is also applied to detecting collision before subway station construction starts. Currently, the research on subway section construction is rare due to the absence of IFC support of tunnels. In order to overcome this problem, Yabuki et al. (2013) developed a product model called IFC-Shield Tunnel. And this model is an expansion of Industry Foundation Classes (IFC) for representing shield tunnels, which would promote BIM implementation in subway projects.

Despite the fact that RFID and BIM are rarely applied in subway section tunnels construction, operation, etc., both of them are promising technologies in construction industry. This paper presents a proposal of integrating RFID into BIM at design phase to realize real-time position tracking for subway project lifecycle safety management.

**THE ARCHITECTURE OF THE SYSTEM**

Figure 2 illustrates the architecture of the system. RFID tags are embedded on tunnel shield segments before coming to the construction site. These tags as well as each tunnel shield segment are registered into BIM-based model in accordance with the construction process where BIM provides a visual model for subway tunnels. In order to read the location information written in these tags, RFID readers are carried by construction workers, carts used to carry construction equipment, subway trains, and maintenance vehicles. With the help of information technologies, the information can be transmitted to the safety management system (SMS) in time and help safety managers get the real-time position of labors, equipment, and trains. Based on Real-time Subway Safety management system with RFID & BIM, safety managers can make decisions and send instructions in time.
Define location-related requirements for subway tunnel construction and operation

An investigation and an interview with safety managers were conducted respectively in a real subway tunnel construction site and Nanjing subway operating company to identify location-related requirements for subway tunnel construction and operation. A tunnel can only provide one narrow path for workers and equipment at all phases. During the construction phase, unlike other outdoor construction sites, the construction of a subway tunnel starts with the excavation of a vertical shaft. The shaft is used as main and sometimes the only entrance for tunnel construction. Due to the limited space, STM has to be disassembled before transmitted to the tunnel, and then it will be put together under the ground again. Carts run behind STM over and over to transport the soil or rocks cut by STM out of tunnels and carry equipment and materials (such as subway tunnel shield segments) into tunnels. During this process, it is of high risk if someone or other equipment is on the way the cart goes through. And, it is the similar concern for safety professionals in operation and maintenance phases. For example, the location of each subway train should be carefully monitored to avoid collision. Hence, a real-time position tracking system would greatly improve the safety performance of subway projects.

The integration of RFID and BIM in subway projects

RFID has long been used in many fields including construction industry. In the manufacturing process of subway shield segments, RFID tags are embedded on the surface of segments and store the necessary information to
control the quality of segments. Normally, a typical RFID system consists of RFID tags, RFID readers, and antennae, to focus on the scope of this research, the type of RFID systems will not be discussed in this paper. In this paper, an Active Reader Passive Tags (ARPT) system is employed. The tags used in ARPT system are cheaper and don’t need batteries, which can meet the requirements of subway projects in two ways. Firstly, due to the large scale of subway lines, the number of tags required is enormous. While passive tags are cheap, it can greatly reduce the costs. Secondly, passive tags do not contain batteries and they can work for a long period, which can also lower the cost of replacing these tags. RFID readers are more expensive than RFID tags and they are designed as wearable device carried by workers and other forms of devices installed in equipment and trains. After RFID tags have been embedded on the segments to help control their quality, these segments must be coded immediately and then the information can be written in and retrieved from the tags. When the readers pass through a RFID tag, the information in the tag can be obtained and sent to the safety management system (SMS).

In this research, BIM serves as a visual platform in SMS. The coded segments are registered in BIM-based model before construction starts, and then the location of each segment can be visualized in accordance with the process of construction in the model. When information is received from readers, the location of tags can be analyzed and the exact position of workers, equipment, trains etc. can be got. The elements such as shield segments can be visualized in the model, which helps safety manager make decisions in time.

Figure 3 shows the sketch of BIM-based subway tunnel model with RFID tags. During the manufacture of subway tunnels segments, FRID tags are embedded on the inner surface of each segment. One ring of subway tunnels is assembled by 6 segments of 3 standardized types making the process of assembling easier.

![Figure 3 Sketch of BIM-based subway tunnel model with RFID tags](image)

Pic. a: one ring of subway tunnels, Pic. b, one piece of tunnel segment
THE COMPUTE OF THE POSITION

There are numbers algorithms for RFID localization and new algorithms with higher accuracy is still emerging (Zhou and Shi 2008). Based on the transmission equation of Radio Frequency (RF) signal propagation in space proposed by Friis (1946), received signal strength is used to compute the position.

\[ p_r = p_t \frac{G_t G_r \lambda^2}{4\pi^2 d^2} \]  

(1)

Where \( p_r \) is power received by receiver antenna, \( p_t \) is the power input to transmitter antenna. \( G_t \) is transmitter antenna gain. \( G_r \) is receiver antenna gain. \( L \) is system loss factor, \( \lambda \) is wavelength, and \( d \) is the distance between transmitter antenna and receiver antenna. The distance between RFID tags and readers can be calculated through equation (1) if the received signal strength is measured. At last, the position of readers can be tracked.

This can be further explained by figure 4. For the subway safety management system proposed in this research, RFID tags embedded on segments are used as reference nodes shown as T1, T2, and T3, in figure 5 whose location information has been recorded in BIM-based safety management system. Workers with wearable devices are required to read these tags which can easily help the system get their position because each of the segments with RFID tags has been marked in BIM-based model. For other equipment like cart and trains, RFID readers are installed at a fixed position to ensure they can read these tags. The position of readers can be calculated as equation (2):

\[
\begin{align*}
\rho_1^2 &= (x - x_1)^2 + (y - y_1)^2 + (z - z_1)^2 \\
\rho_2^2 &= (x - x_2)^2 + (y - y_2)^2 + (z - z_2)^2 \\
\vdots \\
\rho_n^2 &= (x - x_n)^2 + (y - y_n)^2 + (z - z_n)^2
\end{align*}
\]  

(2)

In real subway projects, there are more tags available on segments, which will improve the accuracy of position tracking.
CONCLUSION AND OUTLOOK

This research proposes an integration of RFID and BIM to realize position tracking in subway projects at design phase and provides real-time location-based information for the RFID &BIM-based subway lifecycle safety management system. The system takes advantage of the ready-made RFID tags in shield tunnel segments, which will not increase the cost of subway projects. After visualizing the tunnel with BIM, the location of workers, equipment, and trains can be monitored accurately and timely. The implementation of such system would improve the quality and efficiency of decisions made by safety managers and fulfill the concept of design for safety.

However, the Industrial Foundation Classes (IFC) still do not support the tunnel, future work may focus on the development of tunnel models to meet the demand of subway projects. The proposed system would also be tested in a real subway project.

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REFERENCE


SAFETY CITIZENSHIP BEHAVIOUR IN THE MIDDLE EAST OIL AND GAS INDUSTRY

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The Oil and Gas industry has a similar risk profile to the construction industry. Those who work in this high-risk sector try to avoid accidents and reduce health and safety risks associated with their business. Root-cause analyses of accidents tend to reveal human error as a significant factor in accident causation. Safety research has revealed that safety compliance is not sufficient in itself to minimise risks and therefore, in order to improve safety performance; organisations need proactive individuals to initiate safe behaviour through voluntary participation in safety initiatives. Safety Citizenship Behaviour (SCB) is a higher-order construct which describes the discretionary behaviours which cumulatively; promote the safety performance of the organisation. There are no SCB studies in the Oil and Gas sector associated with the Middle East. However, research has shown that the Middle East has its own culture and systems which may influence employees’ safety behaviours (compliance and SCB). The main purpose of this paper is to review the extant literature on SCB and present findings from a pilot study that was part of ongoing research to assess SCB in the Middle East oil and gas industry. The research investigates the existence of SCB, how SCB is perceived, what could be the motivators for SCB existence, and the effect of SCB on the general safety performance of organisations. The findings from this study will add to existing knowledge, and provide further understanding of the concept of behavioural safety from the worker’s perspective. A pilot study (N=52) ascertained whether SCB is perceived discretionary or part of the job, and showed that the higher the education and work position the more SCB is considered part of the job rather than a voluntary behaviour. Interviews conducted so far (N=11) highlight that SCB is not a common behaviour amongst workers in the Middle East oil and gas industry.

Keywords: Citizenship Behaviour, Safety Performance, safety culture, Middle East oil and gas

INTRODUCTION

The Oil and Gas industry has a similar risk profile to the construction industry. Those who work in this high-risk sector try to avoid accidents and reduce health and safety risks associated with their business. Statistics from the International Association of Oil and Gas Producers (IAOGP) indicated that there were 139 fatalities in the oil and gas industry across the Middle Eastern countries, between 2005 and 2015 (IAOGP; 2017). Despite the implementation of engineering controls and management systems; accidents still happen and in many occasions have had catastrophic impact not just on individuals, but also on the environment and economy directly and indirectly (HSE, 2012). Investigations and root cause analyses of major accidents like Chernobyl (1986) and Piper Alpha (1988) have revealed that human error has been a major contributor to these accidents and that human behaviour is at the midpoint of the sequence of failures (Cullen, 1990; Reason, 2000). It has been argued that most organisation’s approach

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towards safety management are usually more focused on technical mechanisms (such as the design of equipment, safety procedures, policies and programmes, etc.), without given enough attention to human behavioural factors (DeJoy et al., 2004, Didla et al., 2009, Griffin et al., 2000). Specht et al. (2006) suggested that human behaviour and attitudes influence how workers identify risks in the workplace and react to them.

The recognition of the role of human factors in accident causation (rather than purely technical failures being at fault) has led to a widening of the spectrum of safety assessment to include more organisational and human behavioural factors (Flin et al., 2000). Subsequently, the behaviour of workers towards the management of safety has become of great importance and the focus has shifted to the safety compliant behaviours of workers (DeJoy et al., 2004,). Further safety research has revealed that safety compliance was generally not sufficient to minimize the risk of adverse events, and that organisations needed individuals with the commitment and enthusiasm to improve safety (Didla et al., 2009; Hofmann, et al., 2003; O’Dea & Flin, 2001; Turner, et al., 2005). This kind of behaviour comprises of compliance behaviour (i.e. adhering to the rules, procedures and avoiding unsafe practices), but also an extra (voluntarily) proactive attitude of workers towards promoting safety and helping others to consider safety, by advising others or even by raising their awareness of unsafe acts and/or conditions, or even by intervening to stop others from performing unsafe acts (Hofmann, et al., 2003). These initiatives are demonstrated in behaviours like helping co-workers, promoting safety programs, demonstrating initiative, suggesting changes for improving safety, which have been collectively recognised and conceptualised as Safety Citizenship Behaviours (SCB) by Hofmann et al., (2003). Since Hofmann et al. Safety Citizenship Behaviour has gained favour in safety literature.

LITERATURE REVIEW

Safety Citizenship Behaviour SCB was first introduced as a concept by Hofmann, Morgeson and Gerras in 2003, to demonstrate employees’ safety behaviours beyond their job descriptions (extra-role) that improve workplace safety performance (Hofmann et al., 2003). Before SCB, conceptualised terms such as Safety Initiative and Safety Participation were generally used in the safety context to describe behaviours which are proactive in nature and which enhance safety performance (Andriessen, 1978; Griffin & Neal, 2000). Therefore, the literature has indicated a few constructs and theories which are similar to SCB, for example Carefulness and initiative Dimensions (Andriessen, 1978); Actively Care (Geller, 1991) and Safety Compliance and Safety Participation (Griffin & Neal, 2000). These concepts may have contributed to the development of the SCB concept, however SCB is a higher-order construct encompassing all safety behaviours which are perceived as voluntary and proactive in nature and which assist in developing an environment that supports safety (Didla et al., 2009). It is stated in the literature that the SCB concept stemmed from Organisational Citizenship Behaviour OCB, however, some SCB features, such as the dimensions and measurement of behaviours, were developed from other theories similar to OCB. the most popular definition of OCB is credited to Dennis Organ (1988), who defines OCB as “individual Behaviour that is discretionary, not directly or explicitly recognized by the formal reward system, and that in aggregate promotes the effective functioning of the Organisation” (Didla et al, 2009; Yong et al, 2011; Podsakoff et al., 2000). In this
definition, Organ (1988) established the main three characteristics of the OCB construct, which are: discretionary, not recognised under a formal reward system, and contributes to the effective functioning of the organisation (Organ, 1997). The origin of OCB construct can be traced back to Barnard (1938) who noted that the effective functioning of an organisation depends on its members’ willingness to cooperate and contribute their efforts to the cooperative system. In other words, it does not just depend on the formal structure and control of the organisation. OCB and its similar constructs are important to understand how SCB was developed; however, such discussion is not in the scope of this paper.

**Similar constructs to SCB**

It has been stated that the SCB concept was built from OCB, which is invariably referred to as the parent construct of Safety Citizenship Behaviour (Didla et al., 2009). However, there are a few constructs and theories similar to Safety Citizenship Behaviour in terms of studying the nature and determinants of workers’ behaviours towards safety. Examples of these theories include:

Carefulness and Safety initiative (Andriessen, 1978)

Andriessen (1978) made a distinction between workers’ safety behaviours and identified two relatively independent but related aspects of safe behaviour, *carefulness* and *safety initiative*. Carefulness refers to an individual’s tendency to take unnecessary risks, while safety initiative refers to the individual’s tendency to improve the safety of the work environment on their own initiative (Andriessen, 1978). Andriessen (1978) assumed that people are more careful when they recognise that thinking and acting in such a way does not hinder their work speed, and that safe behaviour contributes to accident reduction. People show more safety initiative when their supervisor and colleagues react positively to it. Andriessen (1978) study suggested that the motivation to go beyond carefulness and take personal safety initiative is strongly dependent on the environment in which the person is operating and that the promotion of safety initiative will particularly promote the general safety of the work situation.

Actively Caring (Geller, 1991)

*Actively Caring* is a term coined by Geller (1991) to refer to employees acting to benefit the safety of others; in other words, employees who care enough about the safety of their co-workers (Roberts & Geller, 1995). An actively caring employee would continually observe unsafe conditions or unsafe behaviours of their co-workers, and then give them constructive behavioural feedback in order to implement appropriate corrective actions (Roberts & Geller, 1995).

Safety Participation (Griffin & Neal, 2000)

Griffin and Neal (2000) distinguished between safety behaviours that are prescribed as part of the job and safety behaviours which support the broader organisational context. Griffin and Neal (2000) differentiated safety behaviours, with reference to Borman and Motowidlo’s (1993) two major components of performance: *task performance* and *contextual performance* (Griffin & Neal 2000). They identified safety behaviours in the workplace as follows: *Safety compliance behaviours*: are the core safety activities that need to be carried out by individuals (as part of their jobs) to maintain workplace safety.
These behaviours include adhering to safety procedures and wearing personal protective equipment as appropriate. **Safety participation behaviours:** include participating in voluntary safety-related tasks, attending safety meetings, encouraging the safeguarding of the safety of others or taking part in the improvement of the safety requirements for the job.

Griffin & Neal (2000) suggested that safety participation behaviours may not directly contribute to workplace safety; however, these behaviours are likely to play an important role in the maintenance of overall system safety and can therefore enhance the safety of the team, the work environment and the organisation as a whole.

**Dimensions of SCB**

No consensus has been reached about OCB’s dimensionality, and frameworks ranging between two and seven dimensions (Didla et al., 2009; LePine et al 2002; Podsakoff et al., 2000) have been presented. In contrast, SCB has a six-dimensional safety-related scale which was developed by Hofmann et al. (2003) through modifying several OCB measures (Hofmann, et al., 2003). The six dimensions of SCB as developed by Hofmann et al. (2003) are constituted of the following:

1. **Helping:** This can include volunteering for safety committees, explaining safety procedures to new members, assisting others in working safely, helping colleagues learn about safe work practices, and helping others with safety related responsibilities.
2. **Voice:** Speaking up and encouraging others to get involved in safety issues, expressing opinions on safety matters even if others disagree, and raising safety concerns during planning sessions.
3. **Stewardship:** Looking after the safety of other coworkers, taking actions to stop safety violations and risky situations, and protecting them from hazards.
4. **Whistle-blowing:** Warning other crew members that safe working procedures must be followed, and that safety violations are not tolerated and will be reported.
5. **Civic Virtue (Keeping Informed):** Attending safety meetings, attending non-mandatory safety meetings and keeping informed of changes in safety policies and procedures.
6. **Initiating Safety-Related Change:** Suggesting improvements to the way jobs are done to make jobs safer, trying to improve policies and procedures and making suggestions to improve general safety performance.

**Measuring SCB**

The six dimensions of SCB are usually measured using a 27-item scale developed by Hofmann et al. (2003). The scale was adapted from Organizational Citizenship literature and validated citizenship scales, which were altered to be safety-specific (Hofmann et al., 2003). Hofmann et al. (2003) used the newly-adapted scale to measure the role definition of SCB by asking participants to rate the degree to which the 27 items were expected as part of their jobs, on a scale ranging from 1 “expected as part of my job” to 5 “definitely above and beyond what is expected for my job” (Hofmann et al., 2003). However, the scale can be used, to determine the extent to which workers are
engaged in SCB; by asking workers how frequently on a scale ranging from (Never – sometimes– always), they are engaged in a specific behaviour

**Antecedents and consequences of SCB**

Safety Citizenship Behaviours are seen as being influenced by certain motivators or antecedents. Going back to Organisational Citizenship Behaviour, Podsakoff et al. (2000), categorised OCB antecedents into four the category including; individual factors, organisational factors, task factors, and leadership behaviour (Podsakoff et al. 2000). Previous studies have reported that SCB has an interlinked relationship with, and is motivated by factors such as, safety culture/climate, individual characteristics and leadership behaviour. However, in the safety context, task characteristics have not (so far) been identified as antecedents of SCB.

**Organisational characteristics**

Several studies (e.g. Griffin et al., 2000, Hofmann et al., 2003, DeJoy et al., 2004, Turner, et al., 2005, Didla et al., 2009) have reported a significant relationship between organisations’ safety climate and the pro-active safety behaviours of workers. SCB results social exchange between organisations and workforce due to organisational activities to support workforce such as health care (Reader et al. 2016)

**Individual characteristics**

Self-preservation and individual priority were found to be among the antecedents of SCB in a study by conducted by Didla et al. (2009). Their study noted that few mentioned that safely was an individual priority to them, which means they see it as a responsibility to care for others as well as their own safety (Didla et al., 2009). Self-serving behaviour was not supported by Didla et al., (2009) as an antecedent for SCB, though they thought that their responses were affected by a social desirability bias. However, studies on OCB reported that employees may engage in OCB just to create a positive self-image in the organisation and because they hope to be rewarded by their immediate supervisors or even to make others look bad (Bolino, et al., 2004; Podsakoff et al., 2000).

**Leadership behaviours as antecedents of SCB**

Leadership is very important factor which has been reported to positively or negatively influence the safety behaviour of subordinates (Clarke & Ward 2006, Yang et al., 2009). Clarke (2013) reported that leadership acts as an antecedent to safety behaviours (both compliance and participation) is supported by empirical evidence. Transformational leadership is more likely to promote participation than compliance. Previous studies (e.g. Clarke, 2013, Hoffmann et al., 2003; Mullen et al., 2011) have shown that transformational leadership has a direct relationship with the level of safety participation and engagement of subordinates. Transactional Leadership is more related to workers’ safety compliance behaviour. Compliance behaviour increases with contingent rewards, and tend to decrease with MBEP (Management by Exception Passive) and laissez-faire styles of transactional leadership (Mullen et al., 2011).

**RESEARCH DESIGN**

The research began with a comprehensive review of the literature on SCB, which enabled the identification of current knowledge on the subject, including any reference to research in the Middle East. This was followed by development of the following research questions:

- To what extent can SCB be observed in the Middle Eastern Oil and Gas industry?
• How is SCB perceived in the Middle Eastern Oil and Gas industry?
• What could be the motivators for SCB to manifest in the Middle Eastern Oil and Gas industry? and
• What is the effect of SCB on the safety performance of organisations in the Middle Eastern Oil and Gas industry?

A mixed method approach will be used to collect the data required to answer the research questions as the issues are complex and messy. This will also provide opportunities for triangulation that are not possible with single methods such as questionnaires. Quantitative questions will seek to establish what perceptions are held by the target sample, whilst qualitative data will help explain why these perceptions may be held. It is also important to have a mixed method approach in order to explore how frequent SCBs are and what benefits can SCB bring to the organisation.

Thus the method for the whole project is (1) semi structured interviews (analysis is not covered in this paper), (2) pilot of the quantitative questionnaire, (3) full deployment of the quantitative questionnaire.

The Semi-structured interviews were utilized to explore the understanding of SCB in the population to be investigated and inform the development of a quantitative questionnaire (discussed later). The respondents will be recruited from a targeted sample in a typical Middle Eastern country. This will essentially be a sample of convenience. However, the methodological limitations of such a sampling strategy are acknowledged.

Secondly a questionnaire will be used to collect quantitative data. The purpose of this data collection instrument will be to ascertain perceptions, motivators and outcomes of SCB as it applies to operatives in the Middle Eastern Oil and Gas industry. The questionnaire will be bilingual (English/Arabic) validated through a reliability test of a pilot sample to confirm that the questions are suitable to collect the required data, and then distributed online in order to gain the maximum responses.

**Measuring**

The quantitative questionnaire consists of eight sections; the first section covers demographics. The second section of the questionnaire is concerned with the perception of SCB; 20 items from Hoffmann (2003) SCB scale are used for this section, participants are asked to determine how frequent they are engaged with these items on a Likert scale of (Never – rarely – sometimes – often – always). The third section consists of 9 statements regarding the safety culture/ climate adopted from Choudhry et al (2009) safety climate scale. e.g. “Management quickly corrects any safety hazard (even if it’s costly)”. Fourth section consists of 5 statements dealing with individual factors; questions adopted from Podsakoff et al (2000), including for example “I’m satisfied with my job”. The fifth section consists of 5 statements dealing with tasks developed from Hoffmann et al (2010) and Podsakoff et al (2000), questions including for example “The tasks I do are riskier compared to others”. The sixth section is concerned with the leadership style, 11 statements are used in this section including for example “my supervisor encourages me to express my ideas and opinion about safety at work”. The statements were adopted from Mullen et al (2009) safety specific Leadership behaviours. For the sections three to six participants are asked to rate to what extent do they agree with each statement on a scale of (Strongly Disagree – Disagree – Neutral / don’t know – Agree – Strongly agree). Section seven is concerned
with safety compliance behaviour; participants are asked to determine how frequent do they conduct each of the 4 statements used in this section e.g. “I carry out my work in a safe manner”. The statements were adopted from Neal, Griffin, Hart (2000). The eighth section collects information about general safety performance; participants are asked to determine how frequent does each of the 3 statements used in this section happens e.g. “Accidents in your department that cause at least interruption of production/ operation/ service”. Most of the questions used in the questionnaire were validated and used by previous researches; apart from the safety performance questions. However, a pilot study was deemed necessary before proceeding to full data collection in order to assess if the questions are valid and relevant to samples form the Middle East. Questionnaire summary and examples of questions are in APPENDIX: A

PILOT STUDIES

Initial survey

The first pilot study (N= 52) was applied to draw an initial understanding of SCB in the Middle East, by exploring the participants’ response to the SCB dimensions. A small questionnaire was used in this study consisting of two sections; the demographic section and the main section which comprises of the 27 items SCB scale designed by Hoffmann (2003). 120 questionnaires were distributed to workers at two of the six fields of Zubair Project, Basra south Iraq. The project is Technical Service Contract between Iraq’s state-owned South Oil Company (SOC) and other international partners mainly ENI (Italy) and Occidental Petroleum Corporation (USA). The average workers per shift in the two fields were 110, therefore it was decided to print and distribute 120 questionnaires.

In general Iraq is a typical Middle Eastern country where social, cultural political and economic situation is similar to other Middle Eastern countries. In addition to that, and most importantly the majority of workers employed for the field activities in this project are from various Middle Eastern countries mainly (Iraq, Egypt, Libya, Algeria, Jordan and Syria) which represent excellent sample of diversity of workers representing wider Middle East population. The study was conducted during the main author’s course of work in the project, which provided an opportunity to recruit participants for the questionnaire. Participants were asked to rate to what degree each of the 27 items are expected as part of their jobs on a scale ranging from 1 (expected part of my job), 3 (somewhat above and beyond what is expected for my job), to 5 (definitely above and beyond what is expected for my job). 52 out of 120 questionnaires returned i.e. (% 43). Questionnaires results were analysed using SPSS. Since 1 represent a positive respond and 5 represent a negative respond; data was back-entered, (i.e. 1, 2, 3, 4, 5 were entered 5, 4, 3, 2, 1 respectively). For each one of the 52 participants an overall score average was calculated. SCB dimensions were analysed separately by calculating each participant average score on each dimension, respond varied as expected. As shown in (figure 1) some dimensions have a wider spread like in (initiating change, voice & whistle-blowing), some are quite symmetric and others were skewed.
The pilot study (N=52) indicated that SCB affected by levels of education and employment. An increase in average scores of SCB dimensions; associated with an increase in education and employment level was demonstrated, as shown in (figure 2). This could be important in the process of determining the type of intervention and the population targeted. ‘Keeping Informed’ scores were the highest with few outliers; in fact, member checks confirm that these figures were wrong, which could be a misunderstanding of relevant questions.

Asking participants to what extent they consider each item from Hoffmann et al.’s (2003) scale; as part of their job is one way of using the scale; this pilot study has used this approach. However, the problem with this approach is that someone may identify SCB behaviour as part of their job without indicating if he/she ever engaged in such behaviour or how frequent he/she engages in such behaviour. Therefore it is important to have a mixed method approach in order to explore how frequent SCBs are and why.

Questionnaire validation
The second pilot study (N =16) was conducted to test and validate the full questionnaire which was designed to answer the research questions by exploring SCB in the Middle East and its possible motivator / deterrent. The pilot study (N =16) targeted Libyan oil and gas workers currently resident in the UK for training and education. I addition to the eight sections of the questionnaire; three questions were added to the to obtain participants feedback about the questionnaire, for example “The questionnaire is too long, there were too many questions” and “Sometimes it is hard to understand the meaning in English and I have to search it.”

Due to the small size sample (N=16) it was not possible to obtain significant statistical figures from the study, however the main finding from study were vital to revise the research method. Findings include for example;

- 13 out of 16 (81.25%) strongly agreed that the questionnaire is too long
- 12 out of 16 (75 %) had to search for the meaning of some words.

Findings from this pilot study has led the researcher to modify the research method to include a qualitative approach prior to applying the research questionnaire in order to obtain a deeper understanding of some of the research questions and also to refine the criteria and type of data needed to be collected by quantitative methods. In addition to that it was decided to reduce the number of questions and provide the entire questionnaire in Arabic language to get the maximum reliable respondents. Full analysis of the interview and the questionnaire will reveal more information that should enhance the understanding of SCB in the Middle East oil and gas industry.

CONCLUSIONS

The aim of this paper was to present findings of a pilot study on SCB in one of the projects in a Middle Eastern country. The pilot study was deployed to gain initial understanding of SCB construct. Participants (N=52) were asked to determine to what extent they consider SCB as part of their job. The study has showed a significant relationship between SCB and workers levels of employment and also between SCB and workers levels of education. Workers with higher education or qualifications would likely consider SCB as part of their job; also workers with higher employment ranks would most likely consider SCB as part of their job. These findings are worth considering in the process of determining the type of intervention and the population targeted by intervention. Regardless if workers have identified SCB behaviour as part of their job or not the study was not able to explore if workers have ever engaged in such behaviours or how frequent they get engaged in them. Therefor it was considered useful to explore how frequent workers in the Middle East engage with SCBs, and what motivates or leads them to engage or not engage with SCBs. This will constitute the next phase of the research.

The second pilot study (N=16) was conducted to test the reliability and validate the questionnaire used to collect the research data. Findings were not significant as the sample was too small to extract valuable information; however, the sample was sufficient enough for the authors to review the research methods and consider reducing the number of questions and have them translated into local language. This is a useful finding for other researchers who wish to reduce their question-sets and improve efficiency in studying critical SCB factors.
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APPENDIX: A questionnaire summary and examples of questions

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Full questionnaire is available on request
Prevention through Design (PtD) involves the explicit consideration of construction and maintenance worker safety by designers during the design phase. Unlike in Europe and many other nations, PtD is not required in the United States (U.S.) and faces significant challenges to diffusion, including perceived risks if it is implemented. This paper provides owner and designer organizations in the U.S. and other nations where PtD is not required with practical guidance on how PtD can be adopted successfully by firms and on projects, based on the assumption that it is best to implement a lower level of PtD at first, then increase the level of PtD implementation on future projects as experience and comfort with the PtD process increase. This theoretical paper suggests three levels of formal PtD implementation: 1) Invisible Safety Constructability, 2) Enabled Voluntary PtD, and 3) Contractual AE-Led PtD. For each of these levels of implementation, the paper recommends eleven organizational characteristics and project processes that will allow potential adopters to reduce risks, reduce resources, and increase the chances of successful implementation. These characteristics and processes include: Strong Leadership and Safety Culture, Life Cycle Perspective, Formal PtD Program, Designer Selection, AE Contractual Obligations, PtD Processes, Constructability Reviews, Collaboration Enhancing Processes, PtD-Related Knowledge and Training, PtD Tools, and Information Technology Infrastructure.

Key Words: Prevention through Design, Design for Safety, Constructability, Construction Safety

INTRODUCTION

In 2015, the number of lost-time injury incidents was 204,700 (BLS 2016a) and the number of fatalities in the United States (U.S.) was 937 (BLS 2016b). These numbers indicate that despite the increased emphasis on safety and health within many firms in the construction industry, there is still much room for improvement. Problems spur innovation, and safety management is no exception. Owner and contracting firms in the U.S. have proclaimed safety as the firm’s number 1 priority, implemented zero-injury programs, and experimented with information technology-based systems (such as online training and smartphone safety applications) to increase safety and health within their organizations.

Prevention through Design (PtD), also referred to as Design for Safety, is a process in which design professionals explicitly consider the safety of construction and maintenance workers during the design phase of a project. PtD is required in New Zealand (New Zealand MBIE 2016), Europe, Singapore and South Africa, and parts of Australia (Gambatese et al. 2005, Goh and Chua 2015, Gambatese et al. 2017) but
has only been implemented on a voluntary basis on individual projects and by individual organizations in the U.S. (Weinstein et al. 2005, Toole et al. 2015). (There are no published studies that document the percentage of capital projects on which PtD was performed, but the authors speculate it is near 0% in the commercial, residential and infrastructure market sectors and 10-30% in the process sector due to their established risk management processes). For pure designers (i.e., designers who never have construction employees and do not participate in design-build projects) and even design-builders in the U.S. building market, it is perceived as a radical innovation with significant challenges to implementation and potential risks even when implemented well. Such challenges include fear of increased inappropriate lawsuits by injured workers, fear of increased designer fees, designers’ lack of the needed safety expertise, conflicts with model contracts, and the prioritization of cost and schedule over construction safety (Toole 2005, Tymvios and Gambatese 2015, Gambatese et al 2017). Many of the same challenges and risks are faced by U.S. owner organizations who wish to implement PtD on their projects.

The goal of this paper is to provide owner and designer firms in the U.S. and other nations where PtD is not required by law with practical guidance on implementing PtD on a gradual basis, in order to reduce challenges and risks associated with implementation and to gain organizational learning that will lead to successful full implementation of PtD. The paper accomplishes this goal by proposing three distinct levels of PtD implementation: Invisible Safety Constructability, Enabled Voluntary PtD, and Contractual AE-Led PtD. It is acknowledged, however, that there is actually a continuum of possible levels of implementation.

For each proposed level, the paper identifies the needed organizational characteristics and processes that should to be followed to maximize success. Many of the organizational characteristics and processes identified in the paper are found in publications from research in the US (Toole et al. 2015, Gambatese et al. 2016) and Australia (Fleming et al. 2007, Lingard et al. 2014). The enablers of PtD from Toole et al. (2015) listed below will be discussed for each level of implementation:

- Strong Leadership and Safety Culture.
- Life Cycle Perspective.
- Formal PtD Program.
- PtD Explicitly a Factor in Designer Selection.
- AE Contractual Obligations.
- PtD Processes.
- Constructability Reviews.
- Collaboration Enhancing Processes.
- PtD-Related Knowledge and Training.
- PtD Tools.
- Information Technology Infrastructure.

The content of this paper is based on funded and unfunded research that the authors have performed over the past ten years. The research has included surveys of nearly 1000 individuals and hundreds of interviews of employees from dozens of organizations in the U.S., Canada and Europe, reviews of standard contracts for design and construction services, as well as review of several sets of PtD guidance documents from organizations in North America. Despite the authors’ research experiences, the paper should be considered a theoretical piece. There is no empirical evidence that firms which implement the components associated with each level of PtD identified in
the paper have been more successful than firms who have implemented PtD in ways not addressed in the paper.

**LEVEL 1: INVISIBLE SAFETY CONSTRUCTABILITY**

Level 1 PtD is referred to as Invisible Safety Constructability because the fact that PtD is performed would not be obvious from reviewing any of the project contract documents. That is, PtD is not mentioned in the request for proposals from architects-engineers (AE), in the AE’s proposal to the owner, or in any contracts for the project. PtD is also not explicitly conducted internally by the AE firm as part of its standard design process. AE capability to perform PtD is not a factor in the owner’s selection of the AE because it is assumed all PtD knowledge used to shape the design to make it inherently safer to construct is provided by the owner and/or one or more contractors. The AE does not ensure its employees and design consultants receive PtD training and does not use PtD design tools.

PtD guidance is provided through comments made to the AE during the constructability reviews, which are typically formal meetings when owner and designer personnel meet to discuss aspects of the design that may cause the construction to cost more, take longer, or be of lower quality because the design aspects are not as constructible as possible. Participants typically include designers and professionals with extensive knowledge about construction materials, methods and processes. Typically, such constructability reviews occur at approximately the 10%, 30%, 60% and 90% stages of design. When PtD is part of a project, however, safety constructability is also an explicit focus of the discussion.

A common mistake is not to hold the first constructability review until later in the design process. As has been noted in the PtD literature (Behm 2005, Weinstein et al. 2005, Fonseca et al. 2014), the ability to influence the achievement of project goals such as cost, schedule and safety diminishes significantly as the project progresses from concept to construction. For Level 1 PtD to be effective, safety issues must first be discussed no later than the 30% stage and meeting participants should include individuals representing design, construction operations and safety, and maintenance operations and safety.

Regarding the type of project delivery method used, Level 1 PtD can be implemented on projects using traditional design-bid-build (DBB), design-build (DB), or integrated project delivery (IPD). However, on DBB projects, the general contractor and subcontractors are typically not known until after design is complete. As such, if the owner’s facility management and construction personnel do not have PtD expertise, it is necessary that the owner hire a firm with construction expertise to participate in design reviews and provide safety constructability input. Such input can typically be provided by hiring the firm to provide design-assist services, which will likely also include guidance on procuring long-lead items and providing a more accurate cost estimate than the AE could provide. The party providing safety constructability feedback may or may not use design checklists and document and track PtD suggestions.

Despite the low amount of PtD activity associated with Level 1 PtD, it will not occur without strong safety leadership and a strong safety culture within the owner organization. It is generally accepted that the culture within an organization significantly influences the behavior of individual employees and that leadership plays a central role in establishing an appropriate organizational culture (Schein 2010). For
PtD to be implemented effectively, organizational leadership must set high expectations for all parties that influence worker safety and health. Safety must be prioritized over other project criteria and leadership must ensure that hazards are reduced or eliminated by pursuing the highest levels of the hierarchy of controls (Manuele 2008, Behm et al. 2014, Walline 2014) when reasonably possible. Unlike the process (i.e., industrial) construction market segment, owners in the building construction market segment have traditionally not prioritized construction safety over cost and schedule. If safety is to be explicitly discussed during design reviews and if a design-assist contractor is to be hired for safety constructability input, the owner organization leadership must direct these activities to happen. Without a strong safety culture within the owner organization, PtD ideas that are suggested during design reviews are more likely to be rejected if they potentially impact project cost, schedule or quality.

LEVEL 2: ENABLED VOLUNTARY PTD

Level 2 PtD can be termed voluntary because, as is the case with Level 1 PtD, the AE is not obligated by contract to perform PtD. Although the owner’s desire to have PtD performed on the project may or may not be explicitly addressed in the owner’s request for proposals, the owner should confirm during AE selection that the AE is willing to perform PtD and should seek to retain an AE with a record of collaboration with other project entities during design reviews, a record of considering maintenance and operations issues over the building’s life cycle, and a willingness to use building information modeling (BIM) software to assist with design for safety reviews.

Level 2 PtD can be termed enabled because the AE is enabled to provide a deeper and broader amount of PtD than is possible just from the safety constructability feedback given in design reviews in Level 1 PtD. Given that most design professionals lack sufficient knowledge of construction safety and PtD opportunities (Gambatese et al. 2005, Toole 2005, Larsen and White 2013, Dharmapalan et al. 2014, Hallowell and Hansen 2016), owners should insist that design professionals have access to discipline-specific PtD checklists (i.e., one checklist for structural engineering, one for electrical, etc.). Such checklists can be created in-house or secured from external sources. The Construction Industry Institute PtD tool developed by Professors J. Hinze and J. Gambatese (Gambatese et al. 1997) provide a database of over 400 individual checklists, organized by construction phase (such as concrete, steel erection, etc.). The www.designforconstructionsafety.org website includes a spreadsheet containing 1600 PtD examples and checklist items that was compiled by Mr. Alan Speegle at the Southern Company. The Australian CHAIR system is another available tool (WorkCover NSW 2001).

Design managers should also consider providing their employees with training and/or encourage the use of reference tools and websites for increasing their employees’ knowledge of construction safety in general and opportunities for designing for safety. Government agencies within the UK, Australia and Singapore have developed helpful tools that can be identified and accessed through links provided at www.designforconstructionsafety.org.

It should be noted that many process/industrial construction owners have created lengthy and detailed risk assessment documents and require their use as part of a prescribed risk management process. Such documents typically provide guidance on how project personnel can evaluate financial, regulatory, organizational and technical...
risks from the concept stage through construction. These documents can serve as a tool to help designers follow a structured process to ensure all potential safety hazards are identified. It should be noted, however, that owners who wish to implement PtD on their projects should not assume their existing capital project risk management documents and processes sufficiently address construction worker safety. It has been the authors’ experiences that many owner risk management documents focus on maintenance and operations risks, not on construction safety.

The AE is also enabled to perform PtD through other mechanisms. The use of BIM facilitates richer safety constructability reviews using 3D and 4D modeling by a broader set of participants, including maintenance and operations personnel (Lingard et al. 2014, Toole et al. 2015). Processes are established to allow designers, owners employees, and contractor employees to communicate about constructability issues outside of face-to-face design review meetings. It may be beneficial for the start of the project to include informal team building interactions between the three entities. Decision tools that allow participants to quantify and weigh safety, cost, schedule and quality factors may be used. The AE is allowed to fully consider life cycle safety and costs, knowing the owner will not reject outright design decisions that offer life cycle advantages but result in higher construction costs. A software system (which could be as simple as a shared spreadsheet, word processing document or database) may be used to enable the owner, AE, and contractor to keep track of PtD suggestions.

While Level 2 PtD does not require that the AE have any sort of formal PtD program, it does require that the owner establish a formal program for the project, for both symbolic and practical reasons. A formal PtD program will ensure that project and non-project employees are aware of the PtD concept and confident that management values safety and will affirm design decisions that prioritize safety over cost and schedule. Without a formal PtD program, an intent to perform PtD is likely to take a back seat to traditional competing project goals.

As is the case for Level 1 PtD, DB and IPD are the preferred project delivery methods to enable PtD, but DBB can be used if the owner has strong PtD expertise (which is very rare in building construction) or if one or more contractors are hired to provide design-assist services. Because the amount of additional design man-hours to perform PtD is likely not zero, the AE may wish to demand above average hours in the design hours cap included in the owner-AE contract.

As was the case with Level 1 PtD, Level 2 PtD will not occur if the owner organization lacks leadership that effectively communicates the importance of safety and health or if the organization does not have a strong safety culture. Given that Level 2 PtD requires a greater commitment in time and greater acceptance of risk than Level 1 PtD, it may be necessary for the AE firm to also have safety-oriented leadership.

**LEVEL 3: CONTRACTUAL AE-LED PTD**

Unlike Levels 1 and 2 PtD in which the AE may participate effectively in the PtD process even if the firm is reluctant or hesitant to do so, Level 3 PtD requires full commitment to PtD by the AE firm. Also, unlike Levels 1 and 2 PtD in which the owner needs to play a key role in championing PtD and ensuring safety constructability feedback is communicated to the AE during design reviews, Level 3 PtD can be implemented without the owner playing a strong role *during* the design process. However, the owner’s role during the AE selection process is even more
critical for Level 3 PtD than for Levels 1 and 2 because the owner must secure the design services of an AE who is committed to and capable of performing PtD. The owner ideally includes in the request for proposals for design services a requirement that proposals explicitly address PtD capability and planned implementation on the project. Also, the owner’s selection of the winning AE is based in part on the strength of the AE’s PtD program and experiences, and plan for the project.

The components of an AE’s PtD program are similar to those found in owner organizations with strong PtD programs. The firm’s leaders actively and sincerely promote safety as a core value and direct communication and resources to maintain a strong safety culture. The firm’s safety culture includes motivation to utilize controls that are higher up on the hierarchy of controls and involve eliminating the identified hazards or substituting in less hazardous materials or products. The AE firm has its own PtD Champion and its own training programs for educating employees on construction safety and how to perform PtD. The AE uses BIM for 3D modeling and has developed its own customized PtD design tools, perhaps by modifying tools that are available publicly in the US and in other nations. In addition to the discipline-specific tools mentioned for Level 2 PtD, the AE should have tools based on historical data and risk modeling that allow quantitative analysis of injuries and costs associated with maintenance and building operations over the building life cycle for various design alternatives. AE employees contribute new suggestions and status updates on previous suggestions within the shared online database of project PtD suggestions.

An additional critical component of a PtD program is the standardized processes that are delineated in PtD guidance documents. Such processes include the AE having an internal safety constructability review before participating in constructability reviews with the owner. The AE works with the owner to ensure informal teambuilding exercises occur at the start of design to help establish needed trust between owner, designer, and contractor personnel, and to establish mechanisms to allow frequent and effective interaction between the parties throughout the design process. Processes must be established for tracking and fully investigating each PtD suggestion.

While PtD ideas can be suggested during an informal conversation or while one party is reviewing design documents online, the most important safety constructability feedback mechanism will be the constructability reviews. It was stated earlier that the ability to influence site safety diminishes significantly as the design moves from concept design to construction documents. Our interviews with dozens of design and construction professionals indicate that one factor behind the shape of this curve is that opportunities for identifying and facilitating prefabrication and modularization typically disappear after the 30% design stage. Because prefabrication and modularization can dramatically reduce construction injuries over “stick-built” construction (Toole and Gambatese 2008), constructability reviews that do not start until after the 30% design stage have significantly lower potential for designing a facility that is inherently safer to construct.

Two brief examples from our interviews of design and construction professionals illustrate the importance of early consideration of construction safety. During the concept design of a large dam project on the Mississippi River, the project owner stated the desire to have the project completed without putting scuba divers in the water to inspect the construction, which is typical on such dam projects. This safety goal led the program manager to decide to base design on the use of very large precast concrete modules. A similar principle is associated with a large solar boiler project
being constructed in the Mojave Desert. The Program Manager’s desire to reduce the amount of construction work performed at height led them to design the 400’ tower to be assembled from very large prefabricated modules. Although the use of prefabricated modules on both projects led to substantial time, cost, and quality benefits as well, it is less likely that the modules would not have been pursued if construction worker safety had not been explicitly considered and valued during the concept design phase.

Unlike Level 1 and Level 2 PtD, Level 3 PtD constructability reviews are led by the AE. In addition to using design checklists, the review should include the specific review tasks shown in Figure 1. Although the AE is significantly more capable of performing PtD than is expected with Levels 1 and 2 PtD, it is still important that constructability reviews include a broad set of participants. While the required participants indicated in the upper right corner of each box in Figure 1 simply refer to “owner,” “AE,” etc., it is important that the groups represented include all relevant engineering disciplines, in-house construction safety, external trades, operational safety, and cost accounting.

After the project is completed, the AE and owner actively solicit feedback on the safety of the final design from contractor personnel. The results of PtD decisions are analyzed and incorporated into corporate Lessons Learned databases to allow future projects to benefit from the project participants’ PtD experiences.

Regarding the types of project delivery methods that are acceptable for Level 3 PtD, it is still the case that while PtD can work on a DBB project with contractor design-assistance, the preferred delivery methods are DB and IPD. Even if designers are knowledgeable

![Figure 1: The Desired Constructability Review Process](image)

about construction safety and PtD, the desired level of collaboration during design between the designers, the lead contractor, construction trades, and construction safety professionals is best provided when the project is not DBB. Ideally, designers and key
construction personnel should be co-located (i.e., have nearby offices) throughout the design. Also, the owner should allocate sufficient time for the design stage, rather than constantly pushing for the design to be completed as soon as possible, which is common in the industry. A unique aspect of IPD projects is that design and construction personnel can share common financial incentives that drive each party to pursue the goals of the project, not just those of their employer. Low project injury rates can be one of the goals that the IPD parties pursue through PtD and effective site safety management during construction.

CONCLUSIONS AND RECOMMENDATIONS

Literature on innovation has shown how the methods used by firms for implementing an innovation can be as important as the inherent advantages of the innovation. Prevention through Design is a safety management innovation that offers compelling benefits but also faces significant challenges to successful adoption. This paper has sought to provide owner and AE organizations with practical guidance on how PtD can be adopted successfully by firms and on projects, based on the assumption that increasing levels of implementation over multiple projects is best. Which level of PtD should be implemented on a project should be determined by the owner based on the AE’s PtD capabilities and willingness to participate. Once the appropriate level of PtD is determined, the owner and AE can maximize the chances of success by ensuring the PtD elements discussed in the paper are provided.

For both owner and AE organizations, advancing to a higher level of implementation will require progress in areas associated with successful innovation, organizational change, and process improvement. A vision for and commitment to higher levels of implementation must be communicated by leaders, and a champion must be present. Standardized processes must be documented. Resources and infrastructure to enable implementation of these processes must be provided. Organizational learning must be facilitated through lessons learned repositories.

An interesting area of future research is whether the collaborative nature of PtD requires that all three sets of participants—owner, AE, and contractors—be somewhat equally capable of pursuing the same level of PtD. It is somewhat intuitive that an owner who is ready for Level 3, for example, should not attempt to force this level with an AE who is still working through Level 2 challenges. Even in the reverse situation, where an AE is ready to pursue Level 3 but the owner has only experienced successful Level 1 or Level 2 PtD projects, it is likely that the procurement processes, project contracts, and design review processes dictated by the owner would likely not support a successful Level 3 project.

Many of the perceived challenges to implementing PtD are associated not with undesirable outcomes that will definitely result but with uncertainty about the range of outcomes that could result. The set of recommended actions and processes for each proposed level of PtD implementation are intended to reduce uncertainty about outcomes, reduce risk, and reduce the level of resources needed to implement PtD. The authors are hopeful these recommendations will help increase the number of firms and projects in which PtD is implemented successfully.

REFERENCES


A CRITICAL REVIEW OF CONVICTIONS OF CONSTRUCTION INDUSTRY ORGANISATIONS UNDER THE CORPORATE MANSLAUGHTER AND CORPORATE HOMICIDE ACT

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The construction industry is consistently considered one of the most dangerous industries in the UK and the rest of the world due to the reported work-related fatalities and injuries. Even though the industry has made an outstanding effort to minimise accidents, there are some areas which still need refinement. The legal system is one of the approaches considered for the improvement of health and safety in the industry. The Corporate Manslaughter and Corporate Homicide Act 2007 was passed with the intention of improving the law on corporate criminal liability for poor health and safety management. Since the Act came to force in 2008, there have been twenty-one (21) convictions with 33 percent attributable to the construction industry. This paper aims to analyse the convictions with the aim of getting an insight into the cases where construction companies have been involved. Besides reviewing the cases, this descriptive study also attempts to clarify the post-conviction status of businesses and draw lessons for the wider industry. All convictions for corporate manslaughter are attributable to small and medium enterprises (SMEs). The analysis, therefore, suggests that the size of the company is a major factor in the degree of exposure to corporate criminal liability.

Keywords: Construction, Convictions, Corporate Manslaughter, Health and Safety.

INTRODUCTION

Health and safety in the work environment has been a major concern during the past decades. Safety management systems have been developed and implemented across different industries to respond to these concerns without being able to provide an acceptable outcome (Howarth and Watson, 2009). The Health and Safety Executive (HSE) reported 144 fatalities and 621,000 non-fatal injuries during 2015/2016 in Great Britain. The construction industry accounted for 43 of these fatalities, the highest proportion of the fatalities among all industries and equivalent to 30 percent of the total (HSE, 2016). This share of the fatalities is disproportionate to the contribution of the construction sector to the UK economy, which averages a gross value added (GVA) of 6.4 percent over the last decade (Rhodes, 2015). Although there has been a lot of research towards delivering improvements to health and safety performance in the construction sector, the number of accidents over the last few decades has remained unacceptably high (Abdelhamid and Everett, 2000; Haslam et al., 2005).

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There has been a historical policy in the UK to promote desirable health and safety outcomes by a combination of legislation and the common law. The legal system has therefore been one of the areas where changes have been made over the years towards improvements in health and safety outcomes. Health and safety legislation in the UK was for a long time reactive rather than proactive and tended to be designed for particular industries or specific types of workplaces (Hughes and Ferret, 2011). As a result, many workers remained exposed to unacceptable risk at the workplace, and this protracted problem led to a comprehensive review of the health and safety legislation in 1970. The “Robens Report” (1972), the outcome of the review, recommended basing the law on general principles instead of different prescriptions for different sectors and activities as the approach to accident prevention. At the same time, it also recommended embracing all industries in a single Act. The report led two years later to the passing of the Health and Safety at Work Act 1974 (HASAWA 1974), which created the Health and Safety Executive as the enforcement body for health and safety law. It imposed duties of care on employers, employees and independent contractors in relation to risks of personal injury at the workplace. It is an umbrella Act under which a variety of regulations have been developed and implemented to govern specific types of risk, e.g., The Manual Handling Operations Regulations 1992.

Causing the death of a human person carries criminal sanctions in most societies. In the UK such criminal liability was for a long governed by common law rather the HASAWA 1974. Under the common law, an individual human person whose direct act or omission causes a fatality may be prosecuted for gross negligence manslaughter if the individual’s conduct from which the death resulted amounts to gross negligence. The maximum penalty for this type of homicide is life imprisonment. In theory, a manager in an organisation may, therefore, be convicted of this crime depending upon the degree of incompetence with which the relevant operation was managed and the nature of the causal link between the relevant act or omission of the individual manager and the death.

A company could also be prosecuted for gross negligence manslaughter although it was notoriously difficult to convict because there was a requirement to establish that a “directing mind and will” of the company was responsible for the gross negligence act or omission. This meant that to convict a company of gross negligence manslaughter, there must be evidence of gross negligence by a person stationed so high in the management structure of the organisation as to constitute its “directing mind and will”. This requirement of derivative liability acted as a great barrier to convicting companies of manslaughter because, with the exception of very small companies, it was difficult to find an individual who was causally linked to the death and was also so high up in the corporate hierarchy as to be considered the company’s “directing mind and will”.

Public reaction to failures to achieve manslaughter convictions against any company after a long string of high profile disasters involving massive loss of human life was one of great outrage that big business and their “fat cat” directors were getting away with “murder” (Home Office 2000; Wells 2006; Harris 2007; Ormerod and Taylor 2008; Ndekuiri 2011). In the construction industry in particular, although there was a general downward trend in fatalities going back to the 1960s, government intervention through regulations under the HASAWA 1974 was not achieving the expected degree of impact (HSE 2002; House of Commons 2004; Donaghy 2009). Views were expressed that the health and safety problem was not being taken seriously enough in
boardrooms and that no amount of legislation would make any impact unless it addressed such *laissez-faire* corporate attitudes to health and safety issues. The Law Commission reported in 1996 that a new offence of manslaughter needed to be created for corporations, but this time without the identification requirement (Law Commission, 1996). Parliament eventually passed the Corporate Manslaughter and Corporate Homicide Act, 2007 (COMCHA), which came into force on 6 April 2008.

The size and structure of the construction industry and the disproportionate levels of fatalities in it make it an ideal prism for studying the impact of COMCHA. The overall aim of the research reported in this paper was thus to provide a bird’s eye view of prosecutions under Corporate Manslaughter and Corporate Homicide Act 2007 and the resulting sentences and to assess its impact on corporate manslaughter convictions in the construction industry. Two objectives were pursued towards the achievement of this aim. First, prosecutions were identified and analysed with a view to assessing the extent to which the legislation has succeeded in making easier to convict companies for very poor management of health and safety. The second prong entailed analysis of sentences imposed and the subsequent impacts on convicted construction organisations.

The methods used to address the above objectives were: (i) a review of the literature on health and safety generally to provide the necessary understanding of the topic addressed; and (ii) identification of prosecutions from electronic databases in the area of law and health and safety. The databases maintained by HSE, Crown Prosecution Service, and WestLaw database of law reports were first accessed. Relevant details of the companies and their annual turnover were then accessed through the online Company House database. Internet searches were also made with the aim of capturing prosecutions that had not been formally reported. The identified prosecutions were analysed by reference to the ingredients of liability in the Act and published sentencing guidelines.

The first section of this paper provides a brief outline of the elements required for conviction under the Corporate Manslaughter and Corporate Homicide Act. This is then followed by an overview of the prosecutions under COMCHA, the convictions and sentences, with special attention to the construction sector. Lastly, the paper critiques the issues arising from the cases and the implications for improving health and safety management in the construction industry.

**INGREDIENTS FOR CONVICTION UNDER COMCHA**

The purpose of the Act is to be able to prosecute and convict a wide range of organisations where there have been very serious management failures resulting in the death of an individual (Ministry of Justice, 2007). The main ingredients for conviction under the Act are as follows (Ndekgugri, 2013).

1. The accused should be a registered company, a partnership or an unincorporated entity other than a human individual (organisation test).
2. The accused must owe a duty of care in relation to the activity from which the death resulted (duty of care test).
3. The organisation acted in gross breach of its duty of care, i.e. the organisation’s conduct must have fallen far below what could reasonably have been expected through failure to comply with any health and safety legislation that relates to the alleged breach, or evidence showing that there were attitudes, policies, systems or
accepted practices within the organisation that were likely to have been encouraged or produced by tolerance of any such failure (gross breach of duty test).

4. The death must have been caused by the way in which the organisation managed its activities (causation test).

5. The way in which the activities of the organisation were managed by its “senior management was a substantial element of the breach (senior management test).

The Code for Crown Prosecutors (CPS, 2013) gives guidance to prosecutors on the general principles to be applied when making decisions about bringing prosecutions under this Act. It notes that there must be sufficient evidence to provide a realistic prospect of conviction. In other words, it must pass an objective evidential test in all 5 elements identified above before prosecution is brought forward. The number of prosecutions is, therefore, a barometer of the ease of assembling such evidence which is reliable, credible and can be used in court.

OVERVIEW OF PROSECUTIONS, CONVICTIONS AND SENTENCES

According to the CPS (2016), less than 30 cases have been considered for prosecutions. This is equivalent to only 3 percent of the fatalities of employed workers over the same period of time. Although the prosecutions follow an increasing trend over the passing years, they still appear insignificant when compared with the numerous fatalities occurring each year. However, most of the prosecutions resulted in conviction, with nearly 100 percent convictions each year.

Since this Act came into force, there have been 28 prosecutions out of which 21 companies (and their senior managers) have been convicted and sentenced to significant fines and prison terms. 15 of these cases had the prosecuted organisations entering guilty pleas, with only 6 going to trial (Appendix 1). Since prosecution of cases entails a long process in the courts, the first conviction took place 3 years after the Act had come into force. The conviction of Cotswold Geotechnical Holdings in 2011 for corporate manslaughter after a fatality in the workplace raised expectations as to the effectiveness of the COMCHA legislation.

The small number of prosecutions overall may imply some inherent difficulties with the application of the law or that there are easier options for securing convictions for health and safety offences. The evidence, however, suggests an upward trend in the number of prosecutions during the past five years. In 2015, 9 cases resulted in convictions, which is a 225 percent increase when compared to the previous year. Lack of familiarity with this law could also have accounted for its slow application.

The issues highlighted above are speculative and require further research to unearth the real causes of the arguably limited application of the COMCHA. However, it is significant to note that there is evidence that the authorities not only pursue organisations for a corporate manslaughter offence but also, the management team (owner, director, project manager) is likely to be prosecuted by alternative routes of prosecution, generally under sections 2, 3, 7, 36 and 37 of the HASAWA 1974. According to the Act, the liability of the management team depends on how aware the person in charge was regarding the risk which caused the fatality. Successful prosecution results in high monetary fines and long periods of imprisonment.
The cases of construction organisations

From the 21 convictions under the new corporate manslaughter act, 7 organisations have a construction related business activity as reported to the Company House (Table 1). The construction industry thus accounts for 30 percent of the convictions under this law similar to the overall proportion of worker fatalities attributable to the industry (HSE, 2015b).

Table 1: Convictions of construction related organisations under the UK corporate manslaughter and corporate homicide act 2007.

<table>
<thead>
<tr>
<th>Organisation Name</th>
<th>Fine (plus costs)</th>
<th>Annual Turnover</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotswold Geotechnical Holdings</td>
<td>£385,000</td>
<td>&lt; 6.5 m</td>
<td>Trapped by collapse</td>
</tr>
<tr>
<td>Cavendish Masonry Limited</td>
<td>£150,000</td>
<td>&lt; 6.5 m</td>
<td>Struck by object</td>
</tr>
<tr>
<td>Peter Mawson Limited</td>
<td>£200,000</td>
<td>&lt; 6.5 m</td>
<td>Fall</td>
</tr>
<tr>
<td>Kings Scaffolding</td>
<td>£300,000</td>
<td>&lt; 6.5 m</td>
<td>Fall</td>
</tr>
<tr>
<td>Linley Development</td>
<td>£200,000</td>
<td>&lt; 6.5 m</td>
<td>Trapped by collapse</td>
</tr>
<tr>
<td>Baldwins Crane Hire</td>
<td>£700,000</td>
<td>£20,000,000</td>
<td>Vehicle</td>
</tr>
<tr>
<td>Monavon Construction</td>
<td>£500,000</td>
<td>&lt; 6.5 m</td>
<td>Fall</td>
</tr>
</tbody>
</table>

The convictions highlighted in Table 1 draw attention to a number of issues that are worth considering in more detail as they signpost challenges and gaps in knowledge that require further investigation. Some of these issues, discussed further below, relate to nature of the work activities and accidents that lead to prosecution, role of organisational size, sentencing regime, and impacts on convicted organisations.

The convictions cut across the spectrum of construction activities from groundworks and general building activities to specialist activities such as scaffolding and the operation of construction plant. It can be surmised from the above that no area of construction activity is immune from the effects of senior management failures. More importantly, it shows that it is possible to find causal links between remote factors such as senior management failures and accidents regardless of the nature of work being undertaken. Suraji et al. (2001), Haslam et al. (2005) and Bomel Limited et al. (2006) have previously argued that such causal links are difficult to establish.

From the definition of the offence, it is not surprising that all the organisations convicted of corporate manslaughter were limited liability companies. Taking into account their turnover, the Company House classifies these companies as SMEs as they all report an annual turnover below £36 million (Companies Act 2006). SMEs represent 99.9 percent of private business in the UK, of which 18 percent is represented by the construction industry (BIS, 2014). In the construction sector, 6 out of the 7 companies are considered small with a turnover less than £6.5 million. Whilst this finding may give the appearance that SMEs are the only companies responsible for the health and safety challenges of the industry, that is not necessarily the case at all.

It is ironic that whilst the legislation was intended to make it easier to convict large companies of corporate manslaughter for poor management of their activities, all the convictions after a decade of the legislation getting onto the statute book have so far been of SMEs. There are several possible explanations for this surprising result. Firstly, SMEs will always be in the firing line because they typically undertake the
bulk of construction operations on-site as part of the supply chains of the larger contractors. This means that they are easier to pursue because of their proximity to the events leading to the fatality. Another explanation is the traditional one of the simplicity of the organisational structure for SMEs and the relative ease of linking fatalities with senior management. In contrast, large companies are likely to have more sophisticated organisational structures and to follow complex and extensive safety systems which are much more difficult to disentangle to obtain all the essential elements for a conviction.

A consensus emerging from the literature is that financial challenges is also one of the primary factors hindering an acceptable health and safety performance in SMEs (Sampaio, Saraiva and Domingues, 2012; Wong, Gray and Sadiqui, 2015). This factor limits the ability of SMEs to invest in elaborate safety management systems to ensure satisfactory compliance to the same extent as the large contractors (see e.g. Manu et al. 2013). The net effect is that SMEs appear to be the frequent target for prosecutors, while large companies still remain out of the spotlight.

**Sentencing**

The sentencing criteria is normally based on the company circumstances and their turnover as mandated by the Sentencing Guidelines in force at the date of the conviction (SGC, 2016). The Sentencing Guidelines Council first suggested a minimum conviction fine of £500,000 (SGC, 2010). Instead, companies were sentenced to a widely varying range of fines and, in most of the cases, less than that suggested by the guide. Consequently, there were criticisms of the poor structure of the guideline in relation to the economic impact of the sentences for the organisations (Davies, 2010; Haigh, 2012). This criticism forced revision of the guideline (SGC, 2016), which was immediately applied to the Monavon Construction case. The most recent construction case resulted in a sentence of a £500,000 fine, which presumably would have a more significant impact on the convicted organisation (Downey, 2016). The new guideline ensures a more proportionate system with other guidelines, and it is intended to be more aligned with the financial means of the offender (SGC, 2015). In this case, the new range of monetary fines is given by a classification of the organisations according to the seriousness of the offence and their annual turnover, suggesting a starting point of £300,000.

Quite clearly therefore, the size of the company has a direct influence not just in prosecution and conviction but even in the fines imposed and how they are paid up (Field and Jones, 2015).

**Causes of fatalities in the construction sector**

The most frequent causes of fatalities in the UK construction industry have been identified as: (i) “falls”; (ii) “trapped by collapse”; and (iii) “struck by object” (HSE, 2016). There have been similar findings in different countries. Accidents related to falls have been one of the leading causes of death in the construction sector in the past decade (Abdelhamid and Everett, 2000; Huang and Hinze, 2003). During 2014/2015, nearly 30 percent of fatalities were attributable to falls from heights, and nearly half of them occurred in a construction environment (HSE, 2015c).

After falls, fatalities caused by something collapsing is the second most frequent in the construction sector accounting for 28 cases over the last 5 years (HSE, 2015a). Lastly, the accidents categorised by the HSE as “struck by objects” is similarly considered a common cause of fatal injuries in the industry. They rank third accounting for 10
percent of the accidents occurring in the construction industry over the last five years. The situation, therefore, does not appear to have improved significantly. It is, therefore, no surprise at all that nearly all the convictions are associated with these types of accidents.

These types of accidents are preventable. Therefore, most of the prosecuted organisations pleaded guilty to the offence. Perhaps it is such guilty pleas, which simplify prosecution allowing cases to proceed to sentencing in a shorter period of time, that resulted in lower fines due to prosecution costs being considered to be part of the conviction fines.

The post-conviction status of construction companies

When convictions are achieved, the fines imposed on the guilty party can reach an intolerable economic value. After being sentenced, it becomes a challenge for SMEs to maintain their business. As previously discussed, the companies convicted for corporate manslaughter under the latest Sentencing Guideline can be sentenced to a fine from £300,000 to an unlimited value, depending on the seriousness of the breach, the size and turnover of the company, and other mitigating factors like guilty pleas (see also Field and Jones (2015) for other considerations). However, the assigned judge will always have the discretionary power to impose any measure depending on the circumstances of the cases.

In the particular case of Cotswold Geotechnical Holdings, the company was dissolved after being sentenced to a fine which represented nearly 250 percent of its turnover (Ndekugri, 2013). Similarly, Kings Scaffolding is also dissolved. Peter Mawson Ltd and Linley Development are currently in the process of liquidation after being convicted for health and safety breaches and fined £200,000 plus prosecution costs. Nevertheless, some companies can still survive after a conviction. According to the Companies House, 3 of the 7 convicted companies with a construction related activity are currently active and are not registered as dormant.

The fine is not the only challenge for the convicted companies, the reputation of the organisations is also at risk. The safety records of organisations is one of the main factors taken into consideration in the contractor selection process (Watt et al., 2010; Huang and Hinze, 2003), implying that the prospects of securing work are significantly diminished by health and safety convictions. This is compounded by the fact that the courts can also impose publicity orders against organisations as part of the sentence, which was indeed the case with 3 of the convicted construction companies (2 of these are among the companies that have ceased trading). Indeed, the publicity orders are superfluous as there is wide publicity of all these cases anyway.

CONCLUSIONS

The need to establish negligence by an individual in a company who constituted it’s “directing mind and will” made it extremely difficult to convict large companies of gross negligence manslaughter under the common law because their structures are often too complex and diffuse to identify such an individual with the certainty required for a criminal conviction. The Corporate Manslaughter and Corporate Homicide Act 2007 (COMCHA) came into force in 2008, establishing the new offence of corporate manslaughter that does not require the application of the “directing mind and will” doctrine.
So far, the successful prosecutions represent a very small proportion of the number of fatalities reported by the HSE since the Act came into force, meaning that generally, organisations are currently at a low risk of being prosecuted for the offence of corporate manslaughter. With fatalities rates still being very high and their causes still being entirely preventable, the number of convictions, in absolute numbers, is surprisingly low. This fact calls into question the HSE’s prosecution policy, which may be responsive to the wide latitude in the criteria for a successful conviction. Considering the large proportion of guilty pleas entered by offenders, the prosecution policy has obviously limited the decision to prosecute to the most glaring failures, thus leaving all the criteria largely untested in court.

All the convictions so far have been of SMEs. A large company is yet to be convicted under COMCHA although they have been fined for breaches of HASAWA 1974. It is, therefore, arguable that, apart from sending a message to stakeholders regarding the consequences of a failure in health and safety management and that Government has responded to public outcry against businesses being allowed by the system to get away with murder, the legislation has achieved very little. This surprising outcome suggests further research in alternative ways of incentivising effective health and safety management.

No clear answer emerges from the data on the question of the impact of a corporate manslaughter conviction on the survival prospects of convicted companies. Significant fines have been imposed and publicity orders issued. However, although all would undoubtedly struggle to avoid liquidation, there was evidence that some of the convicted companies were still trading at the time of writing this paper.

REFERENCES
CPS (2016) Personal information provided to author in response to a Freedom of Information request (17/08/2016)


APPENDIX 1
Convictions under the UK corporate manslaughter and corporate homicide act 2007.

<table>
<thead>
<tr>
<th>Company</th>
<th>Place and Year of Conviction</th>
<th>Nature of Business</th>
<th>Fine (plus costs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotswold Geotechnical Holdings</td>
<td>England (2011)</td>
<td>Engineering Activities</td>
<td>£385,000</td>
</tr>
<tr>
<td>Lion Steel</td>
<td>England (2012)</td>
<td>Manufacture of office machinery and equipment</td>
<td>£480,000</td>
</tr>
<tr>
<td>J Murray and Sons</td>
<td>Northern Ireland (2013)</td>
<td>Other business support service activities</td>
<td>£110,000</td>
</tr>
<tr>
<td>Princes Sporting Club</td>
<td>England (2013)</td>
<td>Activities of sport clubs</td>
<td>£135,000</td>
</tr>
<tr>
<td>Mobile Sweepers Limited</td>
<td>England (2014)</td>
<td>Other building and industrial cleaning activities</td>
<td>£12,000</td>
</tr>
<tr>
<td>Cavendish Masonry</td>
<td>England (2014)</td>
<td>Development of building projects</td>
<td>£237,000</td>
</tr>
<tr>
<td>Sterecycle Limited</td>
<td>England (2014)</td>
<td>Treatment and disposal of non-hazardous waste</td>
<td>£500,000</td>
</tr>
<tr>
<td>Diamond and Son</td>
<td>Northern Ireland (2014)</td>
<td>Sawmilling and planning of wood</td>
<td>£90,000</td>
</tr>
<tr>
<td>Peter Mawson Limited</td>
<td>England (2015)</td>
<td>Other building completion and finishing</td>
<td>£220,000</td>
</tr>
<tr>
<td>Pyranha Mouldings</td>
<td>England (2015)</td>
<td>Manufacture of other plastic products</td>
<td>£200,000</td>
</tr>
<tr>
<td>CAV Aerospace</td>
<td>England (2015)</td>
<td>Manufacture of air and spacecraft and related machinery</td>
<td>£725,000</td>
</tr>
<tr>
<td>Nicole Enterprises</td>
<td>Northern Ireland (2015)</td>
<td>Recreational vehicle parks, trailer parks and camping grounds</td>
<td>£100,000</td>
</tr>
<tr>
<td>Kings Scaffold Engineering</td>
<td>England (2015)</td>
<td>Scaffold erection</td>
<td>£300,000</td>
</tr>
<tr>
<td>Huntley Mount Engineering</td>
<td>England (2015)</td>
<td>Other manufacturing not elsewhere classified</td>
<td>£150,000</td>
</tr>
<tr>
<td>Baldwins Crane Hire</td>
<td>England (2015)</td>
<td>Other construction activities not elsewhere classified</td>
<td>£900,000</td>
</tr>
<tr>
<td>Sherwood Rise</td>
<td>England (2016)</td>
<td>Non-trading company</td>
<td>£300,000</td>
</tr>
<tr>
<td>Monavon Construction</td>
<td>England (2016)</td>
<td>Construction of commercial buildings</td>
<td>£500,000</td>
</tr>
<tr>
<td>Bilston Skips</td>
<td>England (2016)</td>
<td>Other business support service activities not elsewhere classified</td>
<td>£600,000</td>
</tr>
</tbody>
</table>
The safety climate on a specific construction project refers to managers’ and workers’ shared perceptions of the adequacy of the safety and health programmes and the consistency between the organization’s espoused safety policies/procedures and the actual conditions at the job site. A mature safety climate and a rich safety culture contribute to achieve a safe workplace. This paper aims to explore and to make explicit some of the key factors / dimensions that have a high influence and need to be considered for the assessment of the maturity level of safety climate. The concept of safety climate is firstly discussed with a review of different safety climate factors from the published literature. The results of the interviews with the construction managers of selected construction companies in Oman that exhibit high level of safety performance are reported. The objective of this research work is to find out which safety climate factors will be relevant to construction organizations in Oman that will need to be considered for assessment and could be helpful to make different plans to achieve the required level of maturity. The results show that Management Commitment, Aligning and Integrating Safety as a Value, Accountability at all Levels, Supervisory Leadership, Empowering and Involving Workers, Improving Communication, and Training at all Levels are some of the key factors that highly influence safety climate in Oman. Since this is the initial finding of the semi-structured interview involving six experienced construction professional, representing top management, further research is recommended to be conducted by giving an opportunity to other members of construction team (site supervisors, skill workers and labours) to express their views of safety climate leading factors.

Keywords: Safety Climate, Construction, Assessment, Safety Performance, Qualitative approach
INTRODUCTION

Statistics published by the International Labor Organization (2015) indicates that at least 108,000 workers are killed on construction site every year, a figure which represents about 30 percent of all occupational fatal injuries. Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater (ILO, 2015). Many more workers suffer and die from occupational diseases arising from past exposure to dangerous substances, such as asbestos. Construction is one of the world’s biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries. It accounts for a large proportion of GDP for many countries for example, 10 percent in the U.K., 17 percent in Japan, and 10 percent in Oman. Statistics published in the daily Times of Oman dated June 09, 2014, noted that a total of 723,000 residents were working in the construction industry. The ongoing and planned development projects in different sectors, including construction, for financial year 2015-2016 is shown in figure 1. The construction sector projects stand out as the largest one, amounting to US$ 43.16 Billion. According to the budget report, spending on development projects are estimated at US$ 3.12 Billion (OMR1.2 Billion), representing the amount to be paid during the year 2017, as the actual work progresses (ToM, 2017).

Figure 1. Values of Ongoing and Planned Projects in Different Sectors of Oman (Deloitte 2015)

In most developing countries, construction is among the fastest growing areas of the labor market, continuing to provide a traditional entry point for laborers. It is, however, one of the most dangerous industries. Construction workers build, repair, maintain, renovate and demolish houses, office buildings, factories, hospitals, roads, bridges, tunnels, stadiums, docks, airports and more. During the course of their work they are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, vibration from tools, among many others. The causes of accidents and ill-health in the sector are well known and almost all are preventable (ILO, 2015). A report published in the daily Times of Oman dated February 28, 2015 states that
there are no official statistics of how many company workers get hurt in the course of their duties but according to the individual Health and Safety Environment’s records of top 10 contractors, more than 3,700 of them needed medical treatment in 2014. The injured workers who get hospitalized made up nearly 10 per cent of the total workers on this list. Sadly, about 18 per cent of them died either at the sites or in hospitals in 2015. In comparison to the previous year, 246 more workers got injured in 2014 but for obvious reason, company directors do not want this part of the record to be made public.

In construction organizations in Oman, most of the workers are foreigners (92% of total workforce) and as such they are not insured under the government authority (NCSI, 2015). As per law of the country, construction organizations are required to seek private insurance for their workers; however, as the risk associated with construction workers is high their insurance premium is comparatively more. Construction organizations further bear high cost at the time of recruitment and pay for repatriation, compensation and replacement in case of accidents involving injuries and death. There is potential for construction organizations to reduce the cost associated with accidents either direct, or indirect, by improving safety culture through safety climate.

In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, has increased. Safety climate is a subset of organizational climate offers a route to safety management, complementing the often predominant engineering approach. An understanding of the safety climate dimensions can be useful in improving the safety performance of an organization. In addition, safety climate investigations are more sensitive (e.g. multi-faceted) and are proactive bases for developing safety, rather than reactive (after the fact) information from accident rates and accident and incident reports (Seo et al., 2004). Over the past century, the focus on factors influencing safety and safety improvements within industries has changed. Hale and Hovden (1998) describe three ages of safety: the technical age (1920’s), the human factor age (1970’s) and the management system age (1980’s). The third wave or age of safety expanded the focus to include safety culture, and the concept of safety culture was first truly introduced and defined after the Chernobyl accident in 1986 (INSAG, 1992). Safety culture; and safety climate are concepts that today attract much attention across a broad number of industries and sectors (Clarke, 2000). One of the reasons for this is that a rich safety culture and a mature safety climate are some of the most important factors in achieving a safe workplace ( Bergh et al 2013). In order to improve the level of safety culture and safety climate it is important to: a) determine the current level of safety culture and safety climate, b) decide what level of safety culture and safety climate is needed, attainable and wanted, and c) to create a plan to achieve the safety culture and safety climate that is wanted (AIChE, 2012).

Safety climate may be defined as shared perceptions among the members of a social unit, of policies, procedures and practices related to safety in the organization ((Kines, et al 2011). The Centre for Construction Research and Training (CPWR) defined safety climate as workgroup members’ shared perceptions of management and workgroup safety related policies, procedures and practices (CPWR, 2014). Researchers and practitioners have identified safety culture and safety climate as key to reducing injuries, illnesses and fatalities on construction worksites (appendix I). Many construction contractors are trying to improve these indicators as a way to move closer to a goal of achieving zero injury worksites. This paper presents the initial
research of how different safety climate could be used by construction organizations to improve their safety performance. The Nordic occupational safety climate questionnaire was developed in the year 2011 has 50 questions on the following dimensions (Kines, et al 2011):

- Management safety priority, commitment, and competence.
- Management safety empowerment.
- Management safety justice.
- Workers’ safety commitment.
- Workers’ safety priority and risk non-acceptance.
- Safety communication, learning, and trust in co-workers’ safety competence.
- Trust in the efficacy of safety systems.

LITERATURE REVIEW

In terms of safety performance, the construction industry in Oman is not as advanced as the UK and USA, therefore it is anticipated that the cost associated with this industry could be comparatively more. An internet based search covering six months (May 2015 to November 2015) of one daily newspaper shows that nine construction workers were killed and twenty-five were injured in Oman at different construction sites. These were major accidents in construction sites located in cities therefore they were published in the newspapers. There could be accidents happened in construction sites which were not reported because it may have happened in a remote area or the accidents were minor, involving less casualties and injuries. The costs of accidents in construction in Oman reported by Umar and Wamuziri (2016 a), is estimated at US$3.237 billion (based on the total value of construction projects) while the compensation costs are approximately US$3·74 million/year. There are challenges for safety in construction in Oman, but opportunities do exist. Safety regulatory organizations such as Occupational Safety and Health Administration (OSHA) in USA and Health and Safety Executive (HSE) in UK have significantly played their roles in improving the safety performance in their jurisdictions. Statistics indicates that Worker deaths in America are down on average, from about 38 deaths a day in 1970 to 12 a day in 2014. The number of worker injuries and illnesses is down from 10.9 incidents per 100 workers in 1972 to 3.3 per 100 in 2013 (OSHA, 2014). The national frame work for safety improvement in Oman presented by Umar and Wamuziri (2016 b) involves all the stakeholders under a regulatory organization as shown in figure 2. There were debates that small and medium construction organizations have none or very low capability and financial benefits for improved safety performance. Research conducted in the UK on cost and benefit analysis revealed that when total costs of accident prevention were compared to the total benefits of accident prevention, the benefits far outweigh the costs of accident prevention by a ratio of approximately 3:1, which means that when contractors, irrespective of their sizes, spend £1.00 on accident prevention, they gain £3.00 (Ikpe et al 2012). The process of using safety climate factors to improve safety performance is shown in figure 3 (Umar and Wamuziri 2016 c).

To identify the safety climate factors relevant for safety performance, an internet search using the key words “safety climate factors” and “safety climate assessment tool” has been conducted. The selected search period was from 1980 to 2011. A total of twelve safety climate assessment tools obtained by this search have been complied
with full details as shown in appendix I. Briefly, the number of assessment tools found through internet search was one in each year 1980, 1991, 1997, 2000, 2004, 2005, 2006, 2008 and 2010; while there were three tools found in 2011. The number of leading safety climate factors used in these assessment tools was 55.

Figure 2. Safety Model for Construction (Umar and Wamuziri 2016 b)

Figure 3. Process of Using Safety Climate to Improve Safety Performance (Umar and Wamuziri 2016 c)
This led the authors to proceed with their research and to evaluate which factors will be more relevant for an assessment tool to be used in Oman for safety improvement.

RESEARCH AIM AND METHODOLOGY

The overall aim of this study is to evaluate the safety climate factors which can influence the safety climate in construction in Oman. Apart from this the authors also wanted to solicit the views of construction professionals in Oman on the relevance of a safety climate approach for safety improvement in Oman. In order to achieve this objective, a qualitative approach as opposed to a quantitative approach, was employed in the study. Briefly, the distinction between these two research strategies is as follows. Quantitative research emphasises quantification in the collection and analysis of data. It takes a deductive approach to the relationship between theory and research and emphasis is placed on the testing of theories. Quantitative research incorporates the norms and practices of the natural scientific model and positivism. It views social reality as an external objective reality.

On the other hand, a qualitative research strategy puts emphasis on words and meanings rather than quantification in data collection. It emphasises an inductive approach in the relationship between theory and research and emphasis is placed on the generation of theories. Research can however combine both qualitative and quantitative approaches – a strategy increasingly referred to in the literature as mixed methods research (Wamuziri 2013). Since the research reported in this paper is exploratory in nature, a qualitative enquiry was deemed to be the most appropriate approach to data collection. Semi-structured interviews were used to collect relevant information and the interview guide or set of questions used for the research are shown in the appendix II. The interview process was flexible and the emphasis was on how the interviewees understood the concept of safety climate for improved safety performance.

The interviewees were selected on a purposive sampling basis. Such sampling is strategic in nature and the philosophy or idea was to interview respondents who were relevant to the research questions. This was achieved by interviewing a total of six senior managers from leading construction contractors in Oman. Managers operating at a senior level with safety responsibilities in construction organizations were considered best placed to provide descriptions of the real world with respect to the safety climate factors. The characteristics of the interviewees are presented here.

a) Interviewee one: A senior engineer in a construction organization mainly working in the transportation sector in Oman having more than 20 years of project management experience in highway sector. The company in Oman was initially established in 1973.

b) Interviewee two: A senior project engineer in construction organization working in the housing sector in Oman, with more than 25 years of experience of project management in building sector. The organization was initially established in 1972 and currently registered as excellent grade company in Oman.

c) Interviewee three: A senior construction manager with over 10 years of experience in one of the major construction companies with offices in all Gulf Cooperation Council (GCC) countries. The company is 100% privately owned with more than 1000 employees in Oman. The interviewee is currently working as project director of a highway construction project with an estimated cost of US $ 305.90 million.
d) Interviewee four: A senior construction manager with over 12 years of experience in one of the main construction companies. The Organization was established in the year 1992 and currently executing some of the main buildings projects pertaining to government and private sector in Oman. The construction manager interviewed from this organization is working on a construction project of an estimated cost of US $ 60 million.

e) Interviewee five: A senior contract manager with over 15 years of experience in one of the world leading consulting organizations having offices in USA, Europe and Middle East. The organization was Founded in 1944, and 100% owned by the employee stock ownership trust with total revenues of $3.2 billion in 2015.

f) Interviewee six: A senior design consultant with more than 8 years of experience in one of the leading international consultants operating the Middle East, Africa, Asia, and Europe with more than 10,000 staff. The interviewee is currently involved as design and supervision consultant in some of the mega road projects in Oman.

The use of semi-structured interviews in data collection offers the following strengths.

(a) It enables the researcher to examine the level of understanding that a respondent has about a particular topic – usually in slightly more depth than is possible with a postal questionnaire.

(b) It can be used as a powerful form of preliminary assessment. That is, it can be used to explore how a respondent feel about a particular topic before using a second method such as participant observation or in depth interviewing to gather greater depth of information. Semi-structured interviews can also be used to identify respondents whose views may be explored in more detail through the use of focus groups.

(c) All respondents are asked most of the questions in the same way. This makes it easy to repeat or replicate the interview. In other words, this type of research method is easy to standardise.

(d) Provides a reliable source of data.

(e) The researcher can contact reasonable numbers of people quickly, easily and efficiently.

The approach however suffers from a number of weaknesses and limitations including the following items.

(a) It can be time consuming if the sample group is very large. This is because the researcher or their representative needs to be present during the delivery of the semi-structured interview.

(b) The quality and usefulness of the information is highly dependent upon the quality of the questions asked.

(c) A substantial amount of pre-planning is required.

(d) The format of questionnaire design makes it difficult for the researcher to examine complex issues and opinions. Even where open-ended questions are used, the depth of the answers that the respondent can provide tends to be more limited than with other qualitative methods.

Despite these limitations, the six respondents in this study provided a rich source of vital information which will be useful in further in-depth investigations on the subject.
In the next section, the results obtained through the interview process are assessed and evaluated.

ANALYSIS AND DISCUSSION OF RESULTS

Effectiveness of Safety Climate for Safety Improvement

All the interviewees agreed that safety climate approach can be useful for enhancing the safety performance of construction organizations in Oman. All interviewees agreed that an understanding of the safety climate approach and using the appropriate safety climate dimensions and factors can lead the construction organizations towards improved safety performance. Interviewee two and three however mentioned that safety is something which responsibility cannot put only on the construction organizations. Interviewee three stressed on the safety inspections by external regulatory organization. He stated that effective health and safety regulations and their implementation across construction organizations are very improvement to expect the maximum safety performance. Interviewees four and five mentioned that although safety is everyone's responsibility, however low safety performance and increased number of accidents are not in the interest of contractors as they are the one who are affected by this. Safety climate approach for safety improvement can be one solution which can lead construction organization to improve their performance in safety. Interviewee six stated that construction organizations have the liberty to adopt any of the approach which can improve their safety performance. Since safety climate is used in different regions worldwide, it can be equally effective in Oman as well and construction organizations need to get benefits from this approach.

Safety Climate Factors

All interviewees were of the view that a rich safety culture can be achieved through a mature safety climate. However, their views on safety climate factors were different when asked with the question on different dimensions or factors that would need to be considered to achieve a mature safety climate and rich safety culture in construction organizations in Oman. They agreed that construction organizations in Oman need to adopt the concept of improving safety culture and safety climate to improve their safety performance. Interviewee one stated the safety training, management commitment and competence for safety and effective safety communication are the key element of a rich safety culture and as such need to be considered as safety climate factors. Interviewees two and three views on safety climate factors were almost the same. They noted that personal commitment towards safety has significant impact on safety outcome. Therefore, personal safety commitment and knowledge of safety are some of the important factors that will influence safety culture and safety climate. Interviewee three however did mention the safety empowerment and stated that workers need to have the right of non-acceptance of risk. Interviewee four highlighted the importance of accountability for safety through active monitoring and enforcing. He stated that safety compliance is important towards a safe work environment and therefore, there has to be a system which ensures that safety is not compromised at any level. The workers must have on job safety training or at least safety briefing before taking a specific work and task. Interviewee five stated that the main factor which can lead towards an improved safe work place is management involvement in safety. How much safety is important to management and how much
they are committed towards safety is a key element. Other elements, apart from
management commitment which need to be considered are safety communication on
site, training of workers and motivation and behaviour of workers. He stressed that
although personal safety comes first, workers need a level of motivation to ensure co-
workers safety as well is very important in achieving a safety working environment.
Interviewee six stated that the factors which can lead a construction organization
towards an improved safety performance are related individual and organization.
Individual factors are motivation, behaviour, knowledge and non-acceptance of risk; 
while organizational factors are commitment and compliance of safety, training,
accountability and effective communication of safety related thing.

Safety Climate Assessment Tool

From the literature review, the authors came across different forms of safety climate 
tools. Although the significant item in these tools is the set of factors which were used 
in these tools for assessment. In the study, an opportunity was given to the 
interviewees to express their view on the possible format of such tools if developed 
for construction organizations in Oman. All the interviewees agreed that they are not 
using any such tool for the assessment of their safety culture and safety climate. 
Interviewees two and five did mention that they normally use the accidents analysis to 
identify the root causes of accidents and to develop strategies to avoid such accidents 
in future. Interviewee five mentioned that if the accident has taken place because of 
the worker knowledge, then they incorporate the appropriate training to avoid such 
accident in future. All interviewees agreed that the leading safety climate factors need 
to be measured on a scoring scale of 1-5 (strongly agreed – strongly disagreed). 
Interviewee one stated that there is no need to give an option for neutral in the scoring 
of any leading safety climate factor and the scale can be from 1-4 (strongly agreed – 
strongly disagreed). Interviewee three mentioned that such questionnaire needs to be 
in multi-language to effectively serve the diverse construction industry in Oman. 
Interviewee six mentioned the use of technology tools for using such questionnaire 
instead of paper's based approach.

Effectiveness of Safety Climate Assessment Tool

Although safety climate assessment tools are successfully used in the different 
industries including construction worldwide, however the authors were interested to 
know the views of construction industry professionals in Oman of their effectiveness. 
All interviewees agreed that a safety climate assessment tool which will allow 
construction organizations in Oman to assess their level of safety culture and safety 
climate will be helpful to improve the safety performance of construction 
organizations. Interviewee two mentioned that construction organizations should have 
sufficient knowledge of such tools before they use it properly and get full benefits 
from it. Interviewee one, three and five stated that it is possible for all sizes of 
construction organizations to prepare their plans for safety improvement through the 
results of safety climate assessment, however small construction organizations can 
face financial and technical issue because of their capacity to implement such plans. 
Small construction organizations will need to have some external support to 
implement such plans to achieve the required level of maturity for any safety climate 
dimension.
CONCLUSIONS

This article represents the research in progress on using safety climate approach to improve the safety performance of construction organizations in Oman. The literature review indicates that this approach has been used in different projects worldwide to assess and improve the leading safety climate factors which results in improved safety performance. The results of semi structured interview with construction professionals working in Oman show that their organizations are currently not using this approach. The overall aim of this study was to evaluate the safety climate factors which can influence the safety climate in construction in Oman. Interviewees identified several factors which could have a high level of influence on safety climate including management commitment, aligning and integrating safety as a value, accountability at all levels, supervisory leadership, empowering and involving workers, improving communication, and training at all levels. This research is based on the views of six construction professionals working as top manager in their construction organization. The construction team of any organization is composed of managers, supervisor, skill worker and labours, therefore their views of different safety climate need to be taken into account before proposing any assessment tool. This could be achieved through a quantitative research using a structured questionnaire. The collected data could be subjected to statistical test and be evaluated with the result of this study in proposing the main safety climate factors relevant to Oman construction industry.

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Currently translated into 25 languages.
APPENDIX II
FACTORS THAT INFLUENCE SAFETY CLIMATE IN OMAN
SEMI STRUCTURED INTERVIEW QUESTIONS

1. In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, has increased. Safety climate is a subset of organizational climate, offers a route for safety management, complementing the often predominant engineering approach. What is your opinion on the effectiveness of this new approach to enhancing safety performance in construction organizations?

2. Most organizations use records of their health and safety performance as an indication of the effectiveness of their health and safety management and systems. Do you think that an understanding of the safety climate dimensions or factors can be useful in improving the safety performance of construction organization?

3. There is a generally held view by researchers that a mature safety climate can help in building a rich safety culture and there are different dimensions or factors identified which influence safety climate. What is your view on different dimensions or factors that would need to be considered to achieve a mature safety climate and rich safety culture in construction organization in Oman?

4. Researchers and practitioners have identified safety culture and safety climate as key to reducing injuries, illnesses and fatalities on construction worksites. Many construction contractors are trying to improve these indicators as a way to move closer to a goal of achieving zero injury worksites. Do you think construction organizations in Oman need to adopt the concept of improving safety culture and safety climate to improve their safety performance?

5. Safety climate of a construction project or construction organization can be assessed by means of quantitative, psychometric questionnaire surveys, so-called 'safety climate scales', measuring the shared perceptions/opinions of a group of workers on certain safety-related dimensions or factors. The outcome of such safety climate scales are regarded as a predictor or indicator of safety performance. What is your opinion on such tool? Does your organization use such tool to assess the safety climate?

6. The leading safety climate dimensions or factors can be measured among different categories of staff working in construction organization or in a project undertaken by the construction organization on a scoring scale of 1-5 (strongly agreed – strongly disagreed). The results will reflect the safety climate of organization or safety climate of the specific project. After the assessment of safety climate leading dimensions or factors, construction organizations will be able to identify and prioritize the weak area for improvement. What could be the possible format if we want to develop a safety climate assessment tool for construction organization in Oman?

7. Do you think that the assessment of safety climate tool will help decision making unit (DMU) of construction organizations to develop different plans to achieve the required level of maturity of safety climate?

8. Different sizes of construction organization (small, medium and large) have different level of resources and competencies. In your view how different sizes of construction organization will benefit from adopting the concept improving of safety performance through safety climate?
SAFETY IN DESIGN: A STUDY OF DESIGNER’S MOTIVATION IN CANBERRA AUSTRALIA

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Improvements in construction safety are driven, in part, by increases in builder safety culture, training of builders and managers, site inductions, PPE and toolbox talks. However, the responsibility for construction safety should not be taken by the builder alone. To further improve safety, we need to look upstream into the design phase. Safety hazard identification during the design phase, referred to as Safety in Design (SID), has been found to reduce safety hazards, improve design quality and deliver long term economic benefits. Despite the benefits, designer’s lack motivation to implement SID. There is a gap in knowledge to explain why designer’s lack motivation and how they can be motivated to increase implementation of SID. This study uses Canberra, Australia as a case study, to examine designer’s motivation from the designer’s perspective. 16 architects and 14 engineers were interviewed and the resulting data was analysed using a mind mapping technique. The study identified six key themes: lack an awareness of SID, lack of clarity to implement SID, designers do not see value in SID, lack of incentives, lack of enforcement and a low safety culture within design industry. A Safety in Design Motivational Model (SIDMM) provided a framework to inform key recommendations to practice including the need to: create awareness of SID, identify value to designer and community, introduce education at the tertiary level, standardised and consistent training within design organisations and build awareness of available SID tools and methodologies. The proposed SIDMM advances self-determination theory through the design of a staged and continuous theoretical approach to increasing the designer’s autonomous motivation to implement SID.

Keywords: Design, Designer, Motivation, Prevention, Safety.

INTRODUCTION

Designers in Canberra are required under the Work Health and Safety Act 2011 (Safe Work Australia 2012a) to implement safety in design (SID) on their projects. While SID is a legislative requirement, the level of SID implementation is being hindered by the designer’s lack of motivation (Musonda and Haupt 2009). This paper aims to identify why designers have a lack of motivation to implement SID and how motivation theory can be retheorised to increase the designer’s self-motivation.

LITERATURE REVIEW

Background

SID is the integration of control measures early in the design process to eliminate or, if this is not reasonable practicable, minimise risks to health and safety throughout the life of the structure being designed (Safe Work Australia 2012b). Decisions made

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during the design phase can contribute significantly to reducing future work-related fatal injuries (Frijters and Swuste 2008, Driscoll et al. 2008). Further benefits to implementing SID include improved design quality (Behm and Culvenor 2011) and long term cost benefits (Ku 2014, Toole and Carpenter 2011). Despite the number of known benefits, SID implementation is being hindered by a number of barriers including liability concerns (Gambatese et al. 2013, Torghabeh and Hosseinian 2012), increased costs (Toole and Carpenter 2011, Behm and Culvenor 2011) and a lack of education (Gambatese et al. 1997, Zarges and Giles 2008). To overcome the barriers, research has identified a number of ways forward such as greater enforcement (Ku 2014), focusing on moral duty (Schulte et al., 2008, Valentine and Fleischman 2008) and increasing collaboration within project teams (Atkinsson and Westall 2010). Despite the proposed ways forward, designer’s motivation is low (Musonda and Haupt 2009) and there are calls for research into ways to motivate designer’s to increase SID (Gambatese et al. 2013).

Look to Theory to Improve Designer’s Self-Motivation

To find ways to increase the designer’s self-motivation and increase the level of SID implementation, we need to look to established motivation theory. Motivation theory can provide a scientific basis to study and further improve our understanding the designer’s SID motivation. Self-determination theory (SDT) investigates the innate psychological needs that are the basis for self-motivation and the conditions that foster its increase (Ryan and Deci 2000). SDT postulates that improvements to autonomy, relatedness and competence can increase self-motivation and lead to enhanced performance and well-being (Grolnick and Ryan 1989). SDT has been used extensively in research to investigate people’s motivation for a number of different activities (Deci et al. 1996) including the motivation of workers (Nie et al. 2015, ÜNiÜ and Dettweiler 2015, Howard et al. 2016). According to SDT, the more autonomy supportive the social context the more it enhances intrinsic motivation and facilitates the internalisation and integration of extrinsic motivation (Orsini et al. 2016, Vansteenkiste et al. 2006). SDT posits that a person’s social context has an influence on their level of self-motivation for a particular task. There is a need for further research beyond SDT to understand and explain how the designer’s social context is influencing their lack of motivation to implement SID. The detailed knowledge of the designer’s situation has been interpreted through the lens of SDT in the following ways:

- To confirm that designers have a lack of motivation to implement SID;
- To provide a description of the motivation level required by designers to increase their SID implementation;
- Identify where the designer’s social context is inhibiting their ability to reach the required motivation level; and,
- Inform a new SID model that uses the principles of motivation theory to increase the designer’s self-motivation.

METHODS

The Case Study: Canberra, Australia

Canberra, Australia, has been used as a representative case study. Canberra is not only the researcher’s place of residence and study, it also contains a representative sample
of small, medium and large design organisations undertaking a mix of local and national design projects. An additional importance of Canberra is its poor construction safety record which is 31% higher than the national average (Work Safe ACT 2012). 16 architects and 14 engineers were interviewed using semi-structured interviews at the participant’s workplace. The selected participants all had previous professional knowledge and experience of SID. The central questions were based around SID benefits, barriers, education, motivation, current implementation and future recommendations. The interview data was initially coded based on the research questions and then further expanded into sub-topics as the data analysis progressed. An interpretive mind mapping technique was then used to sort the coded data into emergent themes.

RESULTS

The resultant themes that emerged from the participant interviews explain where the designer’s social context is influencing their level of motivation to implement SID. Six key themes emerged including a lack of awareness of SID, a lack of clarity on how to implement SID, a lack of incentive to implement SID, a lack of enforcement of SID, a lack of safety culture in the design industry and a lack of evidence of the value of SID. These themes emerged from a consolidation and synthesis of the findings.

Awareness

Incomplete education programs across all training sectors including formal education providers such as tertiary institutions, industry associations and informal training within design organisations, have led to many designers having a poor knowledge of SID. Awareness of SID is further inhibited when the construction project is perceived as simple and obligations to SID are overlooked as the designer focuses on core business outcomes.

Clarity

The lack of clarity of SID implementation can be attributed to a perceived overburden with bureaucracy leading to a lack of time and will for designers to familiarise themselves with how to undertake SID. Clarity on how to implement SID has been further inhibited by a lack of available SID tools such as standardised SID software and flow charts for designers to follow, limited construction experience and challenges around effective coordination of multiple designers on large projects.

Incentive

A lack of time and increasing costs as a result of not increasing client fees to cover the cost of SID has meant designers have not had the incentive to implement SID where it is not enforced. The lack of incentive to increase SID has been further inhibited by tight design programs, heavy workloads and the view among designers that SID is a low priority.

Enforcement

A number of participants had implemented SID only when it was contractually required. Difficulties in determining responsibility and a lack of awareness of SID has led to a lack of enforcement by authorities and clients. This lack of enforcement of
SID also extends to design organisations, shortfalls in quality assurance systems and the absence of a SID requirement at the building approval stage.

**Culture**

Poor safety culture can be attributed to a belief within the design industry that safety is the builder’s responsibility and that considering safety during design hinders design creativity. The poor safety culture in the design industry is being further inhibited by the attitude that “we’ve been fine so far so why change?”

**Value**

A lack of evidence in the value of SID, attributed to a belief that it is only a tick-the-box exercise having no effect on safety, has led to a lack of motivation to implement SID. The perceived lack of value in SID is further reinforced by the designer’s view that only the builder can impact safety and that SID reports are just filed away by clients once they are completed.

**DISCUSSION**

Established human motivation theories such as SDT are insufficient in their current form to be used to motivate designers to increase SID due to their generality in nature. SDT is a general theory of human motivation that does not target any particular person or group and its general nature presents a number of theoretical limitations to explaining the designer’s SID motivation. SDT cannot know the designer’s social context and where the designer’s three basic needs for autonomy, competence and relatedness are being thwarted. Due to the limitations in applying SDT directly to designer’s SID motivation, there is a need to retreorise. Retheorising allows the principles of SDT to be applied to the practical situation of SID motivation. Retheorising can link the valuable lessons learned from established motivation theory with the identified contextual and environmental influences on designers identified in the research findings. The research findings have been viewed through the lens of SDT to develop the following retreorisation:

- Motivation theory such as SDT can be used to motivate designers to increase SID if SDT is retreorised to specifically consider the designer’s situation;
- Changes to the designer’s social context will need to be implemented in stages to allow focus on areas of importance and to allow designers to commit their time in smaller allocations;
- There is a need to focus initially on overcoming the designer’s lack of awareness of SID and the value they see in SID as opposed to the lack of clarity and enforcement of SID;
- It is important to develop long term strategies to increase the designer’s self-motivation, such as improving the safety culture of the entire design industry, to ensure increases to SID motivation are sustained;
- The lack of enforcement and lack of incentive to implement SID should not be seen as a negative as they can both be forms of controlled motivation; and,
- A SIDMM should be developed to provide a graphical framework to SID motivation theory and to present SID motivation theory to the wider community.
To extend the practicality of the SID retheorisation, its principles have been represented in a graphical model that highlights the priorities, staging and continuous improvement suggested to increase the designer’s self-motivation.

**The Design of a New Safety in Design Motivational Model (SIDMM)**

The SIDMM allows the principles of SID motivation theory to be graphically represented in a way that can be further updated or amended as the designer’s SID motivation increases and improved safety is realised. The key role of the SIDMM is to interpret the SID motivation theory into a methodology that can be used to inform recommendations to practice.

The SIDMM, shown in Figure 1 below, applies the principles of SDT to the specific situation of designer’s SID motivation. The SIDMM provides a theoretical framework to increase the designer’s SID motivation from current amotivated and controlled levels to autonomously self-motivated.

![Figure 1 - SID Motivational Model](image)

The SIDMM focuses on influencing the designer’s social context to enable satisfaction of the need for autonomy, competence and relatedness. According to SDT, positively changing to the designer’s social context, where it has been found to thwart satisfaction of the three needs, allows designers to internalise or take in the values and attitudes from their surrounding environment and to transform to more autonomously motivated behaviours. The establishment of a new SIDMM advances existing SDT in the following ways:

- The SIDMM applies the general principles of SDT to the specific situation of the designer’s SID motivation;
- The SIDMM recommends a staged approach as the most effective method to influence the designer’s environment; and,
- The SIDMM proposes a continuous revolution of stages one and two.

One of the key advancements of the SIDMM is to retheorise the principles of SDT to suit the designer’s situation. The principles of SDT have been applied to a number of industries and activities (Nie et al. 2015, Deci et al. 2001, Howard et al. 2016, Gagné and Deci 2005, ÜNlÜ and Dettweiler 2015, Ambrose and Kulik 1999) however there is no indication of SDT having been directly applied to designer’s SID motivation.
The findings have identified those areas where each of the three basic psychological needs for self-motivation is being thwarted. The time designers can allocate towards SID is restricted due to large workloads, making it impractical to attempt to satisfy all three needs at once. The SIDMM spreads out the designer’s commitment by initially focusing on the most important of the three psychological needs, autonomy (Deci and Ryan 2000). The satisfaction of the needs for competence and relatedness are then followed in stage two. A further reason to break up the SIDMM into stages is to minimise the financial impact on designers. Designers, who do not see the long-term cost benefits of SID, would find satisfying all three needs at once as a short term cost burden they could not afford to take. A staged SIDMM will be more attractive to designers from a cost point of view.

Improvements to education at tertiary, organisational and industry association level as a result of the implementation of the SIDMM will take time to roll out. Staging the SIDMM will ensure the effectiveness of new SID courses and training programs over the long term. The SIDMM will need to address perceived barriers such as the designer’s fear of liability. Designer’s actual legal obligations will need to be explained and clearly understood to ensure that designers are informed how SID can reduce their exposure to liability before trying to attend training and seminars on how to improve SID implementation. Many designers currently implementing SID are not sure if their SID report is meeting their legal obligations. Ensuring an initial understanding of the designer’s legal obligations in stage one will support awareness creation strategies and assist in learning SID implementation methods in stage two. Stage one of the SIDMM will initially identify the value of SID to designer’s and the wider design industry. Early identification of the value of SID to the wider community means building owners will be motivated to include SID in the designer’s contract and as a result, increase demand for stage two by designers wanting to improve their ability to implement SID in response. The advantage of staging the SIDMM is to use the creation of awareness and value in stage one as the impetus to motivate designers in stage two to learn how to implement SID.

The SIDMM involves a continuous cycle of stage one, the satisfaction of the need for autonomy and stage two, the satisfaction of the need for competence and relatedness. The process of continually repeating the staged approach allows positive lessons gained from continuous learning (Tracey et al. 1995) to be applied to the situation of designer’s SID motivation. While creating awareness and identification of the value of SID in stage one provides the motivation needed to effectively implement stage two, effective implementation of stage two can provide important outcomes that can be reintroduced back into stage one. Positive consequences of stage two that can be used to enhance stage one include the design of new SID tools, improved safety incident statistics and advances in safety culture. Stages one and two continuously inform and improve the effectiveness of each other. Stage three has been intentionally left out of the continuous nature of the SIDMM as its only purpose is to capture amotivated designers that need increased enforcement as a motivator to commence SID implementation. The SIDMM, through continuous improvement, aims to provide the most up to date framework to support current designers as well as future designers starting their design studies and careers.

The aim of the SIDMM is to focus on overcoming those areas of the designer’s social context that are specifically affecting their satisfaction of autonomy, competence and relatedness, the three basic needs for self-motivation. A supportive social context will
allow designers to internalise the values of their environment and in turn improve their self-motivation. The SIDMM incorporates the understanding that by creating certain conditions, people can, at any time, fully integrate a new regulation, or can integrate an existing regulation that had been only partially internalized (Gagné and Deci 2005). The SIDMM has been designed to create the optimal environmental conditions to support designer’s satisfaction of the need for autonomy, competence and relatedness and allow them to reach the highest levels of extrinsic and intrinsic motivation.

Stage 1 - Satisfaction of the need for autonomy is the most important element for increasing the designer’s level of self-motivation (Deci and Ryan 2000). The SIDMM places satisfaction of the need for autonomy at stage one due to its importance and priority among the three required needs. Satisfaction of autonomy is essential in addition to satisfaction of relatedness and competence, to advance to identified or integrated forms of motivation (Gagné and Deci 2005). Satisfaction of the need for autonomy requires the designer’s social context to be changed to increase their awareness of SID and to allow designers to see the value of SID.

Stage 2 - The second stage of the SIDMM focuses on satisfaction of the needs for competence and relatedness. Stage two uses the key research findings, that designer’s lack clarity on how to implement SID and the lack of safety culture in the design industry, to identify where the designer’s social context is thwarting their need for competence and relatedness. SDT maintains that people, who experience satisfaction of the needs for competence and relatedness with respect to behaviour, will tend to internalise its value and regulation (Gagné and Deci 2005). While satisfaction of the needs for competence and relatedness are key foundations to improving self-motivation, they are located in stage two due to their secondary importance to autonomy. By satisfying only these two needs, extrinsic motivation will not get passed introjection (Niven and Markland 2016). Satisfaction of autonomy is needed in addition to competence and relatedness to distinguish if identified and integrated motivation will occur in addition to just introjection (Gagné and Deci 2005). Once designers are made aware of SID and identify with the value of SID, they will be more motivated to learn how to implement SID. Strategies to improve the designer’s SID competence will be made easier if the designers are willing to learn.

Stage 3 - Motivation via external enforcement and compliance is seen by SDT as a form of controlled motivation and not conducive to higher levels of self-motivation. Its inclusion in stage three is seen as a final attempt to motivate designers that continue to neglect SID despite the implementation of stages one and two of the SIDMM. Through increased enforcement, carrying penalties for non-compliance, amotivated designers will be left with no alternative but to commence SID. A further benefit to the inclusion of enforcement in stage three is that once SID has been started, additional motivating factors may become evident such as the finding that SID is not that hard once you start and it is not that time consuming when done correctly. Stage three has not been included within the continuous cycle of stages one and two as the focus of the SIDMM is not on controlled forms of motivation. Increased enforcement is not conducive to increased self-motivation and designers that continue to neglect SID despite the implementation of stages one, two and three, are perhaps best left to the authorities to deal with through convictions and penalties.
CONCLUSION

The designer’s social context is thwarting satisfaction of their need for autonomy, competence and relatedness, and leading to low levels of self-motivation to implement SID. A retheorisation of SDT has led to the design of a new SIDMM that enables SID implementation to continue to increase when controls are removed, allowing designers to implement SID autonomously and without direction. The SIDMM focuses on providing a methodology to positively influence those areas of the designer’s social context that are thwarting their satisfaction of autonomy, competence and relatedness. The SIDMM also considers the barriers designers face, such as time and cost restrictions, to ensure designers increase their self-motivation in the most effective manner. The SIDMM takes the emphasis away from SID enforcement and instead focuses on the designer’s awareness of SID and increasing the value of SID to designers.

The next phase of this research will be to investigate ways and means for the SIDMM to be used in practice. Prior to further research, the SIDMM should be disseminated throughout the design industry so that its existence is known and its initial value as a framework for tertiary curriculums, industry association seminars and organisational training can be realised.

REFERENCES


Safework Australia (2012b) Safe Design of Structures Code of Practice.


Considering the part which the built environment plays in the economy of South Africa, the failure of contractors, despite interventions to identify and eradicate the root of the problem, is a matter of concern. The purpose of this paper is to focus on surface and core competency requirements and self-empowering objectives for contractors becoming sustainable contractor enterprises in cidb Grades 6 to 8 through structured initiatives. To achieve the research objectives, a survey of the literature in terms of current contractor best practices required for competence and required human and capital resources in a medium sized construction organisation was undertaken. Secondly, archival research, which entailed a review of relevant Grade 5 to 9 cidb registered contractor data and statistics, was undertaken. The research entailed both qualitative and quantitative studies, collated from interviews and e-mail questionnaires from a wider sample population. The research indicates that there is a sustainability problem in the built environment, and that there are insufficient Professional Construction Managers to service the industry. From this it is concluded that the built environment should be made attractive to newcomers by limiting the transitory nature of the industry. There is also a shortage of competent, qualified construction staff, which contributes to overheads becoming a challenge. In this regard, training from trades’ level upwards must become a priority.

Keywords: Competencies, Entrepreneurship, Self-empowerment

INTRODUCTION

The Construction Industry Development Board (cidb) was established by an Act of the South African Parliament with the intention to promote a regulatory and development framework that builds construction industry delivery capability for South African social and economic growth as well as a construction industry that delivers to globally competitive standards (cidb 2015). All contractors that intend to procure work from the state or state parastatals must be registered with the cidb, to enable them to tender for government and parastatals, and are graded into designations established from their assessed financial and works capability. A Grade 6 contractor is considered capable of undertaking contracts up to R13 000 000, a Grade 7 up to R40 000 000, and a Grade 8 up to R130 000 000 (cidb 2013). It is argued that in the South African context, Grade 7 and 8 contractors can be regarded as medium size construction businesses.

The cidb (2011) expresses serious concern with respect to the high rate of enterprise failure and the potential consequences of this on the industry’s ability to deliver. The transitional phase of the cidb Grade 6 to 7 and then further to Grade 8 contractors, where the move from small business to an entrepreneurial venture is made, can be regarded as a totally new dimension in the lifespan of a construction business as a new and different business strategy must be adopted. Then, as a business grows, the function of co-
ordinating the various activities and resources gradually expands beyond the capacity of one individual (Windapo and Cattell 2011).

Construction surface and core competencies relative to entrepreneurship, leadership, and management need to be balanced. Burke (2006) argues that as the workload increases, the entrepreneur cannot control the organisation in its entirety, and therefore skilful delegation is the key to effective leadership and growth. It is thus essential that the entrepreneur builds a competent management team. One of the most significant barriers in the built environment identified by PricewaterhouseCoopers (PWC) (2013) is the limited pool of experienced, qualified individuals suitable for managerial positions, and the steep learning curve and time frame required to equip graduates with management capabilities (PWC 2013). The objective is to find a solution to this phenomenon, and by implication the high rate of enterprise failure.

REVIEW OF THE LITERATURE

Organisational structure, staff competence and business maturity

Construction is based on teamwork. The transition from small to medium size contractors (Grade 6 to 8) cannot be fast tracked. Smallwood (2012) states that production mainly takes place on projects, and is merely one of the functions of many such as, general management, production, procurement, marketing, financial, human resources, public relations, legal, and administration and information technology in an organisation. Medium-sized enterprises have a complex management structure, even those that are still owner controlled. The distinguishing factor between small and medium enterprises is the division of labour and the decentralisation of power that includes an additional layer of management (Ngcamu 2002).

Entrepreneurial ventures

Nieman and Pretorius (2004) define small business as any business that is independently owned and operated, is not dominant in its field, and does not engage in any new or innovative practices. On the other hand, an entrepreneurial venture is one where the principle objective of the entrepreneur is profitability, and growth. The true quality of a successful entrepreneur is the ability to select and find competent and capable managers (Nieman and Pretorius 2004). Leadership style needs to change to a more formalised management approach to enable effective, organising, planning, and control (Burke 2006; Nieman and Pretorius 2004). Continued growth of construction organisations inevitably leads to the appointment of a management team, and as growth continues, to formal departments or business functions (Nieman and Pretorius 2004). Growth means delegation of authority, to a management and supervisory team that can excel through well-established surface and core competencies. Delegation to a subordinate is the highest degree of empowerment, involving the assignment of tasks, the authority to carry out those tasks, and the assumption of accountability for performing them, as well as trust, motivation, influence, and leadership. However, the superior retains ultimate responsibility (Nel 2012; Kreitner and Kinicki 2010).

Construction management surface and core competencies

Sanghi (2004) and Vazirani (2010) (cited in Smallwood and Emuze 2011) state that competencies are divided into: surface competencies which entail knowledge - information regarding content, and skills - ability to perform a task. Core competencies,
which entail self-concept - values, aptitude, attitude and self-image, traits - self-confidence, team player and handles ambiguity, and motives - focus on client success and preserve organisation / personal integrity. Core competencies are the capability to perform in a consistently superior manner, which leads to above average organisational performance (Clardy (2007) cited in Smallwood and Emuze 2011). According to Smallwood (2006), management and control of the business of construction, includes the functions of: customer service; entrepreneurship; ethics; management systems; procedures; total quality management; risk management; procurement systems; dispute resolution; benchmarking; service management; facilities management; design management; design (temporary works); research; worker participation, and reengineering. Furthermore, he states that these functions integrated with the functions in an organisation identified as: general management; production; procurement; marketing; financial; human resources; public relations; legal, and administration and information technology, dependent upon the size of business, are generally the functions that the successful management of the business of construction including projects are structured upon. To drive business growth these functions cannot be performed by one or two people. The increased complexity of larger construction projects requires exceptional project management, construction management, and business of construction management discipline and skill at all levels. Failure in these disciplines and skills can result in a material decrease in project profitability (PWC 2013: 16).

Construction industry executives have distinct phases in their careers; the initial period is spent on site (operational – the management of specific projects), followed by middle management duties at the project level (middle – the management of a number of projects), culminating in a career with executive head offices (top – the management of the business of construction) (Smallwood 2006; Harris and McCaffer 2006). Smallwood’s (2006) research conducted among Chartered Institute of Building (CIOB) members in South Africa concluded that construction managers spend a limited number of years at operational management level, and more at middle and top management level. The research findings of Smallwood and Emuze (2011: 391) conclude that the importance of surface competencies in the form of knowledge and skills in the practice of construction management cannot be denied, however the empirical findings of the study clearly indicate the importance of core competencies in terms of the practice of construction management and their contribution to project and business success.

Core competency in relation to business leadership and management

Nel et al. (2013: 313) state that leadership focuses on vision, strategic development, and initiative, whereas management behaviour entails formulating detailed plans and schedules and the implementation of these plans to achieve the vision.

Management of an organisation considers the effective and efficient application of resources necessary to achieve improved outputs and the thinking attempts to eliminate risk and uncertainty to achieve the goals in the most productive manner (Nieman and Pretorius 2004). Combined with this is knowledge, the prerequisite that makes the business competitive and operationally efficient (Harris and McCaffer 2006). Management, leadership and knowledge go hand in hand and are the essential substance of core competencies. A lack of expertise affects an organisations’ ability to complete projects and it also affects the organisation’s growth, therefore sourcing and retaining skilled staff is critical to the sustainability of a construction firm (PWC 2013).

Construction Management legal requirements
The South African Construction Regulations 2014 (CR 2014) (Republic of South Africa 2014) govern the surface competency requirements of the competent responsible person in control of a site, and address the duty of ensuring health and safety (H&S) compliance. The cidb (2014) Inform Practice Note #31 states that in terms of relevant Acts, the South African Council for the Project and Construction Management Professions (SACPCMP) and Engineering Council of South Africa (ECSA) registered persons are competent to undertake construction management. The Identification of Work and Scope of Services as identified by the SACPCMP (2006) focus on surface competencies, which are essential for contractual compliance, and the delivery of projects.

RESEARCH METHOD

The related literature led to a greater empirical study. However, this paper only reports on the findings relative to the role of surface and core competencies and self-empowering objectives for contractors becoming sustainable contractor enterprises registered in Grades 6 to 8 General Building (GB) / Civil Engineering (CE) are reported on. Quantitative and qualitative dimensions were employed for a mixed-methods approach in terms of gathering the data. The research method is a combination of a descriptive quantitative survey, and archival research. The approach to the data is firstly reliant on the archival data input from the cidb for all Grade 5 to 9 GB/CE contractors registered with the cidb during the period 3rd quarter 2005 to 2nd quarter 2015. The first section of the descriptive quantitative approach is based on statistics and cross-tabulation that deals with survey interviews that explored the demographics of a small sample population, which were obtained by conducting personal interviews with 8 emerging contractors. Through this the researcher collected demographic data, which allowed inferences to be drawn about a large population by collecting data from a relatively small sample (Leedy and Ormrod 2014: 289). The approach was also reliant on a descriptive quantitative questionnaire and the subsequent responses obtained from relevant emerging contractors and relevant departments or parastatals population. The research questionnaire was distributed between all 18 Contractor Development Programme Practitioners (CDPPs) conducting Contractor Development Programmes (CDPs) for Grade 5 to 7 contractors, as well all 113 CE and GB contractors forming part of CDPs for Grade 5 to 7 contractors.

RESEARCH FINDINGS

Archival research

The shortage of CRPs, in the management and supervisory workforce pool identified by The Department of Construction Economics and Management of the Faculty of Engineering and the Built Environment of the University of Cape Town (2011), emphasises the importance of construction management surface and core competencies, which are indispensable for the management of the business of construction.

cidb Registrations vs Contractor exiting statistics

The cidb (2015) identifies contractors exiting the cidb register of active contractors as either, suspended, de-registered (suspended for more than one year not yet expired) or expired (three-year renewal not done). Table 1 indicates active contractors registered between 2005Quarter (Q)3 to 2015Quarter (Q)2 as well as the contractors exiting the cidb register of active contractors during this period.
Table 1: 10-year view of cidb registered contractors that achieved a Grade 5 to 9 during 2005Q3 to 2015Q2

<table>
<thead>
<tr>
<th>Total cidb registered</th>
<th>GB</th>
<th>CE</th>
<th>Total GB &amp; CE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reg.</td>
<td>Exit</td>
<td>%</td>
</tr>
<tr>
<td>Downgrades below grade 5</td>
<td>176</td>
<td>148</td>
<td>324</td>
</tr>
<tr>
<td>Grade 5</td>
<td>558</td>
<td>735</td>
<td>56.8</td>
</tr>
<tr>
<td>Grade 6</td>
<td>623</td>
<td>633</td>
<td>50.4</td>
</tr>
<tr>
<td>Grade 7</td>
<td>301</td>
<td>231</td>
<td>43.4</td>
</tr>
<tr>
<td>Grade 8</td>
<td>115</td>
<td>66</td>
<td>36.4</td>
</tr>
<tr>
<td>Grade 9</td>
<td>42</td>
<td>33</td>
<td>44.0</td>
</tr>
<tr>
<td>Total</td>
<td>1639</td>
<td>1698</td>
<td>50.8</td>
</tr>
</tbody>
</table>

Source: Adapted from Milford 2015

An average of 49% of contractors between Grades 5 to 9, that registered with the cidb between 2005Q3 and 2015Q2 exited the current active list of cidb registered contractors over the 10 years under consideration. There are a multitude of reasons why contractors exit cidb registration, and therefore the above statistics can only indicate possible enterprise failure. However, the statistics are alarming if it is considered that half of the contractors registered over the last ten years are not active at a certain point in time. This reflects an industry in trouble, and an industry that does not offer job security.

**Analysis and sample population description**

The first section deals with the personal interviews conducted with 8 emerging contractors. These interviews explored the human resource demographics of the sample population of Grade 5 to 7 emerging contractors (ECs). Cross tabulation on an Excel spreadsheet was used to examine the available human resources. Experience in the construction industry, average tertiary qualification of human resources, and business structure were assessed. These interviews enabled the researcher to draw demographic inferences regarding Grade 5 to 7 GB and CE contractors.

The second section deals with the responses and results of the questionnaire that were circulated to Grade 5 to 7 contractors forming part of CDPs, as well as the CDPPs that conduct CDPs for Grade 5 to 6 contractors. The questionnaires for ECs and CDPPs were assessed separately and the results and findings recorded separately. The primary data obtained was evaluated by means of descriptive statistical methods, and the respondents’ feedback was recorded in tables. The questionnaire was based on a descriptive study of the emerging contractors between Grade 5 to 7 population forming part of a CDP, in relation to the total of 2 787 active emerging contractors between Grade 5 to 7 GB and CE (Milford 2015). 7 out of 18 CDPPs that are running CDPs for Grade 5 to 7 contractors responded to the questionnaire, which equates to a response rate of 39%. Considering dual registrations in the CE and GB of Grade 5 to 7 contractors, 113 contractors forming part of CDPs are registered. Of these, 25 contractors responded, which represents a response rate of 22%.

These results and findings were sub-divided into demographic inferential statistics and descriptive e-mail questionnaire responses. The descriptive e-mail questionnaire responses were further sub-divided into responses received from Grade 5 to 7 ECs and responses received from CDPPs.
Demographics - descriptive statistics

Table 2 indicates the current cidb designation grading, workload and ownership of the eight Grade 5 to 7 ECs who were interviewed.

**Table 2: Eight assessed emerging contractors’ current workload and ownership**

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Designation Grade</th>
<th>Current contracts</th>
<th>Number of Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5CE</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>5CE</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>5CE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>5GB</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>6CE</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>6GB</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>7CE</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>7GB</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3 summarises the mean statistics of the numbers employed in every broad category as well as mean highest education, practical experience and professional registrations. It also indicates professional registrations statistics that are required in terms of the CR 2014. Only contractor H partly complied with this requirement.

National Qualification Framework (NQF) levels include section 13, and 28 artisans under NQF 4.

**Table 3: Grade 5 to 7 emerging contractors’ human resources**

<table>
<thead>
<tr>
<th>Human resource</th>
<th>Mean no. employed</th>
<th>Mean highest qualification</th>
<th>Years practical experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Ownership</td>
<td>2</td>
<td>1-2</td>
<td>3</td>
</tr>
<tr>
<td>Site management &amp; supervision</td>
<td>2-3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>OHS Personnel</td>
<td>1</td>
<td>1-2</td>
<td>2</td>
</tr>
<tr>
<td>Support personnel</td>
<td>&lt;1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Management, QS and procurement personnel</td>
<td>0</td>
<td>&lt;1</td>
<td>5</td>
</tr>
<tr>
<td>Office personnel</td>
<td>&lt;1</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

SACPCMP and ECSA Professional Registered persons in the business

- PrCM: 1
- PrCM / Pr Technician: NQF6, 10+
- PrCM: NQF7, 10+
- SACPCMP - Student: NQF4C, 3.5-5, 10+
- PrCM: NQF4B, 3.5-5
- SACPCMP: NQF4B, 3.5-5
- SACPCMP: NQF4, 3.5-5
- SACPCMP: NQF4, 3.5-5
- SACPCMP: NQF4, 3.5-5

From Table 2 and 3 the following could be inferred regarding ownership and management structure. The ownership of 25% of the Grade 5 contractors resides in a single individual, and 75% represent a family controlled business with dual ownership. The ownership of 50% of the Grade 6 contractors resides in a single individual, and 50% represent a family business with dual ownership. Both Grade 7 contractors interviewed are proprietary companies [(Pty) Ltd] and are controlled by shareholders, who are also directors. Neither of these two businesses are family controlled. All the core business functions such as management, tendering, progress certificates, cost control, procurement, HR and admin, are performed by the ownership. However, in Grade 7 ECs, a different management structure of top and middle management was observed. Effectively, this means that the owners in the lower grades theoretically
possess all the construction core competencies, but in the case of Grade 7 ECs, this is delegated to management personnel.

The Grade 5 contractors can be identified as two types of businesses. 50% of the grade 5 contractors rely on completing one contract at a time, supervised and managed by the owner of the business. The other 50%, newer developing Grade 5 contractors, involving younger founders with higher tertiary qualifications, performing more than one contract at one time, and are more reliant on site middle management and supervisory personnel. It is evident that 25% of the contractors do not employ an H&S manager or officer. This function is also not outsourced. None of the H&S personnel of interviewed contractors comply with the requirements of the CR 2014.

Grade 6 contractors are reliant on appropriate site middle management and supervisory personnel, due to the size and complexity of the projects that they were busy with. 50% of the H&S personnel of interviewed contractors do not comply with requirements of the CR 2014.

Grade 7 contractors no longer rely on the ownership to manage every facet of the business, and these contractors made the conscious choice to entrust management staff with the management of their businesses. It is notable that in the case of the Grade 7 contractors, 25% of other ownership’s highest qualification is an Advanced Certificate / National Diploma, 50% a trade certificate, and 25% is recognition of prior learning. It can be noted that the mean tertiary qualification of the Grade 7 contractors of the research population have the lowest qualification. This corroborates with the notion that a tertiary qualification is not the alpha and the omega. Practical experience, entrepreneurial will, and skills are of great importance in achieving growth in any business. The average practical experience of all ownership exceeds 10 years. The contractors have similar types and numbers of site management and H&S personnel. H&S personnel complied with the CR 2014. Contractor G, at the stage of the interview was busy with 8 contracts, and contractor H was busy with 9 contracts. 33% of the ownership is deployed as the managing director, 50% as site management / supervisory personnel, and 17% as a financial manager. Contractor G outsources the QS, estimating, and procurement functions.

Descriptive study

The following section deals with the analysis of the data from ECs between Grade 5 to 7 forming part of CDPs, as well as the CDPPs running CDPs.

Importance and extent of construction management surface and core competencies in a successful construction business

Statement 1: Extensive construction management core competencies are the basis for completing projects successfully

The MSs of 4.24 (ECs) and 4.57 (CDPPs) are $> 4.20 \leq 5.00$, which indicates that the respondents agree to strongly agree / strongly agree with the statement. This statement attracted the highest MS in the case of both groups.

Statement 2: Extensive construction management surface competencies are the basis for completing projects successfully
The MS of 4.16 (ECs) is marginally outside $> 4.20 \leq 5.00$, whereas the CDPPs’ MS (4.57) is $> 4.20 \leq 5.00$, which indicates ECs and CDPPs agree to strongly agree / strongly agree with the statement. In terms of the ECs’ responses, this statement achieved the second highest MS. In the case of the CDPPs’ responses the MSs relative to the surface and core competencies are the same.

**Importance of entrepreneurial ability and skills in a successful growing business**

*Statement 3: Unwavering commitment, a desire to self-empowerment forms an integral part of the entrepreneurial spirit that is essential for business growth*

The MS of 4.57 for CDPPs is $> 4.20 \leq 5.00$ and the MS of 4.00 for ECs is $> 3.40 \leq 4.20$, which indicates that CDPPs agree to strongly agree / strongly agree, and the ECs are neutral to agree / agree in terms of concurrence. This indicates the importance of commitment, and a desire for self-empowerment that forms an integral part of the entrepreneurial spirit required for business growth.

*Statement 4: Entrepreneurial spirit and skills form an essential part of a successful growing business*

The MS of 4.28 for ECs and 4.43 for CDPPs both fall within the MS range $> 4.20 \leq 5.00$, which indicates that both ECs and CDPPs agree to strongly agree / strongly agree with the statement. This response indicates the importance of entrepreneurial spirit and skills in the growth of any business.

**Comments expressed by respondents to the demographic descriptive survey and descriptive e-mail questionnaire responses**

The descriptive questionnaire contained an open-ended request that requested respondents’ opinions, remarks and industry knowledge with respect to business problems facing potential ECs in cidb Grades 5 to 7. During personal interviews with eight ECs the researcher also posed an open-ended discussion regarding business problems faced by ECs in cidb Grades 5 to 7. The following constitute the key issues.

**Emerging contractors**

The respondents regarded a certain element of newcomers to the industry as lacking in construction surface and core competencies. From this it was concluded that ignorant competition, lacking in terms of construction core and surface competencies, leads to tender prices being far too low. There is a serious shortage of experienced and capable site management and supervisory personnel. Tradespeople’s skills, productivity and competence are also a serious challenge. An extensive training drive was deemed necessary in terms of improving the situation.

**Contractor Development Programme Practitioners**

Many Grade 5 to 7 ECs struggle to complete projects on time, within budget, and to the required quality standards. There is a lack of technical and managerial experience, as well as construction management skills and business planning. The respondents have seen businesses start and fold. In most cases this is where there is a lack of surface and core competencies. Businesses are forced to cease trading after a ‘hit and miss’ management approach.
CONCLUSIONS

From the literature review and descriptive study, it can be concluded that in a growing entrepreneurial venture, construction surface and core competencies, combined with an unwavering entrepreneurial spirit, which include business and financial acumen, are the essence of any growing construction firm. From the data, it transpired that surface competencies are easy to identify, because they are tangible, such as education, training, experience, and prior learning. However, core competencies are more obscure because they are intangible. Core competencies enable a person to excel in their surface competencies and therefore excel in their work. This is up to the individual’s personal motivation and aspirations. A serious lack and shortage of these surface and core competencies was identified.

When there is a shift from Grade 6 to Grade 7, this requires an additional tier of management with a concurrent shift in the responsibilities of the founders. Leadership, entrepreneurial drive, delegation, and control become the focus of the ownership, while management is delegated to appropriately qualified, core competent staff. The CR 2014 requires professional registered employees to be present in construction firms from Grade 7 upwards, to manage every single project as well as to ensure compliance with H&S regulations. H&S appears to be the management function to first suffer from neglect, and non-compliance becomes the norm.

Based on the findings and conclusions, there is no ready solution with respect to the shortage of people with the required construction surface and core competencies. The cidb registration versus the contractor exiting statistics clearly indicate that there is a lack of sustainability in the South African built environment, as nearly 50% of the contractors registered with the cidb exited the industry over the 10-year period 2005 to 2015. The research confirmed that enterprise failure, and exiting from the cidb register of active contractors, occurs across the board in Grade 5 to 9. This contributes extensively to the transitory nature of the industry, which in turn discourages young people from embarking on a career in the built environment. The recommendation is to attract new entrants to the industry by limiting the transitory nature of construction. This dilemma in the built environment can be also be eased by developing, training, and assisting enough construction managers with well-established core competencies.

An alarming shortage of competent qualified construction staff was also identified by the research population. This problem originates at the base of the industry, in the trades, where virtually no training took place over an extensive period, and filters upwards into the top structures. The solution to the problem of insufficient surface and core competencies lies in training.

Finally, in a developing country where the built environment is one of the major providers of employment, enterprise failure is a huge concern, as it contributes to unemployment.

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AN INVESTIGATION ON HEALTH AND SAFETY PRACTICES FOR THE PUBLIC DURING CONSTRUCTION IN THE ZAMBIAN CONSTRUCTION INDUSTRY

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Construction activities expose both workers and the public to hazards. Therefore, the research aimed at investigating health and safety consideration for the public on construction sites in the Zambian Construction Industry (ZCI) and how it can be enhanced. In order to achieve this, a sample survey and 2 case studies were used to collect data. 63 questionnaires were distributed to contractors, consultants and regulatory bodies. Stratified and convenience sampling methods were used to select the respondents. It is worth mentioning that 2 case studies and 63 responses may not be representative of the ZCI. The results revealed that there is poor consideration of the public regarding health and safety in the ZCI exhibited by poor contractor compliance through non-use of hoarding and proper signage to alert the public of the hazards. Major hazards that the public are exposed to included dust and noise. It was also found that the publics’ awareness of hazards was low. Further, research on public health and safety during construction in Zambia and other developing countries is very limited even when there has been an increase in infrastructure projects in urban areas of Zambia. Hence, it is imperative that there is increased awareness of hazards which the public are exposed to and mitigation measures should be implemented. Therefore, in order to enhance health and safety for the public, enforcement by regulatory bodies must be enhanced. Sensitization programs to alert the public of the hazards that construction sites pose must also be conducted.

Key words: Zambian Construction Industry, Public, Health and Safety.

INTRODUCTION

The construction industry has been known to expose not only its employees but also the public to a number of hazards and accidents. According to the International Labour Organisation (ILO), construction related accidents and diseases contribute 3.9% of all deaths and 15% of the world’s population suffers an accident or work-related disease in any one year (ILO, 2005). However, much consideration is given to the safety practices of the construction team with little emphasis on the public (HSE 2014). Thus, the health of the public who might be affected by construction activities has become a major concern. One factor leading to a large number of accidents has been due to the labour intensiveness of the sector. Therefore, as a major employment generator, the potential rate for serious accidents on and around construction sites is very high (ILO, 2005; Fewings 2005). The construction sector on the other hand in Zambia has been identified as a potential driver for economic growth since it creates a number of jobs and provides the various infrastructure products that are needed by the public.

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country such as roads, medical and health facilities and many other social and commercial buildings (NCC 2014). Conversely, the sector in Zambia is poorly regulated in terms of public health and safety. Notably, according to the Central Statistical Office (2012), the construction industry reported 58 fatalities between 2003 and 2007. From this number of fatalities, 17 were members of the public with another 34 seriously injured. More recently, in a preliminary study conducted in Nkana East (Kitwe) during the construction of township roads, residents complained of the high levels of dust emissions and noise from the earth moving equipment. This is what was also observed by Banda (2015). In Lusaka during the constructions of roads under the L400 and the Pave Zambia 2000 respectively during the first quarter of 2015, 34 accidents were reported involving the public from August 2013 to September 2014 with the most recent resulting in a death caused (Tembo, 2014). Further, on the Ndola – Kitwe dual courage way, the Road Transport and Safety Agency (RTSA) attributed 16 road traffic accidents to the high levels of dust during the construction period (Mukuka, 2014). This shows that the public is adversely affected by the construction works and as such there is need to reduce these negative impacts of construction on the public. This is important because the quality of life of the public should not be affected by construction works as much as the construction works are necessary (HSE 2014; Thodesen et al. 2011). Therefore, the main aim of this research was to assess the health and safety hazards the public are exposed to as a result of construction activities and the effectiveness of the mitigation measures in the ZCI.

CONSTRUCTION HEALTH AND SAFETY AND THE PUBLIC

According to the International Labour Organisation (2005), the main focus in public health and Safety is to ensure that the construction site and surrounding areas are maintained in a manner that is safe for the public. Health and safety for the public therefore is an area concerned with protecting the safety, health and welfare of the public such as residents, pedestrians and motorists who may be affected by construction activities (Ridge, 2001; Faining, 2003). Addressing this concern is important for the sector because construction sites have a negative impact on the health and quality of life of the neighbouring community (Glass and Simmonds 2007). Some of the hazards that have been noted that the public are exposed to include dust, vibrations, noise, traffic diversion, fumes, increased traffic from site vehicles and deliveries (Hadi 2001). Further, construction activities affect a number of people in a community. However, according to the HSE (2009), the main groups that need particular attention include; the children who do not have the ability to perceive danger in the same way as adults do and the disabled. Essentially, any project must priorities all members of the public near its construction site. This is important for moral, legal and financial reasons because good health and safety practices can reduce injury to the public and illness related costs such as medical care and disability benefit/claims (Ridge, 2001). Hence on any project, the priority of health and safety must be extended beyond the project team members to include the public.

Mitigation Measures

Realizing the far reaching effect of construction hazards to the public, involving all stakeholders is cardinal in mitigating the hazards (Thodesen et al. 2011). According to the HSE (2009) it is important to liaise with the public that will be affected so that they can be made aware of the risks the construction site may pose. Further, involvement of subcontractors, suppliers and any other would be visitors to the project site remains critical. Importantly, contractors should familiarize themselves with the
regulations and develop systems to meet their requirements during the earliest stages of project planning. The works should also be programmed to avoid busy periods such as school start, finish and break times (HSE 2009).

**Public Health and Safety Plan**

The preparation and use of the Public Health and Safety Plan on projects essentially is another important action that can be undertaken by contractors. Its aim is to promote and maintain the health and safety of construction workers and the public on site (Dodo 2014). Thus the plan identifies the hazards and sets in place mitigation measures and eliminates the possible accidents or injuries to the public by the contractor (Teo et al, 2010). This is important for both the public and the contractor because when the health and safety plan is properly implemented the benefits do not only accrue to the public through reduced or zero accidents, there will also be an increase in productivity due to the non-occurrence of accidents (Dodo 2014). Hence, every contractor must include the safety and health of the public during construction.

**OVERVIEW OF THE ZCI AND HEALTH AND SAFETY FOR THE PUBLIC**

The Zambian Government has established legislation that encourages protection of workers in their places of work and the public that may be affected (ILO 2012, Auditor General’s Report 2015).

**Main Registration of Health and Safety**

The main document that gives guidelines on the health and safety in the country in relation to construction is the Factories Act, Chapter 441 (Act No. 13 of 1994). This act generally provides for the regulation of the conditions of employment in factories and other places with respect to the safety, health and welfare of persons employed therein (ILO, 2012). The following statutes have also been developed in the management of health and safety in the ZCI;

- The Workers’ Compensation Act, Chapter 271 (Act No. 10 of 1999): This Act provides for the establishment and administration of a fund for the compensation of the workers who are disabled by accidents or diseases contracted by such workers in the course of their employment (ILO, 2012).

- The Occupational Health and Safety Act, 2010: This covers the protection of persons against risks to health or safety arising from activities or any related matters at their work place (ILO, 2012).

- The Public Health Act, Chapter 295 (Act No. 22 of 1995): This act provides for the prevention and suppression of diseases and generally regulates all matters connected with public health in Zambia (Auditor General's Report 2015). It also deals with the control of habitation in factories, construction sites, workshops and trade premises and their application extends to most of the Local Authorities in the country.

Further, in the ZCI, contract conditions also give guidelines on managing health and safety for the public by ensuring that the site hoarding is elected. Insurance cover is
also used by contractors to cover the injured in case of an accident. Notably, the above provisions on the other hand have been known to have limitations in the sense that they are not specific on what should be done in achieving health and safety by the various sectors covered in the country. In particular, the Factories Act of 1994 contains general rules and regulations that every employer in Zambia has to abide to. Reinforcement of these legislations and monitoring by the authorities is also weak (Auditor General's Report 2015). Further no specific regulation exists in the ZCI to give direction on how the public can be protected from construction hazards and accidents which hugely remains a major challenge in improving health and safety of the public.

**METHODOLOGY**

The research adopted an exploratory approach since it attempted to establish or understand a theory by reviewing the set research question and then later make a conclusion based on the data collected (Saunders et al. 2012; Blumberg et al. 2005; Fellows and Liu 2008). Hence, in this research, this was done by investigating the current state of public health and safety in the ZCI in order to enhance public health and safety during construction. Both qualitative and quantitative methods were adopted for data collection and analysis. The data collected was analysed using quantitative and qualitative methods. In quantitative method, Microsoft excel was used and the data collected was also presented in different formats like graphs, tables, pie charts and tables. The discourse method was used in analysing data qualitatively (Blumberg et al. 2005).

**Data Collection Tools and Sampling Area**

A survey was adopted for data collection. Structured self-administered questionnaires were used due to the fact that they give ample time to respondents and an opportunity to consult and get extra information on the subject matter. A survey is also considered to be faster and easier to reach the target groups (Saunders et al. 2007). A case study was also used since it gives an in-depth understanding on a subject, in this case to understand the common hazards during construction and mitigation measures in relation to public health and safety in the ZCI. Purposeful sampling was also used in selecting case studies (Phoya 2012; Flyvbjerg, 2001; Yin 2003). Lusaka and Copperbelt provinces were selected for data collection since they have a higher number of construction activities in Zambia. These places are also among the cities in Zambia with a highest population.

**Target Groups and Sampling Methods**

The target groups consisted of contractors (52), consultants (26) and regulatory bodies (12). Contractors are categorized according to their NCC registration grades, 1 to 6 hence stratified sampling was used. Since subgroups of architects, quantity surveyors and civil engineers were considered under consultants, stratified sampling was also used to select the consultants. Regulatory bodies were sampled using purposeful sampling method since they have information which can only be gathered from them (Saunders et al. 2007). From the total 90 questionnaires distributed, 63 were received giving a response rate of 70%.

**Research Limitations and Scope**

Only 2 provinces with 63 respondents and 2 cases studies were considered for this research and this may not be representative of the entire ZCI. The research did also not measure the number of public related accidents on construction sites. It is
therefore recommended that a wider number of provinces and cases be considered in future related research in order to establish the nature and number of construction accidents involving the public.

FINDINGS, ANALYSIS AND DISCUSSION

From the data collected, the following are the main findings which is divided in two sections Section A discusses findings from the survey while section B covers findings from the case study.

Section A: Survey Findings and Analysis

Nature and Finance for the Projects

The nature and type of projects is dominated by civil engineering related projects at 41.8%. The other types which include commercial and residential combined accounted for 58.2%. Public funded projects accounted for 76.4%. Therefore, this remains as an opportunity for the government to influence or give conditions which have specific requirements in ensuring that the contractors and other project parties pay particular attention to the health of the public since they are the major client and financier.

Most Common/Occurring Hazards

The findings indicate that the most occurring hazards are dust (86%) followed by noise emission (75%) and presence/movement of heavy vehicle (70%). The least occurring were waste generation (42%) followed by vibrations (43%) and traffic diversion (56%). Evidently, the public in the ZCI is exposed to various hazards and this needs to be mitigated by the parties involved in the construction process.

Effects of the Hazards on the Public

The respondents were also asked to explain the effects the hazards had on the public and subsequently 54% of the respondents indicated that too much dust in residential areas created discomfort and on many occasions, residents resorted to not opening the windows during the construction period. Discomfort in homes due to vibrations and noise from heavy vehicle traffic was also experienced. With business entities, closure of roads leading to shop fronts was another effect resulting in loss of business. What has been noted by other researchers (Thodesen et al. 2011) is the fact that the effects of these hazards on the public may last longer than the construction period resulting in health complications such as lung or hearing problems caused by dust and noise respectively. Thus it is imperative that all construction parties must ensure that these hazards are eliminated or reduced realizing their effects on the public in the ZCI.

Public Awareness of Construction Site Hazards towards the Public

The findings showed that only a small part of the public (34%) indicated that they are aware and understand the hazards and risks that construction sites pose. 12% were not sure while 54% indicated that they are not aware. This was also observed by Spangenberg et al. (2003) who asserts that this contributes to construction site accidents involving the public. Therefore, mitigation process against public health and safety in construction must involve the public and other key stakeholders.

Contractors’ Compliance and Effectiveness of Mitigation Measures

The compliance levels for waste disposal were 56% while excavation protection was 51%. Dust suppression and noise reduction both had 48% while vibration was 47%.
It can be noted therefore that indeed efforts are being put in place in trying to mitigate the hazards to which the public is exposed. However, with dust being the most occurring hazard yet with low compliance, this clearly shows that there is more that needs to be done by contractors and the regulatory bodies in mitigating these hazards in order to improve the publics' health and safety during construction.

**Contractors Mitigation Measures and Tools**

The field survey showed that contractors were using basic tools to alert the public of the hazards on their sites. The most common used was the sign boards (54%), red tape (35%) and security personnel (14%). Considering the low numbers in the use of the red tape and having security personnel, this in itself was sufficient proof that contractors were not fully complying with the hazard mitigation measure as earlier highlighted and the tools are ineffective.

**Regulations Considered in Managing Health and Safety by Contractors**

A question was posed on the available regulations that are used in the ZCI by contractor with respect to health and safety for the public. From table 1, the most used regulation was the Workers Compensation Act of 1999 while the Factories act of 1994 is the least used. The workers' compensation act is mostly used by contractors because they are mandated to have a scheme for their workers and make contributions to the Workers Compensation Control Board and this does not cover the public.

<table>
<thead>
<tr>
<th>Statute</th>
<th>Rank</th>
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<tbody>
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<td>Workers' Compensation Act, Chapter 271</td>
<td>1</td>
<td>4.618</td>
<td>0.4903</td>
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<td>(Act No. 10 of 1999)</td>
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<td>Occupational Health and Safety Act, 2010</td>
<td>2</td>
<td>4.582</td>
<td>0.8320</td>
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<tr>
<td>Public Health Act, Chapter 295 (Act No. 22 of 1995)</td>
<td>3</td>
<td>4.290</td>
<td>0.6555</td>
</tr>
<tr>
<td>Factories Act, Chapter 441 (Act No. 13 of 1994)</td>
<td>4</td>
<td>4.109</td>
<td>0.9939</td>
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</table>

On the other hand, as much as these regulations are being applied, many of these applicable regulations are generic as noted in the Auditor General's Report (2015) with specific measures to be implemented by contractors. Were the construction sector is covered, it only considers the workers with no emphasis on the health of the public with respect to construction. Hence there is need to have specific regulations to address the health of the public.

**SECTION B: CASE STUDY FINDINGS**

The two case study sites were each from, the building and the road construction sector respectively.

**The Building Construction Site** -

The hazards observed included; (1) Construction Waste - Some waste was just dumped outside the site which could contain hazardous substances or dangerous
objects (2) Buried Services: Striking services such as high voltage electricity cables, water pipe or other buried services can lead to electric shock, burns and fire or rapid flooding of the excavation. This may also result into major business disruption to other service users in the area. (3) Unfenced site boundary, this exposes the public to numerous hazards because there is no control on who can access the site. (4) Unprotected excavation areas - with no fence or proper site hoarding, the public will be exposed to falls when using the site as an alternative route.

**Road Construction Site:**

Apart from the dust, the following hazards and disturbances were observed; (1) Poor signage at the crossing point made it difficult for the residents and motorists especially the children when crossing the road. (2) The absence of proper signage made driving very dangerous when the road was flooded because the extent of the road could not be properly identified. (3) Traffic controllers were also not on the road construction site. The absence of the traffic controller resulted in traffic jams at peak hours as some motorists did not want to give chance to road users.

**Mitigation Measures**

From the sites visited it was observed that the contractors used a water bowser to suppress the dust. Waste generated was just dumped at designated dump sites without separation. For road construction, the contractors constructed side roads which accommodate the disturbed traffic and maintained them. The contractors from the case studies also mentioned that they minimized using construction processes that used equipment that caused too much vibrations or noise.

**CONCLUSIONS**

From the findings, the public in the ZCI is exposed to hazards such as dust, noise and vibrations. Hence there is need for all stakeholders and regulatory bodies in the construction industry to address these problems and use other mechanisms such as encouraging contractors to prepare a public health and safety plan that will help to enhance the health and safety of the public during construction. Since it was observed that there is low mitigation of dust, regulatory bodies such as the National Council for Construction should enhance inspection and introduce stringent penalties for violations to ensure that contractors comply fully. Sensitisation programmes to alert the public of the hazards that construction sites pose to the public should also be done since there is low awareness of the construction hazards by the public. Ultimately, specific regulations addressing health and safety of the public should be formulated. This is due to the fact that the existing ones are generic and do not give specific actions or measures to be put in place by stakeholders in order to improve the health and safety of the public during the construction process.

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MARIJUANA USE WITHIN THE CONSTRUCTION WORKFORCE: THEORETICAL CONSIDERATIONS AND A RESEARCH PROPOSAL

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Alcohol and recreational drug use in construction is an area of growing concern, workers often found to have higher prevalence of such behaviours than those in other industries at both global and national levels. Potential reasons for this are many. The social determinants of health (the reasons why people drink or take recreational drugs) negatively associated with work can be readily identified in construction work with temporary contracts, long working hours and a lack of employment security for work within high-pressure and high-hazard environments. The legalisation of marijuana in several states of America has led to concerns from industry that there will be an increase in use amongst the local workforce, but also created the opportunity to study this phenomenon without ethical constraints around legality that may occur in other countries. This paper, presented for discussion rather than the dissemination of completed work, explores the theoretical issues that surround marijuana use within construction, focusing on its impact on construction site safety. This includes necessary considerations of accident causality, worker impairment and physiological issues around the drug itself, as well as inherent problems with drug testing, and its effectiveness as a means of management control. This critical contextual review has been used to inform the development and proposal of a methodological approach to effectively examine this phenomenon empirically in the field, as part of a future research project to be undertaken in Colorado, USA.

Keywords: construction workforce, drug use, marijuana, safety, methodology

INTRODUCTION

There is growing concern around the use of alcohol and recreational drugs amongst construction workers, and the consequential impact this can have on sites, particularly around site safety. Indeed, research of drug and alcohol use in the Australia construction industry found that safety managers feel this problem is '… a major issue that is only getting worse' (Biggs and Williamson 2012:450). The legalisation of marijuana in several US States has resulted in various legal, moral and technical dilemmas for employers. Many assume that legalisation will increase use amongst their workforce with negative consequences for safety and productivity.

Within the high-pressure, high-hazard construction site environment, any form of impairment can have serious repercussions not only for the workers concerned but all those working on the site. Yet marijuana as a drug raises several unique problems. It is a natural product with different potencies which are in turn influenced by how it is used, therefore its effects can vary significantly. There is also a lack of scientific agreement of quantifiable effects on human performance and inherent problems with

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drug testing using standard methods, as its longevity in the body long outlasts actual intoxication. All are aspects that require careful consideration now the legal context has changed, and states have granted their citizens the freedom to use it recreationally without punishment.

This paper sets the scene for a proposed research project, itself aiming to establish how the legalisation of marijuana has impacted (or not impacted) construction site safety. At present, the impacts of marijuana use on construction safety and worker well-being and legalisation of marijuana are unknown. The theoretical and social context of marijuana legalisation is explored in depth, and then used to inform the development of a methodological approach to effectively examine this phenomenon empirically in the field.

MARIJUANA AND CONSTRUCTION WORK

Construction workers take drugs. The industry consistently ranks very highly for illicit drug use (e.g. Gerber and Yacoubian 2002; French et al 2004; Minchin et al 2006; Larson et al 2007; Schofield et al 2013; Bush and Lipar 2015, cited in Fardhosseini and Esmaeili 2016), with statistically significantly higher use than in other comparable high-hazard industries such as oil and gas (Tan and Lloyd 2016).

There are a number of reasons why this could be the case. Researchers have highlighted the links between work related stress and drug use (Fardhosseini and Esmaeili 2016), the contribution of unsocial work patterns, long travel and abnormal shifts to elevated risks of substance abuse (Miller et al 2007), and remote job locations meaning workers are far from family and friends, feel lonely and so become bored and tempted (Pinto et al 2011). Feelings of powerlessness that come from short term employment and job insecurity (Frone 2013) and the very nature and pressure of construction work, including facing hazards on a daily basis (Biggs and Williamson 2012) can also have a major effect, associated as they are with the social determinants of health, the reasons why people take drugs (Wilkinson and Marmot 2003).

It is arguable that this 'why' is perhaps the more critical consideration here, and research could better focus on such fundamental causes of poor worker health, rather than simply examine the symptoms, of which drug use is just one. The reader should be reassured that this work is being undertaken elsewhere (Sherratt 2016a). For the purposes of this paper, focus shall remain on the symptom of drug use amongst the workforce, specifically marijuana, and the concerns this has raised for construction site safety given recent changes in its legal status for recreational use in the USA, alongside due consideration of the potential benefits and positive impacts of marijuana use and legalisation.

MARIJUANA, WORKER IMPAIRMENT AND SAFETY

The physiological and psychological effects of marijuana have been well researched, not only because it is the most consumed illicit drug in the world (Fernandes and Moreira 2011:95), but also due to its potential medicinal benefits. Effects of its use have been found to include dizziness, tachycardia (accelerated heart rate), psychomotor retardation, alterations to perceptual and motor speeds and coordination, whilst cognitive function, learning and memory are also affected (Fernandes and de Campos Moreira 2011). There has been recent debate around the extents of cognitive impairment caused by marijuana, and no accepted answer has yet been found (Caulkins et al 2015:35), although long-term users can have problems around brain development, intelligence quotient (IQ), reaction time (Caulkins et al 2015), attention,
loss of memory and be prone to knee-jerk reactions (Fernandes and de Campos Moreira 2011). Yet as Caulkins et al (2015:33) also note, problems in determining the extent of such cognitive functions are linked to the difficulties of separating the direct effects of marijuana from what they term 'the personality traits' of the user.

However, these effects are not consistent from user to user, marijuana affects everyone differently. In part, this is because marijuana is a natural product and its potency varies from plant to plant, resulting in no 'standard' dosages. Active cannabinoids within the plant can vary in concentration from 0.3-30%, which results in variation in the levels in human tissues after use (Fernandes and de Campos Moreira 2011). The way the drug is used also alters its effects, which can fluctuate significantly (bioavailability of the drug can vary from 2-56%) due to what are termed 'smoking dynamics' - hold time, number of puffs, inhalation volume – all of which influence the degree of drug exposure (Huestis 2007). A rough 'time-line' of impairment has been established: peak concentration of the drug comes 10-30 minutes after inhalation, it is then stored in the fatty tissues of the body, from where it is slowly released and removed (Fernandes and de Campos Moreira 2011). The effects last for about 3-5 hours, after which the influence on physiology wear off and the user gradually returns to normal (National Highway Traffic Administration 2015). It should also be noted that marijuana use can also create a 'stone-over' effect, similar to an alcohol-related hangover, in which aspects of impairment can also continue into the following day.

From the above, it is unsurprising that concerns have been raised around marijuana and safety, particularly in the workplace. It is often argued that any substance abuse creates a recognised serious risk to the safety of the user and others (Miller et al 2007), and evidence has been established from controlled laboratory trials that ' … marijuana use reduces psychomotor performance in ways that increase overall risk of accidents, and in particular, impairs driving (e.g. Ramaekers, et al 2004; Ramaekers et al 2006: cited in Caulkins et al (2015:33). Miller et al (2007) also note that although limited, previous studies that have examined the relationship between illicit drug users and occupational injury found that drug users have higher injury rates, whilst Spicer et al (2003) state simply that illegal drug use causes impairment, which in turn triggers occupational injury. Indeed, there are many studies that have correlated impaired co-ordination and the reduction in worker ability to perceive and respond to hazards (see Miller et al 2007 for a summary of studies around driving vehicles, ships and aircraft). However, this body of research often examines the impacts of impairment within relatively controlled work environments, where decision making can be linear and follow relatively simple and prescriptive sequences. Construction sites are highly complex places, and so impairment within these environments may be even more problematic.

Yet in spite of such findings, and suggestions of correlation between specifically marijuana use and accidents, causality is much harder if not impossible to prove. Indeed, Caulkins et al (2015: xii) state that current literature 'is insufficient to determine the extent to which marijuana use is casually linked to any of these outcomes'. Wickizer et al (2004) suggested that substance abuse may be a risk factor for occupational injuries and accidents, but there is conflicting evidence about the 'risk gradient', with some studies unable to find a link, others establishing a weak link, and others an arguably clearer link, although all vary in the parameters of type of drug, frequency of use and amount of use. The problem is the difficulty in establishing a direct correlation between workplace injury and drug use, and some researchers have
even suggested there is no correlation at all (e.g. Pidd and Roche 2014), whilst Frone (2013) goes further to argue that the correlation of drug use, cognitive and psychomotor performance to work safety is not only unconvincing, it is also to some extent prejudiced. Little is known about what proportion of construction site accidents are directly attributable to marijuana use (Biggs and Williamson 2012), yet given the inherent complexities and multiple causes behind almost any accident on a construction site (e.g. Gibb et al 2001) the lack of any statistically significant causal relationship is perhaps not all that surprising.

It should be noted that marijuana use and, by extension marijuana legalisation, may have some positive benefits. Use of marijuana is well-known to induce short-term increase in relaxation, decrease in stress, and increase in appetite. For some construction workers, use of legalised marijuana may be beneficial in the same way that many patients have benefitted from medicinal marijuana for years. In this study no presumptions are made about the net positives or negatives of marijuana use; however, it is recognized that being high at work is unacceptable.

**DRUG FREE WORKPLACE PROGRAMMES**

The response to increasing issues around drug and alcohol use within any industry workforce has often been to implement drug-free workplace (DFW) programmes. As Gerber and Yacoubian (2002:54) note with specific consideration of the construction industry, the ‘…high rates of alcohol and other drug use coupled with the high risk safety-sensitive nature of the industry have prompted the development of a variety of drug surveillance and prevention strategies’, and there has been an increase in policy development to improve safety through addressing problems of worker impairment (Biggs and Williamson 2012). DFW programmes can involve a variety of worker education and assistance elements, but most tend to include some form of drug and alcohol testing of the workforce. This can be introduced in a number of ways, either carried out pre-employment, post-accident, randomly, or because of reasonable suspicion, or some combination of all four (Schofield et al 2013), with the goal of deterring substance abuse amongst currently employed workers, and avoiding hiring drug-using applicants (Minchin et al 2006).

Although testing programmes have been associated with reductions in safety accidents, again causality has not been proved. For example, Schofield et al (2013:99) found that construction companies using drug testing programmes generally exhibited lower, although often non-significant, injury rates than companies not using drug testing programmes, with results varying by trade and injury types. Waehrer et al. (2016) established that drug testing was only effective to lower minor injury rates with no lost-work, but they could not establish any relationship with lost-work injuries.

The much-quoted work by Gerber and Yacoubian (2002) found that construction companies with drug testing programmes experienced a 51% reduction in incident rates within 2 years of implementation, although this did not continue to improve beyond the first few years of implementation, and the authors were careful to present this statistic as an association with no claim to causality, despite its misuse since.

Indeed, Gerber and Yacoubian (2002:67) twice reiterate in the conclusions to their work that ‘drug testing does not, in and of itself, constitute a drug-abuse prevention programme…only one component.’ Indeed, it is highly probably that the introduction of a new safety-related programme, be it educational or simply involving drug and alcohol testing, reorients the workplace to safety, which then in turn sees improvements in practice. This cyclical relationship in safety management has been
established by Lingard et al (2017), where intervention and consequential improvement can readily be seen on sites, followed by an increase in safety failures as the worksite reverts to 'normal' practice. Indeed, ancillary benefits to safety have been found with many different types of intervention, as Goldenhar and Stafford (2015) found with 'stretch and flex' programmes for worker health, which saw unintended improvements in many other areas, including safety. This hypothesis of beneficial consequences around intervention is also acknowledged by Miller et al (2007:566), Schofield et al (2013) and Wickizer et al (2004:107) throughout their DFW research.

Marijuana has certain characteristics that do not facilitate a simple testing process. The 'active' ingredient in marijuana is tetrahydrocannabinol, known as THC, and this is what creates impairment. It has been argued that any presence of THC could be indicative of sufficient impairment, because although THC only lasts for a relatively short time in the body, consequential psychomotor effects can last for 8 or more (Caulkins et al 2015). However, testing methods (using urine, blood or hair) do not test for THC, instead they test for one of the cannabinoid metabolites. This chemical, called C-THC, is actually generated as the impairing effects of THC are wearing off, and has a much longer life in the body than THC itself. This time duration can vary from person to person, depending on the marijuana strength, frequency of use and the individual's physiology. C-THC can last in the body for over 30 days, and varies considerably between users, even in controlled studies, where the does and smoking pace is controlled. A standard positive test for marijuana (e.g. a urine test) therefore only indicates that drug exposure has historically occurred, it is not confirmation of current impairment (Huestis 2007). Despite scientific best efforts, there are not yet accepted quantitative metrics that correlate a level of THC or its metabolites to the more familiar measure of blood-alcohol, although in Washington State, a legal level of impairment has been set at 5nano-grams of THC per millimetre of blood, this has not been adopted countrywide.

LEGALISATION OF MARIJUANA IN THE USA

Although marijuana remains a Class 1 Drug under US Federal Law, some State Law has seen a shift towards decriminalisation and the legalisation of its use for medical and most recently recreational purposes. In 2012, Colorado and Washington both legalised recreational marijuana, and although the full impacts of this are unlikely to be established for some time due to their complex social consequences (both good and bad), initial benefits have been sufficient to encourage two other States to follow suit in 2014 and four more in 2016. The rather confusing situation is that marijuana is both technically legal and illegal, although the US Department of Justice has stated it will tolerate state-led legalisation as long as there are effective regulatory and enforcement systems to ensure public safety, health and other law enforcement interests are not compromised (Calukins et al 2015).

Yet, this adds a further level of complexity to that already established around marijuana use. First and foremost, legalisation can influence existing use patterns as well as potentially encouraging more users. Calukins et al. (2015) suggest that changes will also occur around frequency and intensity of use, modalities of use, as well as the potency and quality of the drug now available. Secondly, construction companies can no longer test workers and penalize them for positive marijuana test results simply due to its illegality. Now it is legal for recreational use in the state, and testing struggles to distinguish between current impairment and historical use, this situation becomes more problematic.
Indeed, there was a reported increase in positive drug test of 20% after the law change in 2012 (Assurex Global n.d.), and although supporters of drug testing admit that it is ‘conceivable that an employee could test positive for marijuana despite not showing any outward signs of impairment’ (Halverson 2013), they are reluctant to acknowledge that this is not just conceivable, but given the problems with testing, it is actually highly probable. Yet this possibility does not seem to have tempered practice, indeed Minchin et al (2006) report a case of an organisation that repeatedly fired employees for failed drug tests, rather than any problems with their work or safety performance, with no consideration that their failed test may have had no link to immediate impairment. Organisations and other worker associations have also fallen back on the fact that marijuana remains a Class 1 Drug under Federal Law, and therefore do not allow the use of marijuana either medically or recreationally within their workforce at all (Halverson 2013). The state legalisation laws generally do not prohibit drug testing of workers or organisational DFW policies, despite problems around what testing is actually indicating, or the lack of direct evidence of causality around workplace accidents.

As a consequence, for failing drug tests, workers can still be fired even in states where marijuana has been legalised for medicinal and recreational use (Bogot and Neville 2015). In different cases, unemployment benefit has been both awarded and withheld from workers fired due to a failed drug test from using marijuana outside of working hours although it was detected by testing during them. Indeed, the acknowledged problems of under-reporting of accidents on sites (Sherratt 2016b) are only likely to be exacerbated by such legal complexities. Similar inconsistencies exist with regards to worker compensation; in some cases, the award has been made and in others it has not, with further complexities added should the claim be made that intoxication was the cause of the accident. Case law is still developing precedent, and so it is perhaps unsurprising that the recommended industry response has been to follow Federal and not State law, to ensure their businesses do not ‘… go up in smoke’ (Halverson 2013).

CRITICAL REFLECTIONS

The above discussion has revealed some interesting considerations about the use of marijuana within the construction workforce, and the implications of its legalisation. Central to this is the continued reliance around testing, particularly pertinent when traditional method of testing is inherently flawed. Furthermore, any testing is arguably an intervention in a workers’ private life (Fardhosseini and Esmaeili 2016) and raises issues around employer violations of worker privacy, freedoms and autonomy, all the more prominent in a situation where the state has seen fit to specifically grant those freedoms to its residents. Yet, testing is likely to continue, not least because companies with an established testing programme are often able to receive discounts on their worker compensation insurances. Furthermore, the desires of the commercial drug-testing industry should also be acknowledged here, it is an industry worth millions and therefore keen to continue to convince organisations that drug testing does reduce accidents on sites (Wickizer et al. 2004).

More worrying is the potential for drug testing programmes to give employers a simple ‘get-out’ in the case of any on-site accident. Despite the fact that testing positive for marijuana does not necessarily equate to worker impairment, it creates a straightforward ‘cause’ for any site accident, enabling more systemic problems such as poor management to be ignored. That is, marijuana use can be blamed for accident causation when the actual impacts may be minimal or nil. Whilst worker impairment
must be recognised as a potential factor in site accidents, and should not be tolerated by managers or peers in practice, care must be taken to ensure that this new step in legalisation is not utilised as an excuse for poor safety management, or a way to simply 'blame the worker' (Frederick and Lessin 2000) for wider management failings. This also has the potential to lead to under-reporting and concealment of incidents for fear of the consequences (Miller et al 2007; Morantz 2008; Schofield et al 2013) should a test prove positive after an accident has occurred.

There is a fairly strong disconnect between company drug testing policies, the drug testing methods themselves, and legal drug use. Where tests for impairment due to alcohol directly measures the quantity in the system at the time of testing, marijuana testing can show positive results many days after legal use and impairment. This disconnect causes some employers to adopt blanket policies where no marijuana use is acceptable, citing Federal law. The risk is that workers will not report marijuana use and that employers will cite any positive marijuana tests as a cause of injury when management issues or other human factors are truly at play.

A RESEARCH PROPOSAL

It has been established that there are several interrelated factors at play within the scope of this phenomenon. The legalisation of marijuana has led to increased concerns around impairment and safety (and indeed productivity), yet 'science' is struggling to respond in terms of establishing causality, developing appropriate testing, and finding solutions to the ethical and moral questions that have now been raised. As Caulkins et al (2015:36) note, there is an 'inherent ambiguity that accompanies non-experimental findings on complex human phenomena involving many potential causal pathways', and whilst human experiments are possible, generalisability often remains questionable.

Indeed, many of these questions would struggle to be answered by research grounded in a positivistic paradigm, where validity and reliability would quickly become challenging. For example, issues around respondent self-implication and corporate protocol can quickly disrupt any quest for the 'truth' around drug use or safety, whilst the debate is still ongoing as to whether accident causality can ever be truly 'proved' (Hollnagel 2011). Given ongoing arguments around the effectiveness of drug testing as a preventative tool, and the fact that despite its use as a deterrent any post-incident testing actually comes too late for safety, as well as the inherent issues around marijuana longevity in the body, research focused on the science of testing is perhaps best left to the scientists. What should be explored, however, are the social consequences of such testing amongst the workers and management on sites. It could be suggested that this has already been carried out, and indeed 'attitudes' to the legalisation of marijuana have been explored from a positivistic foundation, yet as the caveats such researches note, whether such attitudes are themselves valid or even relevant in terms of future utility is certainly up for debate.

Therefore, an alternative is proposed. A social constructionist approach (Gergen 1999) grounds itself methodologically in the perspective that the world we experience is socially constructed by the people within it through interactions, systems and practices (Gergen and Gergen 2004). This results in shared versions of knowledge within particular communities (Gergen and Gergen, 2003; Filmer et al, 2004), and the ‘truth’ is simply as the current accepted way of understanding the world (Burr, 2003). Social construction is therefore able to accept shifting truths, it allows for conflict or inconsistency between and within individuals' understandings, something that could
predictably emerge given the complex nature of the phenomenon under examination here. Indeed, such an approach has been demonstrated to be useful in exploring sensitive issues such as construction site safety, whilst also allowing for inconsistency, complexity and change within individuals (Sherratt et al 2013; Sherratt 2016b).

Such an approach can ask deceptively simple questions, such as 'how is the legalisation of marijuana working on this site?', which will in turn reveal how people are now making sense of this legal change and creating new shared understandings around marijuana use both recreationally and in the workplace. Employing discourse analysis to explore conversations, focus groups, induction scripts or slides, site posters and other documentary data (Sherratt 2016b), marijuana, its legalisation, its role in impairment and its relationship to safety on the construction site can be illuminated and therefore better understood. It is perhaps important to note here that the sample for this study will focus on the workers and site-based management, those for whom safety actually matters, as the majority of previous work in this area has focused on the opinions of employers, human resource or safety managers and not those actually carrying out the work (e.g. Gerber and Yacoubian 2002; Fardhosseini and Esmaeili 2016). Focusing data collection on the site is essential to explore how marijuana legalisation has actually changed understandings and practice. As Miller et al. (2007:570) note, informal norms take precedence over formal policies, and are not readily revealed by a questionnaire completed by a senior manager.

Furthermore, a social constructionist approach, by exploring and highlighting the network of discourses that create our shared social understandings, is also able to better illuminate that highly sought after yet infuriatingly intangible asset - site safety culture. This very much reflects the goal of the approach, if not the methodology, of work currently being undertaken by Biggs and Williamson (2012) around drug and alcohol use on sites in Australia, itself grounded in a 'safety culture' approach seeking effective interventions, with the goal of such interventions 'to render it unacceptable to arrive at a construction workplace with impaired judgement' (ibid 2012:446). The project presented here seeks a similar goal: to explore how things are currently understood on sites, so as to better inform the development of programmes that seek to support a site safety culture where immediate impairment is not acceptable, yet is able to find fit with the wider societal change around legalisation.

SUMMARY

This paper presents a theoretical context and a research proposal. The legalisation of marijuana for recreational use in various States of the USA has led to the emergence of a complex and ethically influenced debate around construction site safety, with no clear way for industry to respond to ensure effective management of this change on their sites. This research proposal, grounded in a social constructionist approach to safety, seeks to explore this through the shared understandings of those who work on sites, and how they are now making sense of the legalisation of marijuana, their work, and their workplace.

The authors have presented this work for discussion, and welcome feedback, comment and critique from our W099 colleagues.

REFERENCES


TECHNICAL FACTORS AFFECTING SAFETY ON A SCAFFOLDING

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Ten building scaffoldings are presented in the paper. The research covered, among others, cataloguing and surveying of the scaffolding, measurements of forces in standards, measurement of forces needed to pull out an anchorage, measurements of accelerations during vibrations of a structure, and cataloguing of defects in scaffolding elements. The in-situ measurements were supplemented by static analysis, modal analysis, and buckling analysis. On this basis for each of scaffoldings, analysis of the technical condition of the structure has been estimated, as well as comfort of the users and the structure capacity. Only fulfilment of all three criteria guarantees the workers’ safety at the scaffolding. Unfortunately, it was found that only 2 out of the total number of 10 scaffoldings do actually meet expectations and assure work safety at the scaffolding.

Keywords: scaffoldings, in-situ measurements, numerical analysis, scaffolding defects, comfort, bearing capacity, safety

INTRODUCTION

The main task of scaffoldings is to ensure the safety of its users when working at height or in places with difficult access. The fulfillment of this requirement is only possible if the following technical factors take the correct values: load capacity of scaffolding structure, dynamic characteristics, decks’ load capacity, technical condition of handrails and toe boards. The first two factors are affected by shape of the scaffold, assembly accuracy, anchoring, foundation on the ground, technical condition of the structural elements.

The importance of design capacity for security is indisputable. However, apart from capacity design, an important element is stiffness of the scaffolding, which affects its dynamic characteristics. Low natural vibration frequencies around 1-2 Hz result with people moving on such structures getting tired. Structures with higher natural frequencies can transmit vibrations from the ground to the workers which can also expose them to discomfort.

Research on safety of work at scaffoldings is quite difficult, however there are some papers dedicated to this subject. Influence of each of scaffolding service life stages on the work safety was described by Błazik-Borowa and Szer 2015. Testing the technical condition of scaffoldings in the USA was described by Halperin and McCann 2004,

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and imperfections analysis and their influence on a scaffolding capacity in Australia was described by Chandrangsu and Rasmussen 2011.

There will be presented an analysis of technical factors on the basis of measurements of ten facade scaffolding in this paper. The research presented here covers much wider area than in the previously mentioned papers. Geometry of scaffolding is obtained on the basis of the inventory and geodetic measurements on scaffolding standards. All elements of the scaffold have been assessed for the amount of damage. The following characteristics have been measured at construction sites: forces in the standards, ground subsidence by using a dynamic probe, forces in anchors and accelerations at selected points of scaffold subjected to dynamic loads. The next step in the research is to make computer analyses, including static and dynamic ones.

**METHODOLOGY OF THE SCAFFOLDING RESEARCH AT THE CONSTRUCTION SITES**

The research on 10 façade scaffoldings conducted in Poland in the year 2016 is presented in the paper. The sizes of the scaffoldings with the symbols used in the paper are summarized in Table 1. On each of the construction sites the research team stayed for one week conducting the measurements. The following tests were performed and the following technical parameters were measured:

- Cataloguing of the scaffolding elements: foundations, frames, braces, decks, circulation paths, handrails, toe boards, anchorages, winches, etc.
- Geodetic measurements of the scaffolding.
- Measurements of axial forces in standards.
- Measurements of the forces needed to pull out an anchor.
- Measurements of the dynamic deflection modulus of the ground.
- Measurements of vibration accelerations.
- Cataloguing of defects in scaffolding elements.

**Table 1: Basic data for analyzed scaffoldings**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Number of modules</th>
<th>Number of decks</th>
<th>Length L [m]</th>
<th>Height [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>5</td>
<td>6</td>
<td>15.0</td>
<td>13.3</td>
</tr>
<tr>
<td>R02</td>
<td>16</td>
<td>7</td>
<td>43.9</td>
<td>15.2</td>
</tr>
<tr>
<td>R03</td>
<td>8</td>
<td>4</td>
<td>20.0</td>
<td>9.1</td>
</tr>
<tr>
<td>R04</td>
<td>4</td>
<td>7</td>
<td>10.5</td>
<td>15.2</td>
</tr>
<tr>
<td>R05</td>
<td>6</td>
<td>8</td>
<td>18.4</td>
<td>17.1</td>
</tr>
<tr>
<td>R06</td>
<td>14</td>
<td>5</td>
<td>41.9</td>
<td>12.3</td>
</tr>
<tr>
<td>R07</td>
<td>11</td>
<td>7</td>
<td>27.2</td>
<td>15.0</td>
</tr>
<tr>
<td>R08</td>
<td>10</td>
<td>7</td>
<td>18.1</td>
<td>15.4</td>
</tr>
<tr>
<td>R09</td>
<td>10</td>
<td>5</td>
<td>25.1</td>
<td>11.2</td>
</tr>
<tr>
<td>R10</td>
<td>7</td>
<td>11</td>
<td>20.5</td>
<td>23.5</td>
</tr>
</tbody>
</table>

Geodetic measurements of scaffoldings consisted in obtaining the location of points in the standards 30 cm below the frame connection. Additionally, for the lowest frames, there were determined locations of the points in standards above the connection of the frame and the base. Location of the points was determined by geodetic measurement of two points A and B at the standard cross-section circumference (Fig. 1). Then on the basis of two coordinates for these points, with use of the circle equation, there were calculated coordinates of the circle center, which is located at the standard’s axis.
System of equations used to calculate the coordinates of the center of a circle with the radius \( R \), representing the standard cross-section circumference:

\[
\begin{align*}
(x_A - x_i)^2 + (y_A - y_i)^2 &= R^2 \\
(x_B - x_i)^2 + (y_B - y_i)^2 &= R^2
\end{align*}
\]

Fig. 1. Scheme for location of the points at the standard

Measurements of axial forces in standards were made with the especially designed equipment. It consists of two parts, and each of these parts is a stiff frame with an attached force sensor. Before a measurement each of the parts is set below one of the standards. With use of bolts, the frame is set to make the sensor show zero force reading. Then the base of the scaffolding is loosened to make the scaffolding lean on force sensors. After this operation the reading is executed. Measurements at one frame was made in three cases: without loading (readings: \( P_{w0} \) – force in the internal standard, \( P_{z0} \) – force in the external standard), with the loading of the \( G \) value at the first level (readings: \( P_{w1} \) – force in the internal standard, \( P_{z1} \) – force in the external standard) and with the loading of the \( G \) value at the highest level (readings: \( P_{w2} \) – force in the internal standard, \( P_{z2} \) – force in the external standard). During the setting of sensors, the reading was not always zero. This error was marked as \( \delta \). Two parameters have been obtained from the measurements:

\[
\alpha = 100\% \frac{2(P_{z2} - P_{w1} - 2\delta)}{P_{z0} + P_{w0}},
\]

(1)

\[
\beta = 100\% \frac{G_2 - G_1}{G},
\]

(2)

where part of the loading transmitted with use of decks to the neighboring frames and anchors is described with the following formula:

\[
G_2 = G - (P_{z2} + P_{w2}) - (P_{z0} + P_{w0})
\]

(3)

and part of the loading from the first level transmitted with use of decks to the neighboring frames and anchors can be described with the formula:

\[
G_1 = G - (P_{z1} + P_{w1}) - (P_{z0} + P_{w0}).
\]

(4)

Both parameters \( \alpha \) and \( \beta \) show inaccuracy in the scaffolding assembly. The parameter \( \alpha \) describes the difference between forces in standards on the assumption that the difference in readings which is not bigger than 10\% and calculated with use of expression \( (P_{w0} + P_{z0}) \) is a measurement error. Whereas the parameter \( \beta \) describes the part of the vertical load is born by anchorages.

Measurements of forces in anchors were made with use of the dynamometer BUK-02p. Because of safety reasons, measurements were made for anchors which were not used to tie the scaffolding. The measurement results are presented in Table 5.
Measurements of the dynamic deflection modulus $E_d$ of the ground were made with use of the dynamic probe ZORN ZFG3000. Measurements were made at each frame, which gave the diagrams of the modulus $E_d$ variation along the scaffolding. The diagrams are shown in Fig. 2.

The next measurements made at the construction sites are measurements of vibration accelerations at the standards. Methodology and the analysis of the obtained signals were presented in the paper Jamińska-Gadomska et al. 2017.

Cataloguing of the defects for each of scaffolding consisted of finding the damaged elements and visual estimation of the damage. Cataloguing was made for all scaffolding elements. Examples of the scaffolding defects are shown in Fig. 3.
DESCRIPTION OF TECHNICAL PARAMETERS

Results of scaffolding tests at the construction sites

The results presented in the paper are obtained as a part of the project „Modelling of Risk Assessment of Construction Disasters, Accidents and Dangerous Incidents at Workplaces Using Scaffoldings” (ORKWIZ), financed by the National Centre for Research and Development within Applied Research Programme (agreement No. PBS3/A2/19/2015). The scope of the project and methodology were described, among others, in paper by Błazik-Borowa et al. 2016, Hoła et al 2016. In this paper there were presented results of measurements which can be used to evaluate the technical parameters and their influence on the work safety on the scaffolding.

Structure capacity and its functionality as assured safety of workers during the process of building construction is decided among others by the shape of scaffolding structure (layout of frames, braces, anchors, the way of support at foundations, ground compaction) and assembly accuracy. Distance between frames of the scaffolding should be accepted in such a way to bear all the loads. The higher scaffolding is, or more uneven loading is, the distance should be smaller. In practice at construction sites, due to economic reasons, it is usually attempted to apply the biggest possible distance of about 3 m. Assembly of braces is also connected with shaping of the scaffolding structures. The braces should always be applied in the outer scaffold working areas. The distances between braces should not exceed 10 m and there should be at least two braces at each level. Example of incorrect bracing is presented in Fig. 5 later in this paper.

Table 2: Quantitative and qualitative information on scaffolding shapes

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Bracing system accuracy</th>
<th>e [%]</th>
<th>d_{\text{avg}} [mm]</th>
<th>\sigma_{\text{imp}} [mm]</th>
<th>\alpha [%]</th>
<th>\beta [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>YES</td>
<td>0.45</td>
<td>33</td>
<td>15.7</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>R02</td>
<td>NO</td>
<td>0.14</td>
<td>103.5</td>
<td>40.2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>R03</td>
<td>YES</td>
<td>1.00</td>
<td>56.9</td>
<td>28.2</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>R04</td>
<td>NO</td>
<td>0.25</td>
<td>36</td>
<td>17.1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>R05</td>
<td>NO</td>
<td>0.30</td>
<td>77.7</td>
<td>47.3</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>R06</td>
<td>YES</td>
<td>1.00</td>
<td>57.3</td>
<td>33.4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>R07</td>
<td>NO</td>
<td>0.44</td>
<td>111.2</td>
<td>78.6</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>R08</td>
<td>NO</td>
<td>0.45</td>
<td>61.8</td>
<td>40.7</td>
<td>8</td>
<td>91</td>
</tr>
<tr>
<td>R09</td>
<td>YES</td>
<td>0.56</td>
<td>71.9</td>
<td>30.3</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
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<td>YES</td>
<td>0.38</td>
<td>31.3</td>
<td>14.6</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>

The system of anchorage depends on the height of the scaffolding. There are many points of elevation where the anchorage cannot be made. The forces needed to pull out anchorages should be checked, as well as the influence of the given anchoring system on the stiffness of the whole structure. The values of the forces needed to pull out an anchorage are given in Table 5 together with the values obtained by calculations.

Cataloguing also included checking of the scaffolding foundation accuracy. The correct foundation fulfills the following requirements: the ground is compacted; the deflection modulus \( E_d \) is in even values along the scaffolding; both supports are set at one foundation, the foundation is set in the perpendicular direction to the elevation. The results of the modulus \( E_d \) measurements are shown in Fig. 3 and in Fig. 4 there are shown inaccuracies in foundation settings. In Table 2 there is presented the \( e \)
coefficient describing steadiness of the ground subsidence calculated as the ratio of the minimum value of $E_d$ modulus to its maximum value, obtained at the same scaffolding. In Table 3 there is given $\kappa_{\text{foundation}}$ coefficient equal to the ratio of the number of incorrect frames settings on the foundations to the number of all frames.

![Fig.4. Examples of incorrect foundation settings](image)

The next important factor determining the scaffolding functionality is accuracy of assembly. This issue was checked with use of geodetic measurements. The results were imperfections, i.e. distances between the real locations of frames points and the locations in the ideal geometry. For each of the scaffoldings mean values of imperfections $d_{\text{avr}}$ and their standard deviations $\sigma_{\text{imp}}$ were calculated. Assembly accuracy was also checked by measurements of the forces in standards. Two parameters $\alpha$ and $\beta$, described in the previous paragraph, were calculated based on the results of measurements. These parameters for all 10 scaffoldings were presented in Table 2.

The result of the defects cataloguing are parameters of the defects calculated as the ratio of the number of the damaged elements without taking into account the wear degree to the total number of elements of this type. In Table 3 there is presented such data for decks ($\kappa_{\text{deck}}$), frames ($\kappa_{\text{frame}}$), guardrails ($\kappa_{\text{guardrail}}$) and bracings ($\kappa_{\text{bracing}}$). The deck defects diminish their load bearing capacity, but the cataloguing showed that they can be still used and there were no accidents at the analyzed scaffoldings. Defects in frames and bracings were treated in the same manner. However, the guardrails defects were treated in a special way. The most common cause of falling from scaffolding is a defective guardrail. Even small defect in these elements may result during a dangerous event sudden hit into the defective guardrail makes it faulty and the worker can fall from scaffolding.
Table 3. Unitless coefficients describing the defect of scaffolding elements

<table>
<thead>
<tr>
<th>Symbol</th>
<th>(\kappa_{\text{foundation}})</th>
<th>(\kappa_{\text{deck}})</th>
<th>(\kappa_{\text{frame}})</th>
<th>(\kappa_{\text{guardrail}})</th>
<th>(\kappa_{\text{bracing}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>0.17</td>
<td>0.20</td>
<td>0.00</td>
<td>0.23</td>
<td>0.00</td>
</tr>
<tr>
<td>R02</td>
<td>0.89</td>
<td>0.25</td>
<td>0.00</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>R03</td>
<td>0.11</td>
<td>0.00</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>R04</td>
<td>0.60</td>
<td>0.07</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>R05</td>
<td>0.00</td>
<td>0.21</td>
<td>0.02</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>R06</td>
<td>0.20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>R07</td>
<td>1.00</td>
<td>0.57</td>
<td>0.05</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>R08</td>
<td>1.00</td>
<td>0.05</td>
<td>0.02</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>R09</td>
<td>1.00</td>
<td>0.12</td>
<td>0.11</td>
<td>0.18</td>
<td>0.00</td>
</tr>
<tr>
<td>R10</td>
<td>0.14</td>
<td>0.29</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

The measurements of vibration accelerations were made to determine the natural vibration frequencies and to evaluate comfort of workers at the scaffolding. The comfort is assured if the natural frequencies are higher than 3 Hz. On the basis of time series of vibration accelerations there were calculated power spectral density functions and their diagrams. They show the power of the signal at the given frequency, which allows determination of natural frequencies. The results of these analyses were presented in Table 4.

Table 4. Natural frequencies obtained from measurements and calculations. Critical buckling load factor.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Natural frequency (measurements) [Hz]</th>
<th>Natural frequency (calculations) [Hz]</th>
<th>Critical buckling load factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First measured</td>
<td>First</td>
<td>Second</td>
</tr>
<tr>
<td>R01</td>
<td>3.00</td>
<td>2.92</td>
<td>5.80</td>
</tr>
<tr>
<td>R02</td>
<td>3.15</td>
<td>3.10</td>
<td>3.25</td>
</tr>
<tr>
<td>R03</td>
<td>3.55</td>
<td>3.31</td>
<td>4.09</td>
</tr>
<tr>
<td>R04</td>
<td>2.67</td>
<td>2.92</td>
<td>4.43</td>
</tr>
<tr>
<td>R05</td>
<td>3.11</td>
<td>1.99</td>
<td>3.13</td>
</tr>
<tr>
<td>R06</td>
<td>3.82</td>
<td>4.10</td>
<td>4.31</td>
</tr>
<tr>
<td>R07</td>
<td>2.58</td>
<td>2.63</td>
<td>3.08</td>
</tr>
<tr>
<td>R08</td>
<td>3.77</td>
<td>3.03</td>
<td>3.51</td>
</tr>
<tr>
<td>R09</td>
<td>4.11</td>
<td>4.19</td>
<td>4.64</td>
</tr>
<tr>
<td>R10</td>
<td>2.44</td>
<td>2.07</td>
<td>2.42</td>
</tr>
</tbody>
</table>

Results of static and dynamic calculations of scaffoldings

Computer models were made for all analyzed scaffoldings (Fig. 5). Scaffolding models were made regarding the catalogued shape of the scaffolding, imperfections and uneven subsidence of the ground. First natural frequencies were calculated (modal analysis). The results of these calculations were compared with the ones obtained from measurements and the models were verified in this way. The results are presented in Table 3. For 8 scaffoldings first natural frequencies were in accordance, while for 2 scaffoldings the second natural frequency from calculations was measured. The difference of the frequency values can be produced by the difference of the model and the reality: not all anchors are mounted correctly and the supports can be moved during the assembly process. The next steps of the numerical analysis were static linear analysis under the operating loads (class according to the standard EN 12811-1) and the critical buckling load analysis. The results of static calculations are displacements, internal forces and stresses.
Fig. 5. Scaffolding R04: a) view of the scaffolding, b) computer model.

Table 5. Selected results of static calculations.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Maximum displacement [mm]</th>
<th>Allowed displacement $L/250$</th>
<th>Minimum and maximum normal stress [MPa]</th>
<th>Allowed stress values [MPa]</th>
<th>Normal forces in anchorages [kN]</th>
<th>Anchorage capacity found at the construction site [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>1.9</td>
<td>60.0</td>
<td>-128.7 128.7</td>
<td>280.0</td>
<td>0.11</td>
<td>8.25</td>
</tr>
<tr>
<td>R02</td>
<td>5.4</td>
<td>175.6</td>
<td>-234.2 159.5</td>
<td>280.0</td>
<td>0.32</td>
<td>1.85</td>
</tr>
<tr>
<td>R03</td>
<td>1.0</td>
<td>80.0</td>
<td>-113.3 110.9</td>
<td>205.0</td>
<td>0.05</td>
<td>1.90</td>
</tr>
<tr>
<td>R04</td>
<td>5.4</td>
<td>42.0</td>
<td>-124.20 123.8</td>
<td>280.0</td>
<td>0.03</td>
<td>2.40</td>
</tr>
<tr>
<td>R05</td>
<td>14.4</td>
<td>73.6</td>
<td>-230.3 239.6</td>
<td>280.0</td>
<td>0.63</td>
<td>2.50</td>
</tr>
<tr>
<td>R06</td>
<td>0.8</td>
<td>167.6</td>
<td>-60.0 129.6</td>
<td>280.0</td>
<td>0.12</td>
<td>3.00</td>
</tr>
<tr>
<td>R07</td>
<td>1.5</td>
<td>108.8</td>
<td>-114.9 114.9</td>
<td>280.0</td>
<td>0.32</td>
<td>2.25</td>
</tr>
<tr>
<td>R08</td>
<td>1.4</td>
<td>72.4</td>
<td>-138.6 138.2</td>
<td>280.0</td>
<td>0.15</td>
<td>5.00</td>
</tr>
<tr>
<td>R09</td>
<td>9.3</td>
<td>100.4</td>
<td>-171.2 205.4</td>
<td>280.0</td>
<td>0.47</td>
<td>1.70</td>
</tr>
<tr>
<td>R10</td>
<td>17.2</td>
<td>82.0</td>
<td>-270.2 317.0</td>
<td>280.0</td>
<td>0.36</td>
<td>10.00</td>
</tr>
</tbody>
</table>
The selected most important results of calculations, i.e. maximum displacements, maximum and minimum normal stresses and axial forces in anchorages are presented in Table 5. The columns with the allowed values of these quantities are also put down in this table. Critical buckling load factor, giving the information how much the load can be magnified without generation of the loss of structure stability, is presented in Table 4. The value of this coefficient should be higher than 1, but the standard EN 12810-2 rather recommends values higher than 2. In all buckling analyses of scaffoldings there have been obtained values of the critical buckling load factor higher than 2.

**Estimation of the safety of the analyzed scaffoldings**

Table 6 presents the summary of the results of the research. This table also allows estimation of the safety of the analyzed scaffoldings. The first column, on the basis of Table 3, gives estimation if the defects are at the allowed levels. It was assumed that the scaffolding is fully functional if at least 95% of guardrails are in good technical condition, and in case of other element groups, if at least 75% of elements in the group are in good technical condition. The second column was elaborated on the basis of Table 4. Fulfillment of the comfort conditions means that the natural frequencies of vibrations are higher than 3 Hz. This parameter is very important, because the lack of comfort means that the workers are getting tired. This can result in dangerous behavior and lead to accidents at construction sites. The last column is based on data from Table 5. The structure capacity is validated if the calculated value is smaller than the allowed one. This estimation takes into account data from Table 2, as well, because such factors as bracing system, ground subsidence, imperfections are included in calculations.

The conclusion from Table 6 is that the first criterion is fully fulfilled by only three of the scaffoldings; the second criterion is fulfilled by 5 scaffoldings and the third one – by 9. However, the safety of workers is fully guaranteed only in case of scaffoldings R03 and R06.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Number of defects in elements</th>
<th>Comfort conditions while workers’ movement at the scaffolding</th>
<th>Load bearing capacity of the structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>out of limits</td>
<td>no comfort</td>
<td>validated</td>
</tr>
<tr>
<td>R02</td>
<td>out of limits</td>
<td>correct</td>
<td>validated</td>
</tr>
<tr>
<td>R03</td>
<td>in limits</td>
<td>correct</td>
<td>validated</td>
</tr>
<tr>
<td>R04</td>
<td>out of limits</td>
<td>no comfort</td>
<td>validated</td>
</tr>
<tr>
<td>R05</td>
<td>in limits</td>
<td>no comfort</td>
<td>validated</td>
</tr>
<tr>
<td>R06</td>
<td>in limits</td>
<td>correct</td>
<td>validated</td>
</tr>
<tr>
<td>R07</td>
<td>out of limits</td>
<td>no comfort</td>
<td>validated</td>
</tr>
<tr>
<td>R08</td>
<td>out of limits</td>
<td>correct</td>
<td>validated</td>
</tr>
<tr>
<td>R09</td>
<td>out of limits</td>
<td>correct</td>
<td>validated</td>
</tr>
<tr>
<td>R10</td>
<td>out of limits</td>
<td>no comfort</td>
<td>not validated</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

On the basis of the research it was stated that 8 out of total 10 analyzed scaffoldings were not providing full safety of the workers. The scaffolding did not fulfil the capacity or serviceability limiting states conditions, and on the other hand scaffolding
elements were in poor technical condition and did not provide enough protection against fall from the height.

In future there should be made a check of the dependence between individual technical factors, but such an analysis demands data from as many scaffolds as possible to treat them as a statistical research sample. The authors of the paper will have such data for over 100 scaffoldings after the project ORKWIZ is finalized in 2017.

ACKNOWLEDGMENTS

The paper is prepared as a part of the project „Modelling of Risk Assessment of Construction Disasters, Accidents and Dangerous Incidents at Workplaces Using Scaffoldings” (ORKWIZ), financed by the National Centre for Research and Development within Applied Research Programme (agreement No. PBS3/A2/19/2015).

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Due to the suboptimal performance levels that organisations attain when focussing on traditional methods, many organisations have started turning to behavioural management in order to improve their performance further. In high-risk industries where the occupational safety and health (OSH) of workers is a main focus, many organisations adopt approaches that are likely to reduce and, perhaps eliminate, behaviours that can lead to major and fatal accidents. As senior management influence the OSH culture and ambition of an organisation, it was prudent to gain a better understanding of the perceptions of the people that hold such positions. This paper therefore presents the findings of a survey of senior managers (n=80), in high-risk industries (including oil and gas and civil engineering) about the behaviours of frontline workers. Clients and contractors emerged as the stakeholders with the highest potential to enhance the overall performance of a project and increase the desired behaviours of frontline workers respectively. Further, among on-site team members, site managers and supervisors emerged as prime candidates to achieve this increase in desired behaviours. Finally, among ten personal qualities, the respondents indicated that the integrity/trust of a supervisor is the most important when trying to increase these desired behaviours. Although organisations typically use legislative standards as their benchmark for performance, the results of this study suggest that organisations ought to complement current efforts by paying more attention to personal aspects of workgroups, such as care and respect, to further improve OSH performance.

Keywords: Behaviour, Engineering Construction, Performance, Safety Management.

INTRODUCTION

Improving performance, whether in financial, sustainability or occupational safety and health (OSH) matters, is at the heart of most successful organisations. To achieve this, organisations invest heavily in training their workforce, increasing financial remunerations and acquiring technology. The dilemma, however, is that while optimal performances may be achieved today, it is likely to be suboptimal in the future as evolutions occur and competitors forge ahead. To this end, it is essential for organisations to continually strive to future-proof their investments. One of the means to achieve this is ensuring that workers are safe and healthy. A safe and healthy workforce is more sustainable than one that is not (ceteris paribus).

To this end, organisations have to ensure that the conditions in which people work are conducive and free from harm to one's OSH. This is particularly significant to organisations that operate in high-risk industries such as oil and gas, construction and civil engineering. For decades, many of such high-risk organisations have aspired to
completely protect the safety, health and wellbeing of their employees but this seemingly utopian feat has not yet been achieved. Even extremely successful developments like the London 2012 Olympic Park project had its OSH challenges (including near-misses) despite having no work-related fatality. In the United Kingdom’s construction industry for example, 43 people were fatally injured in 2015/16; there was also an estimated 66,000 self-reported workplace injuries (Health and Safety Executive (HSE), 2016). More globally, one merely needs to follow the news to grasp the extent of severity of the matter with multiple fatalities occurring in engineering construction (Offshore Energy Today, 2016).

It has been established that one of the main causes of accidents and unwanted incidents (AUI) is human behaviours (HSE, 2009). The Federal Aviation Administration suggests that behaviours can account for as much as 80 per cent of accidents (FAA, 2008) and can be influenced by internal and external factors such as beliefs and culture respectively (Talabi et al., 2015a). These external factors (including culture and climate) are typically influenced by the senior management of an organisation. Hence, this paper presents the findings of a study that aimed to gain better insights into the perspectives of the people who hold these senior positions within high-risk organisations. As frontline workers are usually the victims of accidents, this study focused on their safety behaviours.

MODIFYING THE SAFETY BEHAVIOURS OF FRONTLINE WORKERS

Sulzer-Azaroff and Austin (2000) showed that focusing on behaviours to improve performance yields dividends. The OSH behaviours of frontline workers can make or break a project. It is therefore essential that managers are equipped with the skills and knowledge required to shape their workers’ OSH behaviours in order to achieve the set goals. Various techniques exist to shape behaviours ranging from setting goals through providing feedback to enabling two-way communication. It is important to identify and prioritise the techniques to focus on, which will lead to the optimisation of OSH performance.

Crucially, organisations must understand when to focus on behaviour modification. Other phases of OSH development (including the legislative and technological phases) should have progressed sufficiently (Pybus, 1996) before focussing on the behavioural approach to managing OSH issues typically known as behaviour-based safety and health (BBSH). Further, in an attempt to be highly reliable, organisations ought to possess an ability to enable them to adapt to changing work circumstances (Dekker, 2001). The occurrence of AUIs should not automatically lead to the introduction of more rules, which is a typical response (Borys et al., 2009), but should instead be treated as an opportunity to learn in order to prevent a reoccurrence of the same or similar AUIs.

Talabi et al. (2015a) provide a synopsis or the techniques used to modify behaviours including classical and operant conditioning. Such techniques should be utilised with care and diligence. The limitations of each technique should also be thoroughly understood and considered before adoption. Misusing the techniques can prove more disastrous than not using them at all. It is also critical to appreciate how project groups or stakeholders influence the performance of projects. In addition, each on-site project team member is likely to affect the behaviours of frontline workers differently; hence, an appreciation for this is useful. This study focused on the influence of supervisors on the behaviours of frontline workers, as they are typically the direct line managers.
of these workers (Greasley et al., 2005). Specific personal qualities were investigated based on the findings of Bolt et al.’s (2012) and Talabi et al.’s (2015b) study.

**METHODOLOGY**

This paper presents and discusses the findings of a survey that was conducted at the European Construction Institute (ECI) conference in the Netherlands in 2015. The conference aimed to facilitate sharing of knowledge between stakeholders within the engineering construction sector. Senior management staff from clients, contractors and consultants were in attendance. The two sets of data presented were collected in two different sessions: ‘plenary’ and ‘breakout workshop’. The plenary session survey was paper-based and presented to all the attendees of this conference. The survey instrument was placed on the desks prior to the commencement of the session with attendees completing the survey at their convenience during the conference. Out of the 87 people who attended, 48 people responded to this plenary survey, resulting in a response rate of 55%, which is deemed to be good (The University of Texas at Austin, 2016). The survey in the breakout workshop session titled ‘Managing People: A Behavioural Perspective’ was conducted electronically via response-card clickers. 32 people attended and participated thereby achieving a 100% response rate. This exceptional response rate likely ensued because the session was more interactive and the attendees voluntarily opted to attend this session, which suggests that they were interested in this subject area. Further, the unusual and engaging nature of the response-card clickers may have played a part too, as the respondents received instant feedback of the results (projected onto the main conference screen).

The plenary session survey consisted of two sections, A and B. Section A collected demographic data about the participants, which has been used to contextualise the results and findings, while Section B collected their perspectives on the stakeholders with the most influence on performance and more specifically, behaviours. All the questions in this section were of the ‘rank’ order; for example, “Rank the following project groups according to their potential to enhance overall project performance (1st, 2nd, 3rd, 4th, 5th): client, contractor, subcontractor, consultant and government enforcing authority.”

The data was analysed using Microsoft Excel. Weights were assigned according to the potential that a particular group had to influence specific factors, as illustrated in Table 1.

<table>
<thead>
<tr>
<th>Potential</th>
<th>Most</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>Least</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

These weights were multiplied by the frequency of occurrence for each project group. The resultant was the weighted frequency, which was used as the basis for discussion. The formula used to calculate this weighted frequency was therefore:

\[ = \text{SUM (Weight of each potential } \times \text{ frequency of its respective rank)} \]

Similarly, the breakout session consisted of two sections. Section A collected demographic data, while section B collected data on the participants’ perspectives of certain personal qualities of a supervisor that influence the behaviours of frontline workers. The breakout workshop session survey relied on ‘rate’ questions: for example, please rate how important the openness/transparency of a supervisor is in
increasing the consistency of desired behaviours of frontline workers (CoDBoF). A Likert scale was used with options of ‘not important’, through ‘somewhat important’, ‘important’, ‘very important’ and ‘extremely important’. The clicker system collated and analysed the data and provided the results for this section, assigning a value for each ‘importance’ category, as illustrated in Table 2.

Table 2: Likert scale values assigned to ‘importance’ categories

<table>
<thead>
<tr>
<th>Importance</th>
<th>Not important</th>
<th>Somewhat important</th>
<th>Important</th>
<th>Very important</th>
<th>Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**CONTEXTUALISATION OF THE DATA**

Table 3 shows the industries that the participants of the plenary and breakout workshop study represented, demonstrating a good spread on the engineering construction sector but a dominance of the oil and gas industry. The following abbreviations apply: O&G – Oil and Gas, Pharm. – Pharmaceutical, HI – Heavy Industrial, C/I – Civils/Infrastructure.

Table 3: Participants per industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>O&amp;G</th>
<th>Power</th>
<th>Pharm.</th>
<th>HI</th>
<th>C/I</th>
<th>Building</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (%) (Plenary)</td>
<td>51</td>
<td>3</td>
<td>16</td>
<td>5</td>
<td>14</td>
<td>0</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>Participants (%) (Workshop)</td>
<td>47</td>
<td>0</td>
<td>17</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 1 shows the job roles of the participants of the plenary study. About half (48%) of the sample held directorial positions and majority of the remainder held other positions of management.

Figure 1: Job role of participants (plenary)

Figure 2 shows the job roles of the participants of the workshop study with 68% holding managerial positions and 31% at director level. The remaining 1% is due to approximations of the electronic response-card clicker system.
RESULTS

Results from the plenary session

Figure 3 shows that, among the project groups, clients are believed to have the highest potential to enhance the overall performance of a project.

However, Figure 4 shows that, among the project groups, contractors were believed to have the highest potential to increase the consistency of desired behaviours of frontline workers (CoDBoF), with clients and subcontractors slightly behind.

Figure 5 shows that, among the on-site project team members, Site Managers (SM) were considered to have the highest potential to enhance the overall performance of a
The following abbreviations apply: Project Manager (PM), Safety, Health and Environment Manager/Adviser (SHEM/A), Quantity Survey (QS), Design Manager (DM) and Frontline Worker (FW).

Figure 5: Potential of on-site project team members to enhance overall project performance

Figure 6 also shows that, of the on-site project team members, Site Managers emerged with the highest potential to increase the CoDBoF. The result delineates the supervisors employed by Tier 1 and Tier 2 contractors. For Tier 2-employed supervisors, a member of their senior management team is likely to visit the site (as opposed to being resident on the site, which is sometimes the case on large projects). This is denoted as SSM (Subcontractor Senior Management).

Figure 6: Potential of on-site project team members to increase the CoDBoF

Results from the workshop session

Figure 7 shows that senior management believe that ‘integrity/trust’ and ‘respect’ are the most important personal qualities of a supervisor that can increase the CoDBoF.
Figure 7: Influence that supervisors’ personal qualities have to increase the CoDBoF

Figure 8 shows that the attitudes and behaviours of supervisors are deemed to be more likely to increase the CoDBoF than that of senior management who typically dictate the culture of an organisation.

Figure 8: Influence of culture and climate on the CoDBoF

Interestingly, the respondents deemed personal aspects (for example care and respect) (61%) to be more important in increasing the CoDBoF than organisational aspects of a company (for example planning and monitoring) (39%).

As a result of the increasingly common use of behavioural management to solve OSH issues, the participants (of the workshop session) were asked if they were thinking about OSH while responding; 57% indicated that they were not and 43% indicated that they were.

Finally, 97% of the participants of this workshop agreed that an increase in general good behaviours by everyone would lead to an increase in safer and healthier behaviours. The remaining 3% were neutral.

DISCUSSION

Out of a maximum of 240 attainable points for the ‘potential for project groups to enhance the overall performance of a project’, clients were ranked first with 224 points, contractors, second with 192 points and subcontractors, third with 119 points. Therefore, clients are believed to be best suited to influence the overall performance.
of a project in the engineering construction sector. Kulatunga et al. (2011) suggest the same applies to the general construction industry. This is likely to be due to the position of the clients in a project delivery network; in that they are usually the developer who scope out what is to be delivered, with the project delivery team then working to bring the project to fruition.

In contrast, contractors emerged as the project group with the highest ability to increase the consistency of desired behaviours of frontline workers (CoDBoF), achieving 208 points from a maximum of 240. Clients were ranked second with 176 points and subcontractors a very close third with 173 points. It is logical that contractors are perceived to have the highest impact on the behaviours of frontline workers, as they tend to set the tone at the site (operational) level. Although they achieved almost equal points, subcontractors would then have emerged higher than the client in this category following the same logic because of their proximity to the frontline workers in the project delivery chain; they are closer and are more hands-on with the workers.

Nevertheless, the view that the client has as much or more of an influence on the behaviours of frontline workers than their employer (the subcontractor) is understandable as some clients in some industries are more involved than others (Hughes and Murdoch, 2001). It is likely that the engineering construction clients are typically more involved for reasons such as the effect that a cataclysmic event could have on their organisation, particularly their brand; the Deepwater Horizon disaster is a classic example (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). This can persuade the client to go above and beyond a minimalist ‘hands-off’ approach to prevent such occurrences.

The consultant and Government Enforcing Authority (GEA) (in the case of the UK, this would be the Health and Safety Executive) were fourth and fifth respectively in both scenarios. The consultants and GEA achieved 109 and 78 points respectively with regards to improving overall project performance and achieved 85 and 78 points respectively with regards to increasing the CoDBoF. Consultants and GEAs are not usually at the forefront of the operations and the frontline workers are less likely to have dealings with them, which may explain these positions. However, the OSH GEA is likely to be known to the frontline workers, as they are usually the prosecutors of perpetrating persons or organisations. It was therefore unexpected that consultants would be ranked above them, although it is possible that the participants were not specifically considering the OSH GEA. This result also suggests that while the GEA is likely to increase the overall project performance to the same degree, consultants are more like to improve the overall project performance more than the CoDBoF.

Achieving 291 out of a possible 336 points, the site manager emerged as the most influential on-site project team member in terms of enhancing overall project performance. The project manager ranked second with 275 points and the supervisors ranked third with 218 points. Interestingly, the frontline workers ranked higher than the safety, health and environment manager/adviser, the design manager and the quantity surveyor. While project managers are typically relied on to bring about the progress required, this study shows the importance of the site manager and supervisor of the workers. Further, it shows the importance of empowering frontline workers to increase their own performance.

With regards to increasing the CoDBoF, two scenarios were posed: one where a Tier 1 contractor employs the supervisor (of the Tier 2 employed frontline workers) and
another where a Tier 2 contractor employs the supervisor and the workers. In scenario one, the site manager again was ranked first (with 274 points out of an attainable 329 points) to realise this goal. The supervisor emerged second with 262 points and the project manager third with 218 points. In scenario two, the site manager was again first in line (with 297 points out of an attainable 360 points), the supervisor second with 267 points and the subcontractor senior management third with 252 points. The project manager and frontline workers tied at fourth with 228 points. The second scenario is particularly interesting and important because most large projects utilise subcontractors. Further, in terms of increasing the CoDBoF, there seems to be no difference whether the supervisor is employer by a Tier 1 or Tier 2 contractor.

Furthermore, the supervisor was ranked above the project manager in both scenarios, which indicates that supervisors have a crucial role to play as well. In many respects, this result is logical because supervisors are the closest to the frontline workers in the project delivery network. They engage with the frontline workers on a daily basis and have a feel for what is actually going on with their work, safety and health. It is therefore curious as to why they are not given more attention and resources to execute their duties effectively (Serpell and Ferrada, 2007).

It is understandable that the quantity surveyor and design manager scored lower than the others because, similar to the consultant, the frontline workers are unlikely to be aware of the role they play in improving performance.

The nature of behavioural matters is so wide-ranging that it applies to many facets of work. However, behavioural principles tend to be used to deal with OSH issues (Choudry, 2014). To this end, the participants were asked (towards the end of the survey) if they were thinking about OSH while answering the questions. 43% indicated that they were and 57% indicated that they were not. This is testament to the potential that behavioural management has, as it can be applied beyond OSH to improve performance of other aspects such as productivity.

The result of this section of the study reveals the need for supervisors to pay attention to the non-technical personal qualities (PQ) that are often lacking in industry. Trust for example is one key attribute that industries struggle with, yet emerged as one of the key tenets for increasing the desired behaviours of frontline workers. This result is in alignment with other studies on trust (Bolt et al., 2012, Chalker and Loosemore, 2016 and Smith and Rybkowski, 2012).

Respect ranked second (4.3 of 5) after integrity/trust (4.4 of 5) indicating that respect for the frontline worker is also key to increasing the consistency with which they choose desired behaviours. These two were the only qualities that achieved above four but below five, 4 < PQ ≤ 5. These qualities are therefore considered to be ‘extremely important’.

The following personal qualities were in the range of 3 < PQ ≤ 4 and ranked third to eighth in the following order: ‘consistent high personal standards’ (3.9), ‘openness/transparency’ (3.8), ‘accountability’ (3.8), ‘ability to empower’ (3.8), ‘fairness’ (3.7) and ‘genuine care’ (3.6). These qualities were therefore considered to be ‘very important’.

Finally, ‘never compromises’ (2.6) and ‘beliefs’ (2.5) ranged between 2 < PQ ≤ 3, and ranked ninth and tenth respectively. They were therefore considered to be ‘important’ in increasing the CoDBoF.
In terms of comparing the attitudes and behaviours of supervisors and senior management, the supervisors emerged slightly above the senior management in terms of increasing the CoDBoF. Although both were considered to be ‘extremely important’, ‘Supervisors’ attitudes and behaviours’ (with 4.3) ranked higher than organisational culture (with 4.2), which is largely influenced by senior management (Talabi et al., 2015a). The ‘workplace environment’ (3.6) and ‘workers own belief/religion’ (3.1) were considered to be ‘very important’, while the ‘workers’ own family background/situation’ (2.7) was considered to be ‘important’.

Again, similar to subcontractors and contractors, it is conceivable that the supervisors’ attitudes and behaviours would influence the CoDBoF more than that of the senior management, as they are usually closer to the workers. It was expected that the ‘workplace environment’ would have scored higher as this is where the frontline workers spend most of their time. This is also referred to as climate, which is known to have a directly proportional relationship with the behaviours of frontline workers. It is acknowledged that a survey of workers themselves may generate different results.

It is interesting that the workers’ beliefs/religion and family situation/background were deemed important. Going by the contents of their websites, many organisations appear to care about this issue, but they do not always take the complementary practical steps required to show the same commitment. Some organisations try to fulfill legal requirements by providing prayer rooms for example, however, more needs to be done to show that they actually care for workers and their beliefs. This study suggests that resolving such issues is likely to bring about an improvement in performance. Further, organisations ought to take active steps to ensure that workers are not distracted by their family situations, as this is likely to affect their OSH at work.

While industries tend to focus on the organisational aspects of work (for example, risk assessment and method statements), the result of this study indicates that the personal aspects of workgroups (for example care and trust) are more important and should therefore receive more attention. This does not suggest that the organisational aspects should be ignored; it merely indicates that the management process can be improved.

CONCLUSIONS

This study found that the members of senior management in the engineering construction industry believe that clients are best placed to improve the overall performance of a project. However, they believe that contractors are best suited to improve the CoDBoF. Further, site managers and supervisors are believed to be the on-site project team members with the highest potential to increase the overall performance of a project and the CoDBoF. To this end, clients and contractors should work even closer to bring about improvements to OSH performance.

Clients ought to set the OSH expectations and benchmarks at the beginning of the project that the project delivery team has to meet. Also, clients should be more involved in ensuring that contractors are achieving those OSH standards. Contractors in turn should ensure that OSH performance is not compromised down the supply chain. As a start, subcontractors should ensure that their frontline workers are being respected at all times and have site managers and supervisors who are trustworthy. Supervisors should foster two-way dialogue between themselves and frontline
workers to ensure that frontline workers are willing to discuss their issues, whether work-related or not.

This study also found that it is imperative to increase the general good behaviours of everyone when trying to increase the number of safer and healthier behaviours of frontline workers. 97% of the sample size agreed or strongly agreed that this is the case. No one disagreed or strongly disagreed with this position and the remaining 3% were neutral on the issue.

Despite the possibility of the respondents interpreting some terms differently, this study gives a sense of the areas that need more attention. The result of this study suggests that site managers and supervisors should be better empowered as they emerged as the most likely site-based project team members to bring about an increase in the overall performance of a project and CoDBoF. Additionally, to improve OSH performance further, the level of trust and respect between frontline workers and supervisors ought to increase.

These findings are particularly significant because the industry may be targeting areas for improvement that may not lead to the peak performance. Training efforts, for example, are likely to be directed towards ensuring that site managers and supervisors are able to write adequate risk assessments and method statements, however this study exposes the inadequacy of this approach. While such procedures are required and useful, their effectiveness is likely to reduce due to a lack of the highlighted personal values of site managers and supervisors of frontline workers.

It is essential that senior persons in the engineering construction industry revisit their approach to management in light of these findings to improve OSH performance further. This is likely to lead to a more transparent and proactive industry, which should in turn make frontline workers more responsible, and therefore more accountable for their OSH behaviours.

It should be noted that this paper presents the perspective of senior management. Future studies should aim to investigate the views of other stakeholders, especially the frontline workers, to see whether the findings are in alignment with those presented in this paper.

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Casualization in the construction industry is influenced by unemployment or lack of decent jobs. Casualization is described as the process of employing people either on a daily, weekly or monthly basis for an undefined task or specified job without issuing a permanent contract. The study explored the motives why unemployed people are choosing casualization and the challenges they face in the construction industry. The qualitative research approach was used in the study to answer: “What does it mean to be a casual construction worker in Bloemfontein?”. In-depth interviews were used to collect the data. The findings show that unemployed people are choosing to become casual workers because they are failing to get permanent jobs from the private and public sector due to lack of requisite education and training. The results further show that casual workers are victims of exploitation through payment problems. Also, clients are failing to provide Personal Protective Equipment (PPE) for casual workers. Therefore, the Department of Labour in South Africa must start to tackle casualisation and compel people who are using casual workers to pay them standard hourly rates (wages) and provide safety protections for them.

Keywords: Casual Worker, Construction, Decent Job, Unemployment, Well-being

INTRODUCTION

Most unemployed people are struggling to get decent job choose to fight poverty and inequality by becoming a casual construction worker. Amidala (2011) described casualization as a method of employing people without issuing a permanent contract public, private and shady informal sectors. Casualization in South African labour market dated from the period of apartheid where racial policies were designed to deliver secondary education and job market opportunity for non-white individuals in South Africa (Lilienstein, Woodard, Leibbrandt, 2016). Lack of decent job opportunities for uneducated and educated people in South Africa makes it one of the unequal societies producing high levels of poverty. Although there has been a slight change of the poverty headcount ratio between 1993 and 2010, falling from 56% to 54% over the period (Lilienstein et al., 2016), the rate of casualisation is still high because of the significant number of unemployed youths in South Africa.

Casualization is adopted in the industries where demands for employment is highly variable and where entrepreneurs are avoiding to employ people in a permanent position in construction work, port work, migratory farm labour and other jobs which require manual labour or unskilled workers (Amidala, 2011). Most contractors have adopted the method of employing general workers through casualization in South Africa with the aim of maximizing profit while keeping up with the competition through cheap labour (Okafor, 2007). People in developing countries are the victim of labour exploitation evident in a bad salary, wages and salary arrears system, poor

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motivation, and every other vice that negate the intentions of decent jobs (Amidala, 2011). This study is driven by the reason that casualization keeps on growing as the dilemma and little is done to eradicate it in the South African construction industry, despite the existence of institutions such as the Department of Labour in South Africa that governs the labour practice through constituted Employment Acts.

CASUALIZATION AND ITS ILLS

Casual workers can be defined as the procedure of employing people without a clear written contract, which is commonly designed for a short period or the contract duration is not issued by the employer at all (Fapohunda, 2012). Amidala (2011) stated that casualization is the process, which is adopted by most construction entrepreneurs to make work less secure by employing people as a freelance and on an occasional basis or short term contract instead of being offered either a fixed term contract or a permanent contract. However, Fapohunda (2012) cited Okafor (2007) that construction casual workers are often a victim of loss which include: absence of medical care allowance, no job security or promotion at work, no gratuity and other severance benefits, no leave or leave allowance, freedom of association which is often jeopardized, no death benefits or accident insurance at work, no negotiation or collective bargaining agreement.

Casualization, which should be a concern of the Labour Department in South Africa, may have been influenced by the outcomes of opening the economy to external forces on free market principles, which may have produced continuing influence on the nature of labour utilization (Anugwom, 2007). Most construction entrepreneurs have got into understanding that the construction industry is driven by unskilled labour under the supervision of either the foreman or site manager, and are manipulating the labour employment regulations by minimizing the labour cost through socialization (Anugwom, 2007). The construction industry has adopted strategies of socialization to align with economic restructuring that favours limited overhead cost by companies. Beside the designed strategies, policies and regulations to protect casual workers are either lacking or poorly implemented to the extent that casual workers are manipulated and cheated in the construction industry through reduced salary, wage and poor health and safety service provided to them (Okoye, Okolie, and Aderibigbe, 2014). Casualization in developing country such as South Africa is commonly practiced in cities because most people are migrating from rural areas to urban cities to seek decent jobs and fail to do so forces them to become casual workers (Yen, Platt, Yeoh, and Lam, 2015).

METHODOLOGY

The qualitative research approach was adopted for this study with the purpose of collecting the study data and developing the casual workers model for this exploratory study. The qualitative research approach was adopted as recommended by Tracy (2013), that it is useful for understanding a range of social issues such as the behaviour or the reason for being a casual worker in Bloemfontein. Yin (2011) described qualitative research as the process of collecting the research data while embracing a mixture of orientations as well as methodological consideration through the possible multiplicity of interpretations of human events; the inherent uniqueness of these events; and the methodological variations available.
The researchers used in-depth face-to-face interviews to interrogate the research question mentioned in the abstract. Semi-structured interviews thus facilitated the collection of data from respondents as termed by Ritchie, Lewis, Nicholls, and Ormston (2014). The interview protocol contains open-ended questions. The sampling technique was non-probability sample due to the reason that the study was not statistical. The researcher adopted purposive sample to appropriately select the interviewed participants as Ritchie et al., (2014) stated that the participants are chosen with a ‘purpose’ to signify a type in relation to the criteria. The sample size of this study was made up to 18 participants, and the majority of them were aged between 25 and 35 years old. This study was conducted between December 2016 and January 2017. The interviews were recorded using cell phones, and later the researcher transcribed the data in the field book. The data collected were analysed by focussing on the central research questions and eliminating responses, which did not answer the research questions. The selection of the participants was unstructured, and the participants were chosen from the side of the streets where they stay daily to market their availability for casual work. The study, therefore, interviewed only people that are involved in casual work in Bloemfontein, South Africa. All the interviewees are not educated, meaning they did not complete their basic education (Grade 12).

FININGS, ANALYSIS, AND DISCUSSION

The main research questions guided the researchers to interview the participants and to analyse the interviewed data. The demographic information obtained shows that 72% (13 out of 18) of the participants interviewed were the youth aged between 25 and 35 years old, while 28% (5 out of 18) of the participants were the older men, aged between 45 to 50 years old. The race of the participants was black, and there were no female participants, and it was discovered that black males are the one choosing to become casual workers in Bloemfontein. The research question was answered through the following subheadings, which lead to the development of the casual worker’s frame model.

Meaning of Being a Causal Worker in Bloemfontein

Definition of casual worker
Most participants described casualization as the procedures adopted by unemployed people, whereby they are standing by the side of the road close to the traffic robots in the town to seek employment in construction by renovating existing houses, building houses, and cleaning the yard, ‘hard manual labour jobs’ and are employed without a contract, they are accepting any amount offered to them by their employers.

Reason for becoming a casual worker
The majority of the participants explained that their reasons to become casual workers are influenced by the fact that they are struggling to get employment in the private and public sectors because of their educational background since they did not complete their primary education (high school). One of the participants explained that his parents passed away while he was still a teenager and he never had anyone to encourage him to go to school and he chooses to become casual worker rather than become a thief. Another participant explained that they grew up working in the manufacturing industries in the townships of Bloemfontein. However, when economic recession began and the firms embarked upon mass layoff, he was affected. In other
words, lay off influenced the decisions to become casual workers where manual physical work can be undertaken because of lack of education.

**Challenges experienced by casual workers**

Most participants clarified the problems they encounter as casual workers. The main problem is poor or late payments of wages since the majority of their employers fail to fulfill their promises relating to the agreed payments. For example, one of the participants explained that:

“One of their clients once took them to renovate his house, painting and to install new tiles, after they completed the work he paid them half of the agreed payment and promised to pay them the rest of the money in town and when they arrived in the town, he instructed them to wait for him as he was going to withdraw money from the ATM 'Automated Teller Machine' and that was the last time they saw him, as he drove away without saying any word.”

The participants explained that they experience oppressors (bullies) among their employers. They say some employers force them to work overtime by threatening not to pay them if they are not cooperating with their instruction and are also refusing to take them back to the town. Another challenge, which the participants highlighted relates to the lack of employment, and they explained that they often take a month without getting any work, especially during winter season.

**Getting employment**

All the participants explained that they walk to the town early in the morning and stand by the side of the road, close to the traffic robots (lights) where people who need assistance relating to construction works and garden works will stop their car, and they will run into them to discuss the job descriptions and their wage for the job. Other participants explained that they had placed the advertisement board around the street light pole in town relating to their skills and they often get calls from clients looking for their services (see Figure 1).

![Casual Workers Advertisement Board](image)

**Figure 1: Casual Workers Advertisement Board**

**Personal Protective Equipment (PPE) and site induction**

The majority of the participants explained that their employer does not provide personal protective equipment (PPE) for them. When an employer provides PPE for them, the employer will usually deduct the cost of their wages. Another participant
explained that employers do not care about their health. The notion that employers only care about the production was emphatic. The participant explained that they are exposed to diseases while they are doing paint work. For example:

‘When you paint a house without wearing a dusk mask, your breath the paint you're exposed to diseases relating to lung problems, you struggle to breathe, and you get a headache.’

The same interviewee reports that when they are installing tiles, they prefer to wear knee cap because they spend the whole day on their knees installing the tiles.

The issue of site induction, the participant’s response is as follows:

‘In 2016, I was taken to a construction site in Kimberly to work for three days, and I never heard of the word site induction, what is site induction and how does it help me.’

‘There is no site induction taking place because most of the time we carry out small jobs which are straightforward without complications.’

‘Medium contractors are the one stressing the subject of site induction, while small contractors don’t even talk about it.’

The textual data and the literature reviewed show that there are links between the factors that are pervasive regarding casualization in the construction industry. Figure 2 is an attempt to bring the identified factors together. The figure shows that casualization can be linked to severe economic challenges in the form of poor job opportunities, failure to have large scale permanent employment in the industry, inability to standardize and police earnings in the industry, and the collapse of production entities where mass employment can be found in manufacturing. There are also regulatory factors to be considered. Such factors are not unconnected to poor social protection for casual workers and poor enforcement of labour laws in the industry.
Figure 2: Casual Worker Frame Model

The social challenges to be overcome by people involved in casualization tend to worsen the situation. For instance, it’s hard for someone with a complete lack of education and training to exit the general labour levels in the construction industry. Such individuals without apprenticeship will be largish at the bottom of the food chain in the industry. Figure 2 shows more factors that the society should understand and address if casualization must be reduced in the sector.

DISCUSSIONS

Figure 2 shows the casual workers model, which highlights the factors influencing society, especially the youth in choosing to become a casual worker in the construction industry. These factors were identified and grouped based on highlighted characteristics as follows: social challenge factor, economic challenge factor, and regulatory factor. The social problem factors involve the social life style of the society, the social circumstance which influences the unemployed people in choosing to become a casual worker. The results show that unemployed people choosing to become casual workers are often a victim of family, educational and community calamities. The economic challenge factor is characterized by the state of a country concerning the production and consumption of goods and service. The economic
problem factors include poor job opportunity, failure to produce permanent jobs, inability to standardize and policy earnings (wages) in the industry, and the decline of manufacturing industries. The manufacturing sector in South Africa is declining as Mavuso (2014) outlined the statement. The Industrial Development Corporation (IDC) in 2013 reported that while the manufacturing industries accounted for 20.9% of the country’s Gross Domestic Product (GDP) of South Africa in 1994, its contribution has since declined to around 12% (Mavuso, 2014). The economic challenge factor is very critical as Fapohunda (2012) asserted that the methods of employing construction workers through casualization in developing countries are a threat to the desired level of economic growth and development of a country. The regulatory factors highlight the concept of the management of employment act. The regulatory factors relate to failure to protect casual workers, manipulation of local business, and non-compliance of firms to labour laws. The non-compliance is most worrying as in South Africa; casual employees' rights are like the rights of permanent employees if they work more than 24 hours in a month. Every employer must regulate the working time of each employee:

- "Following the provision of any Act governing occupational health and safety,
- with due regard to the health and safety of employees,
- About the code of good practice on the regulation of working time issued under section 87 (1) (a); and
- the code of good conduct issued by the Minister of Labour under section 87 (1) (a) will contain provisions concerning the arrangement of work and in particular, its impact on the health, safety, and welfare of employees" (Department of Labour, 2004).

CONCLUSIONS

An exploratory study on the behaviour and characteristics of the casual workers is the focus of this paper. As the number of casual workers increases and companies (private and public) fail to produce permanent roles for uneducated people in South Africa, the ills of casualization may never leave the society. The data collected in this study reinforce the perception that casualization is a negation of decent jobs. The construction industry in South Africa appear to have stagnated in recent years and growth is not predicted for the near future. This blink situation contributes to the increase in the population of the casual construction worker in South Africa. The motive why unemployed people are choosing to become casual workers is detailed in the casual worker’s frame model. The frame model discusses issues found in social, economic and regulatory problems. Social challenges highlight difficulties from family, educational, and community problems. Economic problems highlight casual worker’s difficulties due to poor job opportunities, lack of adequate permanent employment, failure to standardize and police earnings in the industry, and the collapse of manufacturing industry in Bloemfontein. The study presented here is not exhaustive. The subject of the casual worker must be investigated on a longer period to understand the motive why unemployed people are becoming casual workers while improving the casual worker's frame model.

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INVESTIGATING THE BARRIERS TO EQUAL REMUNERATION PACKAGES BETWEEN MALE AND FEMALE SOUTH AFRICAN BUILT ENVIRONMENT PROFESSIONALS

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The purpose of this paper is to establish the prevalence of unequal remuneration packages among female and male South African Built Environment Professionals. The study examines the causes of the wage disparity, such as direct discrimination, HR policies implemented in the workplace, traditions and stereotypes. The respondent (n=92) demographics reveal gender, ethnicity and career progression inequalities, commonly associated with the construction industry, namely that white men predominantly hold senior executive positions. The perceptions of South African Built Environment Professionals concerning the influence of certain causes of unequal remuneration practices showed a remarkable difference in opinion between men and women who undertook the survey. However, consensus was achieved to concede that ethnicity (race and colour) and gender play a significant role in the disproportionate remuneration packages offered between the sexes.

Keywords: remuneration packages, gender disparity, wage gap.

INTRODUCTION

Gender equality is Goal 3 in the Millennium Development Goals (MDG) of the United Nations (UN) (Facts, 2010). However, the construction industry is the most male dominated industry of all the major industrial groups (Fielden et al., 2000). South African females employed in the construction industry only constitute 2 percent compared to 12.6 percent of males (Statistics South Africa, 2013). A UK study (Fielden et al., 2001) showed that 15 years ago the majority of women in the construction industry were involved in administration duties and usually on a temporary basis. South Africa’s construction industry is still rampant with discriminatory practices, structural inequality, cultural factors, prejudices, patriarchy and sexism among a few negative characteristics, despite having a constitution and legislation that advocate for equal rights (Agherdien & Smallwood, 2012). At present, whether a woman is part of the professional team or a general site worker, they all face the same unfair treatment, discrimination and impertinence (Jahn, 2010).

One of the manifestations of unfair labour practices, concerns the wage disparity experienced between men and women working in the construction industry. In a study of job satisfaction of South African quantity surveyors, Bowen et al. (2008) found that over a third of female respondents claimed that they were discriminated against in terms of salary. Across various industries in different countries, women are subjected to a gender pay gap. According to the European Commission (2014), the average gender pay gap prevalent in the European Union (EU) is 16.3 percent. Organisation for Economic Corporation and Development (OECD) countries which span the globe experience higher median wages for men than those for women, with the average difference between medians exceeding 15 percent (OECD, 2013). In countries such as

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Korea, Japan, Germany, Switzerland, Canada and the United States, male median earnings to be more than 20 percent higher than those of women among people in full-time employment, while in countries such as New Zealand, Belgium, Poland, Greece and France, the wage gap is less than 12 percent (OECD, 2006). In majority of the OECD countries, the gender gap was larger for the high wage earners relative to low-income earners (ibid). According to Burmeister (2015), South African women earn in a full year what men earn in eight months. Legislation was brought to bear to reduce the 33 percent pay difference between men and women employed in South Africa for the same task (Harries, 2014; WEF, 2016).

In addition to the Employment Equity Amendment Act of 2013, the Constitution of South Africa, the Labour Relations Act, and the Construction Sector Code, all serve to promote equitable conditions of employment, which prohibit discrimination on the basis of race, gender, disability, etc. (Government of South Africa, 1996; Department of Labour, 1995; Department of Labour, 1998; Department of Labour; 2014).

This research sought to understand what determines how much people are paid and what the causes of wage disparity could be, tested within the context of the South African Built Environment Professions.

WHAT DETERMINES HOW MUCH PEOPLE GET PAID

Human Capital Accumulation

Human capital involves a person’s abilities and skills acquired for personal improvement to increase earning capacity (Ben-Porath, 1967). Every form of traditional human capital investment, including formal schooling, cognitive talents accumulated, current workplace experience, and earlier time spent on the job, contribute significantly to an individual’s wage rate (Goldsmith & Veum, 2002). Employers tend to base earnings and promotions based on skills, abilities, and experience (Thacker, 1995). Accumulation of human capital has positive effects on salary (Thacker, 1995; McGuinness & Bennett, 2007).

Better educated individuals earn higher salaries than those who are not (Dolton & Silles, 2008). Skills attained while on the job through on-the-job-training, add to an individual’s human capital investment (Medoff & Abraham, 1980; Thacker, 1995). Goldsmith & Veum (2002) found that experience is largely homogeneous and that the composition of an individual’s workplace experience does not necessarily influence their current wage. Work experience has a positive effect on wages only after a job change, different occupation and a different industry. Productivity is an elusive measure of compensation when output is difficult to measure (Konrad & Pfeffer, 1990). Other measures for productivity are based on experience and training, which are strongly correlated to perceived productivity, of which positively influences salary (Holzer, 1988). However, Medoff & Abraham (1980) had a different outcome with regards to productivity and earnings, finding that performance on the job was not a contributing factor to salary, amongst individuals with the same level of education and labour market experience.

One would expect that the existence of the above mentioned salary determinants, level of education, experience and skills, would ensure an equal basis of salary irrespective of gender (Takahashi & Takahashi, 2011).
Legislation

Legislation and labour laws govern the relationships between employers and employees in the workplace, ranging from conditions of contract to dispute resolution. These laws therefore impact on what determines how much people are paid.

The Employment Equity Act was enacted in 1998 by government to address disparities in employment, occupation and income in the South African labour market that were a result of apartheid legacy (Department of Labour, 1998). The Employment Equity Amendment Act of 2013 came into effect in August 2014 (Department of Labour, 2014) and was specifically introduced to address concerns around South Africa’s pay gap, with the legislation allowing female employees to demand the same pay as their male counterparts for work which is the same, similar or of equal value (Harries, 2014).

The South African Government saw the need for intervention in the housing and construction sectors as they are perceived as being key areas that could provide opportunities for transformation in terms of both race and gender (Property Wheel, 2016). In spite of having legislation such as the South African Constitution, the Labour Relations Act and the Employment Equity Act governing relations in the labour market, the government drafted the Construction Charter in a bid to address the issues faced in the construction industry, a sector which had been described as being the most untransformed in the country (Department of Trade and Industry, 2006; Sangweni, 2015). In June 2009, the Construction Sector Code was enacted in terms of Section 9(1) of the Broad-Based Black Economic Empowerment Act No. 53 of 2003 (Construction Sector Charter Council, 2009) in a bid to transform the industry and advocate for equality whilst fulfilling economic goals (Department of Trade and Industry, 2006).

CAUSES OF WAGE DISPARITY

Direct Discrimination

Direct discrimination of females is when females are treated less favourably than males simply for the reason that they are females (National Association of Citizens Advice Bureaux, 2016). Wage discrimination against females in the workplace is explained as the extent to which females and males with the same characteristics are treated differently and unequally i.e. males earn more than females (Oaxaca, 1973; Robinson & Wunnava, 1989).

Grün (2004) found that females in South Africa are subject to a high degree of discrimination especially during the hiring stage. Females are underrepresented in the South African labour market and there is a continued trend of inequality between the two genders (Shepherd, 2008). In the construction industry, females they are usually seen as appendages to males (Kakad, 2002).

Women seeking to grow their career in the construction industry (engineering to be precise) are expected to work harder than their equal male counterparts (Bennett et al., 1999). They are perceived as not having potential to take on managerial positions/professional roles (Littrell & Nkomo, 2005). de Graft-Johnson et al. (2003) established that women in the construction industry are prejudiced and discriminated against in terms of upward motion and remuneration.
Company Policy

All organisations have a common objective; that is operating effectively and efficiently (Moule & Giavara, 1995). In order to achieve this goal, they need to employ policies procedures (Moule & Giavara, 1995; Wolosz, 2007). Company policies are defined as general principles with regards to an organisation’s operations which are established and authorized by the leaders of the company (Baack, 2016).

It is of utmost importance that companies write and implement effective policies that are non-discriminative (Fahrenhorst & Kleiner, 2005). Companies mainly use Human Resource Policies to govern their operational functions and manage their employees and to eliminate discrimination (Ellerman & Kleiner, 2000; National Association of Citizens Advice Bureaux, 2016). Due to the fact that females and their femininity are less valued than males and their masculinity in the workplace, it is usual practice for Human Resource Policies to be more favourable to males (Lee & Pow, 1999; Mennino et al., 2005).

Females are usually recruited for operational level positions and their male counterparts are usually recruited for managerial level positions (Lee & Pow 1999). Holding a managerial level position has remuneration implications; the higher the position, the higher the remuneration (Tesluk 1998). Males are therefore usually compensated more than females (Kara, 2006). Lack of knowledge about remuneration rights and salaries of other professionals and colleagues, seems as the heart of why women do not demand fair and consistent treatment in terms of salary and other rewards (de-Graft et al. 2003).

Traditions and Stereotypes

Tradition refers to the process of handing down items, customs, processes and practices or thought processes from generation to generation or over time (Horner, 1990). A stereotype is a preconceived perception about a group of people, based on what is believed to be generally true of them (Odekerken-Schröder et al., 2002). What is believed of these individuals is founded on a set of exaggerated, usually negative, character traits (Barker, 1999).

Traditionally, men are associated with strength, aggression, and dominance, whilst women are characterized as being passive, nurturing, and subordinates (Boundless, 2016). In the context of the construction industry, up to two thirds of women are employed as support staff providing administrative, secretarial and other services, rather than the higher paying technical, professional or managerial roles (Fielden et al., 2000). This is due to women being perceived as less objective, less aggressive, less capable of contributing toward organisational goals, less ambitious, less self-confident, and less capable of learning mathematical and mechanical skills than their male counterparts (Mathur-Helm, 2005).

The conflict between work and family obligations is more severe for women than for men (Amaratunga et al., 2006), as the responsibility for domestic duties in most households is borne primarily by women (Higgins et al., 2000). Dainty & Lingard (2006) argue that women’s achievements within the construction industry are impeded by the interplay of organisational policies and male-dominated culture of the construction industry on women’s career decisions, which influence the stage at which the decisions are made and family expectations. Women are therefore more likely to take time out of the workforce due to family responsibilities and to return in a part-time capacity or at a lower work level (Mathur-Helm, 2005). In the engineering and
construction industry, working part-time has an impact on career progression as firms often structure career progression around hours worked (Ministry of Women’s Affairs & Institution of Professional Engineers New Zealand, 2012).

Overall, the under-representation of women in positions of responsibility or management in the construction industry has been established with “glass walls” and “glass ceilings” driven by traditions and stereotypes. Glass walls deny individuals access to certain positions. Glass ceilings inhibit the progression of qualified individuals within their occupations. Career sexism and occupational segregation contributes to the gender pay gap (Gurjao, 2006). The ‘gender pay gap’ starts off small but widens as careers of men and women progress (Belgorodskiy et al., 2012).

This fact was corroborated by the RICS’ Raising the Ratio survey, which recorded the differences in pay between men and women across age ranges, with men out performing women consistently, except in the 36-40 age range when women briefly caught up for a while. The most remarked difference occurred in the 41-45 range where men are revealed to earn nearly 100% more than women in the same age range. (Ellison, 2003).

Equal opportunities mean equal pay and suggestions for closing the gender pay gap include greater transparency concerning pay structures as well as submitting to legislated ‘equal pay audits’ to ensure fair remuneration (Belgorodskiy et al., 2012).

METHODOLOGY
A desired independence by the researchers (observers) from the measurable facts (Fellows & Liu, 2003:18) allowed for a positivistic methodology to be employed to support a traditional quantitative approach to collecting the data through a survey. The sample was composed of members of organisations representing the interests of Built Environment Professionals (BEPs), namely Association of South African Quantity Surveyors (ASAQS), Consulting Engineers of South Africa (CESA) and South African Institute of Architects (SAIA). The online survey consisted of a combination of closed, semi-closed multiple-choice as well as open ended questions. The data comprised two sections, one which collected demographical information relevant to the study (such as gender, age, race, profession, highest level of education and professional status, duration of working in the industry, current job title, remuneration range) and the other perceptions concerning causes of wage disparity, employment equity barriers and legislative compliance.

The survey link was mailed to the BEP organisations for distribution to their members. The response rate (n = 92) was dependent on the willingness of respondents to earn Continuing Professional Development (CPD) hours or points for participating in the survey. No feedback was received from the architectural professions.

The data was analysed using SPSS to provide descriptive statistics. The findings are discussed against the framework established in the literature review.

FINDINGS, ANALYSIS AND DISCUSSION: EVALUATING INDUSTRY RESPONSE
The demographical data revealed the continued trend of a male-dominated construction industry (Littrell & Nkomo, 2005), and specifically within the South African context, a white male domination. The majority of respondents were male (n = 66) and classified themselves as white (n = 61). Among the female respondents (n = 25) there were 6 black women. The median age of the respondents was 44 years,
ranging between 21 and 57 years old. The dominant age group represented was the 31-40 years. The respondents (n = 92) representing the BEPs were biased in favour of engineers (n = 49) and quantity surveyors (n = 34). Out of interest, the majority of respondents were from Gauteng (n = 40) and the Western Cape (n = 23) with minimal representation from the other provinces (1.1% - 12.5%). How this relates back to the population of ASAQS and CESA members could not be established.

The Human Capital Accumulation among the respondents was evident through the level of education and professional status of the respondents, as well as their years of work experience and current job titles. As would be expected among BEPs, the majority of male and female respondents had a university education (n = 81) with more males than females (male n = 16, female n = 4) having a master’s degree or PhD (male n=2). Only three respondents indicated they were not registered with the appropriate government councils, the remaining respondents were either in-training (n = 10) or professionally registered BEPs (n = 78). The distribution of work experience versus job title is graphically illustrated in Figure 1 below.

**Figure 1: Distribution of years in the construction industry by job title and gender**

Most of the male respondents (n= 34) have been in the industry for over 21 years and 65% (n=22) of them are directors. Majority of the female respondents (n=14) have been in the industry for not more than 10 years. The trend illustrated by the respondents’ data corroborates the sentiment of Dainty et al. (2000) who blames the top-heavy management structures and the congested hierarchies within middle management for the lack of promotional opportunities within organisations, compounded by the cyclical economic nature of the construction industry which impacts on workloads.

Given the relative equal educational background of the male and female respondents, it is clear that the Remuneration Range distribution mimics the work experience distribution in Figure 1 as suggested by Thacker (1995) and Farber & Gibbons (1995). As illustrated in Figure 2 below, female respondents dominate the gross monthly salary of less than R45,000 per month and earnings are “capped” at R95,000 per month compared to the majority of male respondents (n = 14) who earn more than R105,000 per month.
When asked to compare remuneration packages between colleagues of similar experience of the same and opposite gender, it was striking that 76% of male respondents believe that male and female colleagues with similar experience are being paid the same as them, compared to the 56% of female respondents who believe they are being paid less than male colleagues, but the same as other female colleagues with the same experience (68%). de Graft-Johnson et al. (2005:1037) report that a “lack of transparency and perceived or real inequities” in remuneration structures in architectural and engineering offices (for example) often lead to discontent among the professional female employees, who feel undervalued or ignored.

When asked whether the respondents’ companies complied with South African legislative requirements which impact fair and equitable remuneration, approximately half of the respondents replied in the affirmative (n = 43), and the other half fluctuated between “no” (n = 8), “I don’t know” (n = 19) and “I hope/think so” (n = 18). There was a distinct difference in opinion between the female (56%) and male respondents (23%) over whether wage disparity is entrenched in company policy. Saadi (2016) suggested that although not explicitly designed to discriminate, company policies or practices are a cause of unequal remuneration between men and women within firms and companies, especially if human resource policies are non-compliant with legislation. Equal opportunities mean equal pay and suggestions for closing the gender pay gap include greater transparency concerning pay structures as well as submitting to legislated ‘equal pay audits’ to ensure fair remuneration (Belgorodskiy et al., 2012).
The Employment Equity Act of 1998 insists that no person may be discriminated again in terms of their race, gender, sex, pregnancy, marital status, family responsibility, ethnic or social origin, colour, sexual orientation, age, disability, religion, HIV status, conscience, belief, political opinion, culture, language and/or birth (Department of Labour, 1998). Respondents were asked to indicate their perception of the frequency of unfair discrimination being used against employees or job applicants in the construction industry. The most common causes of discrimination were identified as being (in order of most regular or isolated incidents practiced some of the time) race, colour, gender, sex, age, pregnancy, language, disability, ethnicity, orientation and family are illustrated in Figure 3.

The data reveals that the construction industry is maintaining its reputation as the most untransformed sector in the country (Department of Trade and Industry, 2006; Sangweni, 2015), however, disturbingly only 20% of male respondents (n =13) compared to 60% (n = 15) of female respondents acknowledge that women are being discriminated against in terms of remuneration simply because they are women (direct discrimination).

The female respondents also indicate a greater belief (68%; n = 17) than the male respondents (35%; n = 23) in the impact of traditions and stereotypes on the cause of wage disparity between the sexes, but the majority concur it the dominant cause of the gender pay gap (n = 40). Men who feel threatened by the employment of women
in the construction industry, are quick to reinforce gender stereotypes (Fielden et al. 2000). As more women enter the construction industry professions, the cultural values and patriarchal traditions are being challenged (Gurjao, 2006).

CONCLUSIONS

Despite progressive legislation being in place to enforce employment equity, the data revealed a distinct differential between the perceptions of male and female BEPs concerning remuneration packages, and the causes of the gender pay gap. The traditional views and stereotypical behaviour of the dominate (aging) white male BEP respondents ensures that inequality in employment conditions continue to prejudice female BEPs. These deplorable traits, however, are only acknowledged by the female respondents and largely denied by the male respondents. As suggested by Dainty et al. (2004) and Caplan (2007), a fundamental change to the construction industry needs to happen from within, through the support and commitment of senior industry figures to provide strong leadership from the top (“champions of change”), and that a well-developed business case for diversity may be the only persuading factor, as opposed to externally imposed legislation.

Further research is required to determine the view of young male BEPs, who Dainty et al. (2000) considers as a largely unrecognised source of change in the industry. Research also needs to highlight any discriminatory practices occurring in the construction industry such as remuneration discrepancies at all levels of employment, i.e. student and professional.

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SAFETY MAINTENANCE REVIEW FROM FACILITY MANAGEMENT TECHNICIAN PERSPECTIVE

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Facility managers are responsible for the maintenance and operation of constructed facilities. In most cases, they are rarely consulted during the design process for input about safety concerns. It is expected that once a facility is delivered, all safety measures are in place for daily maintenance operations. Facility managers may disagree, and point to situations where maintenance tasks were difficult or situations where they were required to eventually make upgrades to buildings in order to accommodate the safety of their employees. Research was initiated to assess the needs facility management technicians and their concerns for daily operations regarding safety. The research team utilized a case study with two North Carolina facility management organizations. The effort included interviews with technicians to identify the possible categorical types of safety concerns to eventually be used to develop a framework for safety planning before the purchase of leased property or during the design phase for new construction.

Keywords: facility management, safety, PtD

INTRODUCTION

The purpose of the research presented in this paper was to explore a specific topic of the overall Prevention through Design (PtD) concept, that of facilities maintenance safety. To date, most of the PtD research is geared toward safety during construction and is not specific to the daily tasks of facilities maintenance personnel over the life cycle of the building. The service life prediction generally assumes a “typical building” life of 30-50 years. When considering personnel safety, this timeframe may provide a much larger probability of a safety risk over the life cycle of a building compared to its construction phase (Gallaher et al. 2004). Additionally, there are generally fewer funds for safety upgrades throughout the lifecycle to correct issues which could have been implemented during construction or design. The results of the initial investigation provided a list of probable categories for a design review for Facility Management (FM) safety. The investigation collected input from FM field personnel to establish a foundational summary of some of the typical safety concerns for both the facility owners purchasing a facility, and also for those inheriting a newly constructed building. Lastly, an investigation of some of the common barriers to the inclusion of FM personnel in design reviews is summarized.

BACKGROUND

Facilities management is viewed as a “cost center” because unlike most departmental entities which exist to make money for a company, facilities management’s primary concern is to work to save money. Therefore facilities departments are often scrutinized for their levels of maintenance spending (Cotts et al. 2010). Facilities management is generally only rewarded or recognized when there are cost savings, and for this reason spending in areas such as safety may conflict with strategies to

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showcase these savings. Research pertaining to safety in the facilities management arena has been almost non-existent and there is a lack of quantifiable evidence that there may be safety concerns resulting from insufficient design. For many maintenance professionals, it is understood that once the construction phase ends and the project has reached the handover and facilities management (FM) phase, the technicians often must live with any difficulties in maintaining the structure. The concern with this scenario is that the operation and maintenance phase is a 30-50 year commitment as opposed to the 1-3 year design and construction phase (Gallaher et al. 2004). Although this is a significant difference in time frame, project teams rarely focus on the long-term needs. Due to the lack of industry documentation regarding the Operations and Maintenance (O&M) stage of a facility and the safety in the FM arena, further research is needed to establish the initial planning for the facilities manager as a checklist for FM safety.

**Literature Review**

PtD is an initiative with “a collective focus on eliminating hazards and minimizing risks to workers and the work environment” (NIOSH 2010). Parikh et al. (1995) used a more specific term, Life Cycle Safety (LCS), when considering electrical reviews for the facility professional and defined it as, “factors that must be considered for the life of a piece of equipment or system.”

The importance of facilities management has recently gained research interest due to the owner’s need to “do more for less.” Most of the focus for facility managers is centered on the design for easier maintenance but not necessarily safety of the maintenance tasks. Since improved safety and cutting costs often conflict, there is a lack of focus on safety for facilities personnel. Overall, the concern is that to date, there is very little awareness in the facility management industry regarding PtD.

The link between an owner’s positive impact to construction safety has been established (Gambatese 2000; Huang et al. 2006), but knowledge of the PtD concept in the owner community is not widespread. Previous studies have been conducted to identify the extent of that knowledge, and results showed that the construction industry is mostly unaware of the concept. Specifically, Toole et al. (2016) conducted a survey which asked the question, “Had you heard of Design for Construction Safety (PtD) before this survey?” The results indicated that 83% of the respondents (n=103) had never heard of PtD. A similar study, Tymvios et al. (2016) investigated the knowledge of the concept in the US construction industry, and results showed that 20.5% of engineers (n=224), 5.4% of Architects (n=221) and 21.5% of Owners (n=121) were aware of the concept. More importantly, the owners in the survey were representative employees from US University departments concerned with capital planning and facilities management. Even though these two studies pertained to construction safety (not safety for facility personnel), Arditi et al. (1999) also conducted a survey of property managers which indicated that overall, functionality is the main concern during design. Their findings conclude that the top 11 factors to be considered by property managers in managing buildings included items like functional layout and lighting; and, none of the top ranked factors were related to maintenance (Arditi et al. 1999), or maintenance safety.
Hinze (2000) stated that one reason for the lack of awareness is the possibility that maintenance workers do not have the same leverage through a lobby group that the general contracting industry provides. He synthesized that if designing for life cycle decisions can be incorporated into design, the same considerations for life cycle safety should be disseminated in the design community and implemented.

There are multiple reasons to engage the design industry in PtD. In terms of FM costs, non-maintenance-friendly installations result in 2 to 3 times more time to perform weekly or monthly routine maintenance tasks, accounting for waste applied over a piece of equipment’s 20-year expected service life (Foster 2011). Hinze (2000) raised awareness to the fact that safety should be considered, especially in light that the owner is ultimately to pay for any injuries through insurance costs and/or lawsuits. And the most pertinent reason was provided by Wetzel et al. (2016) who cited that between 2008 and 2012 the FM industry had 1.3% of all work related fatalities (293 deaths), which was a 64% increase over that time period.

Incorporating FM input during design is possible, and that is showcased in a case study by Hecker et al. (2004) which investigated how PtD can be incorporated with input from designers, contractors, owners and FM. The purpose of the study documented the efforts of a focus group in the development of a process they termed Life Cycle Safety (LCS) and concluded that a similar process is feasible for the design-for-safety goals for capital projects. Since the study focused on the process, the publication did not provide a list of safety concerns in the results.

Safety Categories in Literature

Previous literature has tried to categorize the hazards associated with safety and facilities. Parikh et al. (1995) listed design considerations for methods to service equipment which included: equipment lockout means, adequate working space and illumination, and arrangement. Additionally, he added terms related to safe operator interface, which included accessibility, component selection (ergonomics), confirmation (audible alerts) and identification of components and warnings. Wetzel et al. (2016) analysed fatality reports which resulted in a focus for falls, exposure to harmful substances and environments, and contact or struck by objects accounted for 64.5% of all FM fatalities and 59.1% of all non-fatal accidents. Cooke et al. (2008) focused on fall safety and roofs and included not only sub-categories (parent/child categories) but also assessed the level of risk as well. For example, as opposed to reviewing roof falls as a category, the level of risk associated with the age and slope of roof.

Standards, Guides and Building Code Requirements

The Occupational Safety and Health Administration’s 29 CFR Part 1910 Code of Federal Regulations for the General Industry, and the 29 CFR Part 1926 Code of Federal Regulations for the Construction Industry pertain to safety in the post-occupancy phase (OSHA n.d.), but there may be knowledge gab between the needs facility managers have and what the design engineers use from the Code to provide with their designs. This gap leads to maintenance operations needs not being conveyed to the designers. Parikh et al. (1995) recognized that code may assist to create some of the built-in needed safety requirements for maintenance. With regards to Guides available, a UK publication, CSM2007 – Workplace “in-use” guidance for designers (Gilbertson 2007) was published specifically for designers to reference for workplace hazards to be considered. A checklist of categories from each of the publications is shown in Table 3.
Table 3. Summary of Risk Categories

<table>
<thead>
<tr>
<th>Physical Environment</th>
<th>Chemical/Biological Environment</th>
<th>Hazardous Systems</th>
<th>Normal Activities (ergonomics)</th>
<th>Slips and Trips</th>
<th>Working at height</th>
<th>Abnormal Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockout</td>
<td>Working Space</td>
<td>Illumination</td>
<td>Arrangement</td>
<td>Identification</td>
<td>Confirmation (audible alerts)</td>
<td></td>
</tr>
<tr>
<td>Falls</td>
<td>Environment</td>
<td>Contact (struck by)</td>
<td></td>
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</table>

**Barriers to Implementation**

The barriers to implementation of safe designs appear to fall into four areas. First, the internal ideals which conflict. For example, Parikh et al. (1995) stated that “one of the biggest challenges to life cycle safety is cost” because all projects have limited funding and the project manager must balance prudent risk and safety.

The second category is awareness. Toole et al. (2016) summarized that the owner must become the driving force to push PtD, for several reasons. First, most A/E teams will not design for safety unless directed by the owner. The AIA boilerplate contract states that the design professional has no responsibility for worker safety. These authors also add that many teams are not knowledgeable in PtD. Although the survey by (Toole et al. 2016) was focused on project related safety, their findings indicate that the industry simply is still unaware of the concept of PtD.

An extension of the awareness category includes the third area of concern - the inclusion of facilities personnel in design decisions. Hecker et al. (2004) stated that the A/E’s reaction to early input from the owner was mixed. Although many design professionals recognize the lack of FM contributions, often it is a concern when strict schedules are applied. A more recent publication by Rui et al. (2016) provided results from a survey about general maintenance requirements, but shows more involvement by FM personnel. The responses (34 respondents) indicated owner involvement in the design phase was 73.5%. It is evident that more owners are contributing to early input into the design but similar to the design professionals, they may not have the background (or awareness) to contribute to designing for safety.

Lastly, communication during the design phase is a barrier to implementing the owner’s safety and general maintenance needs (Rui et al. 2016). Gallaher et al. (2004) reported that the interoperability costs were significant in the construction phase and O&M phases. The fragmentation of safety information and additionally, the fact that many tasks are time-sensitive in nature are major contributors to incidence (Wetzel et al. 2016).

There is also a delineation between the design for safety and the use of informational procedures during the FM phase. The lack of building data provided at handover creates problems such as labelling, and identification for shut down procedures. Identification requirements after handover can be costly and time consuming.
Therefore it is important for the owner to designate the appropriate naming conventions that consider organizational operations, standards and the safety requirements before design is initiated. Parikh et al. (1995) recommended not using words such as new and north since the interpretation of those terms may change if the equipment is rotated or when the term “new” is no longer applicable. Nameplate labelling is also important for lockout procedures. The concerns for labelling are finally beginning to be addressed through the efforts of technologies such as BIM, and RFID, as well as the overall concern for the owner’s documentation. But again, it is rarely considered from a safety standpoint. The handover information for owners has been noted by authors (Arditi et al. 1999; Mayo et al. 2016; Wetzel et al. 2016) as an import step to ensure the owner has the information necessary to operate and maintain the building. However, as Wetzel et al. (2016) noted, often it is difficult to retrieve this information because it exists in multiple formats and locations. These disconnects may also indicate that difficulties in communicating important safety information to those that need it contributes to safety concerns.

**METHODOLOGY**

The research team wanted to identify the safety needs and concerns O&M personnel have regarding safety, and for this pilot investigation two sites were evaluated. Both facilities were in the Charlotte area, and the investigation took place with facilities personnel that included both management and technicians.

- Facility 1 – University dining facility constructed in 2015.
- Facility 2 – Existing commercial facility ready to be purchased by new owners.

The visits were coordinated with personnel from the facilities under review, and each walkthrough provided an opportunity for the personnel to provide examples and concerns on issues regarding safety during maintenance operations. The major items discussed during these visits are summarized below:

**Commercial Facility**

1. The maintenance and replacement of atrium lighting requires the deployment of scaffolding or lifting equipment and the use of a two-person crew. Since the lights are at an elevation of about 25 feet, every time that is necessary, the atrium is off limits to occupants. The facility manager in order to eliminate the need for a frequent replacement of the lights, decided to upgrade the lights to LED. That replacement was achieved by showing evidence to reductions in maintenance costs over time. The main hazard encountered by maintenance personnel when replacing these lights is falling. A picture of the atrium lights is shown in Figure 2 (left). Furthermore, the replacement of the lights requires the floor to be protected with plywood, so that the equipment does not scratch the marble.

2. In the atrium area again, the tall windows need to be washed twice a year. The crew that undertakes this activity uses ladders and there is always a risk of falling, especially when they are carrying their cleaning supplies. The atrium did not include any method for the workers to raise their equipment to the top level, and leaning the ladder against the window is not suggested.
The main hazards encountered here again is falling. Maintenance workers could use an extendable squeegee, but they do not get enough pressure on to the glass and windows do not get cleaned to the satisfactory level, and the use of scaffolding systems is also expensive. A picture of the atrium entrance, from the inside, is shown in Figure 2 (right). An additional concern is the sleekness of floors often encountered in high-end facilities such as this, that pose a concern for occupants slipping, as well as securing a ladder during maintenance operations.

3. In this building all the water heater tanks are placed in a utility closet on platforms at a height of about 7 feet. As observed in Figure 3, the platform is right above the door, leaving enough room for fire suppression equipment and pipes. The facility manager commented that maintenance to the water heater tanks and systems is impossible without the removal of the shutting and draining of all the water in the fire suppression system, and the removal of the door and platform. As a result such maintenance never takes place. If maintenance were to happen, or if a replacement was needed, maintenance crews would have to work in awkward positions, and in cramped spaces.

4. The lighting system in all of the offices is directly over the desks, making it difficult to replace lights, or maintain electrical components. When this scenario exists, a scaffolding system needs to be erected around the desks and planks placed over them.
so that maintenance crews can access the ductwork and wiring above the ceiling panels. The hazards associated with these activities include falling, electrocution and awkward postures. Pictures of the ceiling system and the light wiring is shown in Figure 4.

![Figure 4. Lights in offices (left), electrical ductwork in ceiling (right)](image)

5. Chemicals required for the air-conditioning system are stored in a closet without any ventilation. The maintenance crews might be exposed to hazardous chemicals during maintenance activities.

![Figure 5. Chemical storage closet](image)

**University dining facility**

6. The atrium chandelier and various lights around the perimeter of the atrium need replacing frequently. The chandelier light can be lowered using a winch that can be accessed from the platform shown in Figure 6 (right). The platform has no railings, but locations to hitch fall protection harnesses exist. Access to that platform can be achieved from the roof, where there is an entrance. The maintenance personnel expressed that they are uncomfortable climbing to that level, and also were concerned that if the winch and lowering mechanism needs maintenance, it would be extremely difficult to access. The perimeter lights are placed in locations that requires workers to be lifted with mechanical means, but placement of such a device is awkward due to the presence of the staircase as shown in Figure 6 (left).
7. As mentioned before, access to the atrium chandelier winch, happens from a platform that can be accessed from the roof, as shown in Figure 7. When the building was constructed the ladder to the cupola was made 19.5 feet tall which is lower than the 24 feet limit that would require ladder safety devices, self-retracting lines, or cage (29 CFR 1926.1053(a)(19)). The maintenance crews expressed that they are uncomfortable climbing on the ladder shown in Figure 7, since they carry equipment when they do so. The owner will install a fall protection system in the near future, at their own expense. This need for fall protection is an example where owners need to modify existing facilities to accommodate maintenance crew safety.

8. A roof ladder was constructed to allow access from one side of the roof to the other as shown in Figure 8. As observed, the steel ladder has side rails that are made of plates which are difficult to grab. Furthermore, when crews are on the roof they usually carry equipment and tools making their tasks difficult to complete. The maintenance crews expressed that they would have liked a better way to climb from one side to the other, with a ladder or steps that would allow them to carry equipment and materials between the two sides of the roof.
The eight observations that were recorded can be categorized according to the hazards they pose to the maintenance crews. That information is summarized in Table 4. As shown the majority of the cases involve a hazard that would lead to a fall, which seems to be very common in maintenance activities. For that reason, it is necessary to develop a set of guidelines for the US maintenance industry similar to the one for the UK maintenance industry which is titled “Safe access for maintenance and repair. Guidance for Designers” (Iddon et al. 2009).

Table 4. Case Studies and Hazard Categories

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Atrium Light Maintenance</td>
<td>Falls</td>
</tr>
<tr>
<td>2. Atrium Window Cleaning</td>
<td>Falls, Slip and Trips</td>
</tr>
<tr>
<td>3. Heater Water Tank</td>
<td>Ergonomics</td>
</tr>
<tr>
<td>4. Office Lights</td>
<td>Ergonomics, Falls, Slips and Trips</td>
</tr>
<tr>
<td>5. Chemical Closet</td>
<td>Hazardous Systems</td>
</tr>
<tr>
<td>6. Atrium Chandelier</td>
<td>Falls, Slips and Trips</td>
</tr>
<tr>
<td>7. Access to Cupola</td>
<td>Falls</td>
</tr>
<tr>
<td>8. Roof Ladder</td>
<td>Fall, Slips and Trips, Ergonomics</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The mitigation of safety issues through design will require more awareness through discussions, training and research. Both teams of owner representatives (facility managers and technicians) the researchers interviewed stated that there are rarely any standards or predetermined best practices on how to maintain assets. Although design for prevention is important, several administrative and political hurdles need to be overcome for it to be successfully implemented. Asset managers and owners are rarely on site and are not aware of what the technicians must go through to maintain a building on a daily basis. The maintenance personnel on the commercial facility stated that often such owners of the larger office space facilities rarely keep a building longer than 5 years and they may own anywhere from 10-100 buildings, and safety for
maintenance personnel is not considered a concern. Therefore, ease of maintenance is not a priority, even when there is a cost savings involved. Although, facility managers, such as the ones maintaining the commercial facility, require safety training for their staff, and are required to stop any work that is not safely being performed, there remains a sense that safety sometimes conflicts with the duties of the job to ensure functioning operations. An additional concern that was noted, was that there might be retribution to workers in a “right-to-work” state, if they raise awareness to possible safety issues that delay work.

The walk-through sessions for each building, highlighted issues that could be mitigated during design and a majority of them fell into the category of heights and falling. This was especially the case as it pertained to electrical and lighting in inaccessible areas and in high locations. The most prominent case was due to a large decorative light in the dining facility atrium, which is very typical of many entry areas in buildings. In this case, the design planned for a winch system to lower the fixture for cleaning and maintenance. However, to access the cable to lower the light, personnel had to access the roof, climb a vertical ladder, and access a platform 3 levels above the floor with no railing. Additionally, there was no safe way to access the actual lowering mechanism if maintenance needed to be performed on it. The 29 CFR 1926.1053(a) (19) OSHA standard states that fall protection must be provided whenever the length of climb on a fixed ladder equals or exceeds 24 feet. In this case, the facilities personnel stated that the design of the ladder to reach the cupola area was purposely designed to be slightly less than the maximum height as to avoid additional safety requirements. Figure 6 and Figure 7 showcase this example. Another common scenario pertains to the placement of lighting. The tenants for the commercial building included a call centre operation, with modular furniture placed directly below the overhead fluorescent lights. To maintain the fixtures, maintenance personnel are required to stand on the desk, place a ladder on the desk, or create a scaffolding system to reach the fixtures. Additionally, while it is not the recommended practice, the maintenance technician noted that they often change ballasts without turning off the breaker since the maintenance crew holds the same hours as the occupants. The need to maintain lighting while continuing operations is a conflicting challenge that introduces safety risks. This is another example where the design teams and the maintenance teams could come together during the design phase and identify more optimum solutions. For example, locating the light fixtures on either side of the desk rows in the aisles, splitting circuits to allow for partial shutoff, and installing remote ballast fixtures.

In conclusion the authors would like to note that the hazards identified during the investigations match the facility management safety categories collected from literature (Parikh et al. 1995; Gilbertson 2007; Wetzel et al. 2016). Further investigation though, with more case studies needs to be conducted in order to ensure a complete categories and subcategories of safety concerns.

Through the interviews and investigations, it has been noted that lack of awareness is problematic. The authors perceive that as project delivery systems evolve to become more collaborative (Design Build, CM @ Risk, Build Operate Transfer, etc.) FM personnel will eventually become more active in the design phase. However, the knowledge base and expertise required of maintenance personnel to effectively contribute during design is not developed. There is a need to document this expertise and outline methodologies to assist FM personnel to be successful in communicating facility maintenance operation safety concerns during design. Future research needs to
be undertaken, to expand PtD beyond the construction phase and incorporate maintenance for life-cycle safety (Hecker et al. 2004).

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AN ASSESSMENT OF ADOPTION OF ERGONOMIC PRACTICES AMONG SELECTED CRAFTSMEN ON BUILDING CONSTRUCTION SITES IN NIGERIA

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Construction is characterised by high rates of injuries and illnesses among craftsmen. In recent years the focus of occupational health and safety has been shifting to preventing occupational illnesses. Musculoskeletal disorder has been identified as a drain to construction productivity. Ergonomics is one of the procedures that eliminate the hazards and risk in construction. It is believed that Nigerian building constructions craftsmen have not implemented ergonomics. The aim of the study is to determine the level of adoption of ergonomics in the work methods, tools and equipment of building construction craftsmen based on best practice (interventions) with a view to enhance health and safety practices on Nigerian construction site. Site observation was used to fill checklist assessing ergonomics practices among eighty tradesmen (Bricklayers, Electricians and steel-fixers) on construction sites. An interview was also conducted. Data was analysed using percentage. It was found that 64\% of tradesmen have experienced ergonomics injury while 92\% of craftsmen do not report cases of ergonomic injuries on construction site. The study concludes that the adoption of ergonomics among craftsmen is low. The study recommends increasing awareness of ergonomics through education and training of tradesmen.

Keyword: Adoption, Construction, Ergonomics, Sites, Health and Safety.

INTRODUCTION

Construction work has high injury rates and by its very nature is difficult. This could be because construction work involves working above the shoulder, below the knee-level and also because building materials are heavy. Working in the construction industry has been identified as a risk factor for chronic disability. Every year many construction site workers are killed or injured as a result of their work, others suffer ill health (Health and Safety Executives 2006). Health and safety in construction is about preventing people from being injured at work or becoming ill through appropriate precautions and providing a satisfactory working environment. Health and safety is an inevitable aspect of construction because for a worker to be productive he needs to be healthy, feel safe and provided with a good working environment which include proper tools and equipment. One of the efforts in trying to prevent occupational illness in construction is ergonomics. Al-Swaity and Enshassi (2012) assert that ergonomics is one of the procedures that eliminate the safety hazards and risk in the construction industry. Ergonomics produces and integrates knowledge from the human sciences to match jobs, systems, products, and environments to the physical and mental abilities and limitations of people (Oostakhan \textit{et al}, 2012). Ergonomics seeks to safeguard safety, health and well-being of workers whilst optimizing efficiency, productivity,
comfort, health and performance. Ergonomics attempts to achieve this by better fitting the task to the worker.

Poor working methods in building construction cause physical and mental injuries including economic losses (Smallwood 2012). According to Jabarani (2013) the construction industry has high rates of injuries and illnesses. Complexity of the projects and extensive scope of the works in the industry exposes the construction workers and artisans to injuries, illnesses and disabilities which could lead to death. One of such injuries is musculoskeletal injuries. Ohio Bureau of Workers Compensation (OBWC) (n.d) adds that many of the injuries in the construction sector are musculoskeletal disorders caused by cumulative trauma which can be associated with such activities as manual material handling, hand tool usage, awkward postures and prolonged equipment operation. This type of injury can really affect the health of the people that are exposed to the hazards for a long period of time. Musculoskeletal injuries can cause temporary or even permanent disability, which can affect the workers earning and contractor’s profit (Albers and Estill 2007). Smagacz (2004) declare that 54% of all construction injuries/illnesses are ergonomic-related. There is a prevalence of unfavourable ergonomic practice in the construction sector thereby affecting the productivity of the construction workers. Findings by Ajayi and Thwala (2012) indicated that the manner in which construction activities are executed in Nigeria’s construction industry adversely affects the health and safety of construction workers as it precipitates into work related musculoskeletal disorders (WMDs). Construction workers in Nigeria are always exposed to unfavourable ergonomic factors and severe environmental hazards which results in acute injury, chronic illness, permanent disability or even deaths through immediate effects of direct exposures.

According to Ekpeyong and Iyang (2014) the overall prevalence of work related Musculoskeletal Disorder (MSD) in the Nigerian construction industry was 39.25%, and iron workers (steel-fixers) experience work related Musculoskeletal Disorder the most at a prevalent rate of 56%. The study called for ergonomics adoption in the Nigerian construction industry. From the above it can be seen that musculoskeletal injury is a problem in the building industry in Nigeria and adopting ergonomics practices can help solve this problem. It is believed that craftsmen in the Nigerian building industry have not adopted ergonomics principles. This research examines the adoption of ergonomics principle in preventing Work related Musculoskeletal Disorder (WMSD) on building construction sites in Nigeria.

**Ergonomics and Ergonomics Awareness**

In recent years’ occupational health and safety has moved from prevention of injury and accidents to preventing illnesses which has been the highest cause of absenteeism and lost days. Ergonomics aims at avoiding injury and improving health, safety and comfort by finding the best fit between the worker and the job. Construction work and job tasks expose employees to potential injuries and illness due to the poor design of workstations, tool, equipment and poor posture. According to Michigan Occupational Safety and Health Administration (2013) ergonomics involves the assessment of job tasks to identify ergonomic risk factors and appropriate engineering or work practices controls to reduce or eliminate the identified risk factors. Ergonomics tries to come up with solutions to make sure workers stay safe, comfortable, and productive (Albers and Estill 2007).
Ahankoob and Charehzehi (2013) also described ergonomic as adapting the physical environment with physiological, physical, and psychological capability and limitation of the worker. Ergonomics considers different discipline such as anatomy, physiology, psychology, sociology, physics, and engineering. According to Kaminskas, Barauskiene and Bingeliene (2013) ergonomics is a new topic for the construction industry in curbing the problem of work related musculoskeletal disorder (WMSD). There is need for adopting ergonomics in construction to prevent and also reduce the likelihood of a worker suffering from long term disabilities caused by WMSD.

Implementing ergonomics on the construction site according to Ahankoob and Charenzehi (2013) will improve quality, increase productivity, make easy the human performance, provide a safe and healthy working environment, reduce disorders, decrease costs, and improve morale of the workers. Ergonomic awareness is important in implementing ergonomics. Awareness among all stakeholders (employers and employees) is critical. Ergonomics awareness entails knowing ergonomics and its benefits, identifying parts of the body that could be affected while working and identifying work activities (risk factors) that can lead to injury (Washington State Department of Labour and Industries, 2012). Employees and supervisors are the most critical stakeholders in ergonomics awareness. Employees are the most affected since they do the job while supervisors ensure they are done properly and in the right way. When majority of the workers have no exposure to ergonomics training they adopt harmful postures at work which will increase the risk of musculoskeletal injuries. According to Adeyemi et al. (2013) it is the responsibility of site supervisor to supervise the safe work procedures and also trained the employees to follow such safe work techniques.

RESEARCH METHODOLOGY

The study assesses the practice of ergonomics among electricians, bricklayers and steel workers on building construction sites in Abuja, Nigeria. The research adopted both the quantitative and qualitative research methods. Construction craftsmen were observed on their working days to assess how much they have adopted ergonomics in their working method, personal protective equipment, exercises, tools and equipment. An interview was conducted among Masons, Electricians and Steel-fixers.

Site observation was used to fill checklist assessing ergonomics practices on building construction sites based on various ergonomic interventions (best practices) that has proven to reduce and prevent musculoskeletal disorder from literature. The interview was on ergonomics in general and work related musculoskeletal disorder. The researchers gave a background lecture to the workers on ergonomics and ergonomic injuries. This was done to help the respondents have a better understanding of the subject matter. The research method (Interview and site observation) was adopted from Alswaity and Enhassi (2012) and Williams (2005).

The population of Masons (Bricklayers and plasterers), Electricians and Steel-fixers are unknown. The sampling size was determined based on the formula Cochran’s formula for calculating sample size when the population is infinite (Cochran, 1977):

\[ n = \frac{z^2pq}{d^2} \]

Where;
\[ n = \] the desired sample size
z = the ordinate on the Normal curve corresponding to \( \alpha \) or the standard normal deviate. For the purpose of this study, a confidence level of 90\% will be adopted. Usually a 90\% level of confidence has \( \alpha = 0.10 \) and critical value of \( z_{\alpha/2} = 1.64 \).

P = the proportion in the target population estimated to have particular characteristic (normal between the range of 0.1 - 0.5)

\[ q = 1.0 - p \]

\( d \) = degree of accuracy corresponding to the confidence level and \( Z \) selected.

Consequently, the sample size is determined as thus,

\[ z = 1.64, \, d = 0.1 \text{ Where } p = 0.2 \Rightarrow q = 0.8 \]

Hence, Sample size \( n = \frac{(1.64)^2 \times 0.8 \times 0.2}{(0.1)^2} = 43 \)

Total number for 3 types of craft (Masons, Electricians and Steel-fixers) for the study is \((43 \times 3) = 129\)

The sample size for the study is One hundred and twenty-nine (129).

The result should not be considered representative of the construction population in Nigeria because of the small sample size, and the fact that only three trades were assessed. A larger sample size is required to determine the degree of adoption of ergonomics in Nigeria.

**ANALYSIS, FINDINGS AND DISCUSSION**

Table 1. shows the distribution of craftsmen in the study. Bricklayers were the highest with 40\%. 25\% were electrician, while steel fixers represented 35\% of the population surveyed. Masons and Steel-fixers were higher in number because most of the building sites visited was at early stage of construction.

<table>
<thead>
<tr>
<th>Trade</th>
<th>Frequency (Nr.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>Electrician</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Steel fixers</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Result from Table 2 shows that majority (61\%) of the respondents learned their trade from the informal sector. 29\% of respondents have college-based training (Primary, secondary, technical college, trade schools and polytechnics). This shows that most of the respondents were trained informally.

<table>
<thead>
<tr>
<th>Type of training</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>College based training</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>Non College based training</td>
<td>49</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

From Table 3 it can be seen that majority (64\%) of respondents have experienced ergonomics injury before. This further reaffirms that musculoskeletal injuries exist among construction craftsmen and it is a problem being faced by construction workers. This finding also in line with Smallwood and Ajayi (2007); Ekpeyong and Iyang (2014); Ajayi and Thwala, (2015) where they asserted that every construction worker is likely to be temporarily unfit to work at some time as a result of moderately serious injuries or health problem after working on a construction site.
Respondents who have experienced ergonomic injuries were asked to indicate the part of the body they felt discomfort. During the interview 8 craftsmen have experienced pain in the elbow. Shoulder injury was experienced by 4 craftsmen. 25 artisans have experienced back and waist problem. Pains in the neck have occurred among 10 craftsmen. Discomfort in the knee accounted for 7 injuries while 9 craftsmen experienced pain in the wrist.

Table 3: craftsmen experience of ergonomic injuries

<table>
<thead>
<tr>
<th>Type of response</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>51</td>
<td>64</td>
</tr>
<tr>
<td>No</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

During the interview electricians complained more of discomfort at the shoulder, neck, leg, waist and arm. Masons complained of discomfort in the waist, rib, back and shoulder. Steel-fixers complain of body pain, shoulder arms, back and waist. The shoulder and neck problem can be linked to working overhead. The physical nature of the construction industry has effect on the body. The back problem could be linked to the prolonged and repeated bending while working, lifting and picking up material at ground level.

Table 4 shows the response of craftsmen on reporting cases of musculoskeletal injuries to their superior or supervisors. 92% commented that they don’t report cases to anyone while 9.6% have reported cases of musculoskeletal injuries to their supervisors or superior. It shows that construction workers do not report musculoskeletal injuries most times. The interview respondents think pain, discomfort and injuries come with the job and don’t see the need to report any incident. This is because they are not aware of the danger of ergonomic injuries.

Table 4: Reporting symptoms of musculoskeletal injuries

<table>
<thead>
<tr>
<th>Type of response</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>74</td>
<td>92</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Managing ergonomic injuries

The research also looked into how these construction workers respond to symptoms of musculoskeletal injuries. This was done to know how workers manage injuries. Most of the craftsmen practice self-medication by taking pain relievers. Others relax, take rest and break from work. Very few respondents go to seek proper medical care by visiting the hospital. Many construction workers practice self-medication, this could be because they feel pain is part of the job. Respondents take pain relievers to help alleviate the pain. These injuries could develop and reach a stage where workers can no longer perform their daily routine adequately and in some cases lead to permanent disability which has been identified as a leading cause of dearth of skilled craftsmen in the industry.

Risk factors responsible for developing work-related musculoskeletal disorders
The study probed into the aspect of construction work that contributes to prevalence of MSD. From the interview respondents identified over exertion as a major risk factor. This occurs while trying to complete the work quickly or working tirelessly to meet work target. This has effect on the worker because it causes exhaustion. The lesser amount of rest makes them vulnerable to various injuries over a period of time. Weather condition affects construction activities because they are mostly carried out in the open. The effect of the weather can’t be neglected. This could either be hot or cold weather. Some respondents perceived that working under the sun makes the task more difficult and working in the cold was said to cause joint pain. Working on the construction site is physical in nature and most construction materials are heavy. It involves lifting, pushing pulling and carrying. Movement of these materials from location where they are stored to their place of use is stressful. Mason complained of lifting heavy bricks without proper grip. Craftsmen also perceive repetitive motion as an injury risk factor. Example of these is a bricklayer bending and picking up hundreds of bricks, raising and placing them. This movement is continuing every working day. The steel fixer while fixing or tying stirrups in placing reinforcement repeat the movement of twisting the wrist continuously. Respondents also stated that the awkward postures they take while working may be the cause of their injuries. Examples of awkward positions stated by craftsmen include; squatting and kneeling, while working and bending the neck backward for long period while working overhead. Steel-fixers also bend for a long period while tying reinforcement.

Table 5: Site observation steel-workers

<table>
<thead>
<tr>
<th>Ergonomic practices</th>
<th>Yes</th>
<th>Percentage</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Stretching prior to starting the day</td>
<td>9</td>
<td>32</td>
<td>19</td>
<td>67</td>
</tr>
<tr>
<td>2 Stretching during break</td>
<td>1</td>
<td>4</td>
<td>27</td>
<td>96</td>
</tr>
<tr>
<td>3 Stretching after a lengthy duration of an extended work posture</td>
<td>5</td>
<td>18</td>
<td>23</td>
<td>82</td>
</tr>
<tr>
<td>4 Stretching after the work day</td>
<td>7</td>
<td>25</td>
<td>21</td>
<td>75</td>
</tr>
<tr>
<td>5 Re-bars stored near location of use</td>
<td>22</td>
<td>69</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>6 Re-bars stored/stacked above ground level</td>
<td>8</td>
<td>29</td>
<td>20</td>
<td>71</td>
</tr>
<tr>
<td>7 House keeping</td>
<td>12</td>
<td>32</td>
<td>16</td>
<td>68</td>
</tr>
<tr>
<td>8 Weight restriction of 50kg</td>
<td>3</td>
<td>10</td>
<td>24</td>
<td>90</td>
</tr>
<tr>
<td>9 Shock absorbing shoe inserts</td>
<td>13</td>
<td>46</td>
<td>15</td>
<td>54</td>
</tr>
<tr>
<td>10 Hand gloves</td>
<td>18</td>
<td>64</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>11 Shoulder pads</td>
<td>8</td>
<td>29</td>
<td>20</td>
<td>71</td>
</tr>
<tr>
<td>12 Rebar tying tool</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5 presents results from observation of steel-fixers. On stretching and exercise It was observed that 32% of steel-fixers stretch prior to starting their working day, 4% stretch during break, 18% stretch after a lengthy duration of an extended work posture and 25% after the working day. Working principles of steel-fixers were observed. Result from observation shows that 69% of materials were stored close to the place of use. 289% of re-bars were stored/staked above ground level to prevent too much bending. 32% of steel fixers conduct good housekeeping. On weight restriction on the amount of load to be carried by a single worker (55 kg by ILO standards) only 10% have.

In terms of the use of personal protective equipment, it was observed that 64% of steel-fixer use hand gloves, 29% use shoulder pads. It was also observed that there was
no use of rebar tying tool by steel fixers. This equipment helps to prevent bending while working. It also eliminates the twisting of the wrist while tying re-bars together.

Table 6: Site observation of Bricklayers

<table>
<thead>
<tr>
<th>Ergonomic practices</th>
<th>Yes</th>
<th>Percentage(%)</th>
<th>No</th>
<th>Percentage(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Stretching prior to starting the day</td>
<td>8</td>
<td>25</td>
<td>24</td>
<td>75</td>
</tr>
<tr>
<td>2 Stretching during short break</td>
<td>7</td>
<td>22</td>
<td>25</td>
<td>78</td>
</tr>
<tr>
<td>3 Stretching after a lengthy duration of an extended work posture</td>
<td>19</td>
<td>60</td>
<td>14</td>
<td>40</td>
</tr>
<tr>
<td>4 Stretching after the work day</td>
<td>14</td>
<td>47</td>
<td>19</td>
<td>53</td>
</tr>
<tr>
<td>5 Shock absorbing shoe inserts</td>
<td>8</td>
<td>32</td>
<td>25</td>
<td>68</td>
</tr>
<tr>
<td>6 Hand gloves</td>
<td>12</td>
<td>38</td>
<td>20</td>
<td>62</td>
</tr>
<tr>
<td>7 Adjustable/split level scaffold</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>8 Motorised screeding machine</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>9 Light weight block</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>10 Blocks notches for hand grip</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>11 Tool handle not exceeding base of the palm</td>
<td>20</td>
<td>62</td>
<td>12</td>
<td>38</td>
</tr>
<tr>
<td>12 Tool handle rounded, soft</td>
<td>18</td>
<td>55</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>13 Tool handle slip resistant</td>
<td>16</td>
<td>49</td>
<td>17</td>
<td>51</td>
</tr>
</tbody>
</table>

On stretching and exercise, 25% of bricklayers were observed stretching prior to starting work, 22% during short break, 40% stretch after a lengthy duration of an extended work posture and 47% after the day’s work (See Table 6).

On the use of personal protective equipment 32% were observed to use shock absorbing inserts in their safety boots. Only 38% of bricklayers were observed using hand gloves while working. It was also observed that there was no use of adjustable/split level scaffold, motorised screeding machine, light weight block and blocks with notches for hand grip.

It was observed that 62% of handles of hand tools do not exceed the base of the palm. 55% of tools handle were found to be rounded and soft. 49% of handle of tools used by bricklayers were found to be slip resistant.

Stretching and exercise can be said to be higher among masons than other craftsmen observed. This could be because of the nature of their work which has to do with repeated lifting and bending. The use of personal protective equipments (shock absorbing shoe inserts and hand gloves) was found to be low. There was no use of split level scaffold, motorised screeding machine, light weight blocks and notches in blocks for hand grip. Most tools (trowel and hand pan) were found to be ergonomically compliant.

Electricians were observed to see how much they stretch on a working day (Table 7). 20% stretch prior to starting the day and 15% during short breaks. It was observed that only 5% stretch after a lengthy duration of an extended work posture and 30% of electricians stretch after work. Stretching and exercise (prior, during and after work) among craftsmen has been seen to be low. No electrician was found using both kneepad and leg wedge.
It was observed that 65% of screwdriver handle do not exceed the base of the palm. 75% of trowel handle are rounded and soft. 40% of tools used were found to be slip resistant while 60% were found to be slippery. It was observed that scissors lift was only provided in 3 sites visited. There was no use of cordless screwdrivers by electricians.

**Site observation of Electrical work**

<table>
<thead>
<tr>
<th>Ergonomic practice</th>
<th>Yes</th>
<th>Percentage(%)</th>
<th>No</th>
<th>Percentage(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Stretching prior to starting the day</td>
<td>4</td>
<td>20</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>2 Stretching during short break</td>
<td>3</td>
<td>15</td>
<td>17</td>
<td>85</td>
</tr>
<tr>
<td>3 Stretching after a lengthy duration of an extended work posture</td>
<td>1</td>
<td>5</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>4 Stretching after the days’ work</td>
<td>6</td>
<td>30</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>5 Shock absorbing shoe inserts</td>
<td>3</td>
<td>15</td>
<td>17</td>
<td>85</td>
</tr>
<tr>
<td>6 Leg wedge</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>7 Knee pad</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>8 Handle not exceeding base of the palm</td>
<td>13</td>
<td>65</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>9 Handle is slip resistant</td>
<td>15</td>
<td>75</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>10 Moulded hand grip</td>
<td>8</td>
<td>40</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>11 Cordless (battery) screwdrivers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>12 Scissor lifts</td>
<td>3</td>
<td>15</td>
<td>17</td>
<td>85</td>
</tr>
</tbody>
</table>

**CONCLUSION**

The study assessed adoption of ergonomics practice among construction craftsmen in Nigeria. The study looked into preventing ergonomic injuries through the adoption of ergonomics through stretching and exercise, ergonomic tools and equipment, material storage and movement and the use of personal protective equipment. The adoption of ergonomics principles by artisans in the Nigerian building industry is low.

The practice of stretching and exercise were found to be low among craftsmen, most craftsmen don’t stretch before, after and during work. One of the limitations of the study is that the research couldn’t determine how much stretching and exercise the workers do outside the working environment. Stretching and exercise has been found to be effective in reducing incidence of MSD. The use of personal protective equipment (knee pad, leg wedges, hand gloves and shoulder pads) was also low.

The study also assessed management of ergonomics injuries (MSD) among construction craftsmen. It was seen that 90% of craftsmen do not report musculoskeletal injury to their supervisors or superior. This could be one of the major causes of low awareness of the impact of work related musculoskeletal disorder in the Nigerian building industry. The problem may be because most employees in Nigeria do not usually pay compensation for injuries and illness caused by work related musculoskeletal disorder. Workers are not encouraged to report. Most of the craftsmen practice self-medication by taking pain reliever.
Employers are also responsible for the low level of adoption of ergonomic principles. Most of the equipment like the scissors lift and adjustable scaffold and rebar tying machine are to be provided by the employees. These construction companies have the most important role to play in adoption of ergonomics on the building construction site through education and training, providing ergonomic PPE’s and providing ergonomic designed tools. Even though some companies argue that there is no evidence that links adoption of ergonomics to increase in profit. But it cannot be disputed that when workers are healthy and are provided with a suitable working environment they are more productive. The study recommends increase in awareness of ergonomics through education and training. The study recommends further research into challenges of adopting ergonomics on construction sites.

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Research about the implementation of health and safety (H&S) in the construction industry is required, as it may create more awareness on strategies to significantly reduce the rate of incidents and fatalities in construction organisations. It may encourage such organisations to improve their H&S performances on construction projects. The aim of this research is to establish the drivers of H&S implementation in construction organisations within the Gauteng Province in South Africa. The research adopted a quantitative research methodology. A survey questionnaire was used to collect primary data. Judgemental and snowball sampling techniques were employed to select the respondents consisting of site engineers, site agents, contracts managers, construction managers and project managers. Data were analysed through descriptive statistics, mean item score and standard deviation. Findings indicated that the most important drivers are the need to manage hazards; organisations regard H&S as important; compliance with the legislation; consideration of H&S as a way to do business and to reduce costs associated with accidents and injuries. These results may assist construction organisations in setting H&S as a priority, since little attention has been paid to the objective of H&S implementation. This study was restricted to large construction organisations within the Gauteng Province in South Africa and therefore may not be generalizable to all construction organisations within South Africa and in other geographical locations.

Keywords: construction industry, health and safety implementation, Gauteng

INTRODUCTION

Construction sites all over South Africa produce enormous numbers of accidents annually and the construction industry is known for being highly dangerous and complex, despite the important role it plays as contributor to economic growth (Smallwood, Haupt and Shakantu, 2009). Okorie and Smallwood (2010) indicated that the construction industry is responsible for the highest cases of lost workdays. Abdul Hamid et al. (2008) indicated that construction accidents are rampant because clients and contractors tend to focus more on profit maximization, and less on H&S (health and safety) implementation and this results in poor housekeeping, decline in productivity, programme delay, increased cost of accidents, increased compensation insurance claims and harm to the environment (Smallwood 2002; Smallwood et al. 2009).

According to Muiruri and Mulinge (2014), health and safety is a humanitarian and economic concern that needs to be managed orderly. They further stated that this economic concern is in form of costs, which can be divided into direct costs

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(hospitalisation, liability and property losses) and indirect costs (delays, training of new workers, etcetera). Therefore, H&S implementation is necessary to reduce the impact of the costs of accidents. Other reasons for implementing H&S as identified by Smallwood (2010) are legislation, financial issues, fines and penalties, quality, late completion and the reputation and image of the construction organisation. In the study by Muiruri and Mulinge (2014), it was indicated that construction managers tend to think profits will decrease and H&S costs will increase when H&S measures are implemented on construction projects. However, it was found that investment in construction H&S increases profitability by increasing productivity and uplifting employee confidence, and it decreases attrition (Muiruri and Mulinge, 2014).

According to the British Safety Council (2014) when an organisation invests in their employees’ H&S, then the organisation invests in success and continuity. It is therefore important to continuously conduct research on H&S implementation and particularly, implementation drivers in order to determine what actually makes construction organisations decide to act on the prevention of incidents, accidents and fatalities. Findings from this study will help in deciphering the root causes of poor H&S performance and in devising ways to tackle the problem. The objective of the paper is therefore to identify the drivers of H&S implementation in construction organisations in the Gauteng Province of South Africa. The next section will review the drivers behind H&S implementation. The empirical results will then be presented and discussed; followed by the conclusion.

**DRIVERS BEHIND HEALTH AND SAFETY IMPLEMENTATION**

The most important parameters of a project are cost, time, quality and H&S. However, cost, time and quality are dominating factors in the execution of a project as they receive more attention and take preference over H&S (Muiruri and Mulinge, 2014). As a result, a higher risk of accident existence will be developed.

According to Smallwood and Haupt (2006), a project team’s efforts to accomplish a project on time within quality and budget can be highly affected by accidents and its associated costs. Furthermore, bad publicity from such accidents may also damage the construction organisation’s name and strain relationships between project stakeholders, where one is quick to blame each other, in terms of responsibility. Therefore, on a project, H&S may be implemented because of the cost of accidents, legislation (the OHS Act 85 of 1993, the Construction Regulations 2014, etc.), improvement in quality, client satisfaction, completion of projects on time, preserving the image and reputation of the organisation and improved productivity and profitability.

**Cost of accidents in the construction industry**

Darshi De Saram and Tang (2005) indicated that construction accidents have an immense impact on families and construction organisations in terms of damages and losses. The cost of a poor H&S record will, either earlier or later on, reflect on the balance sheet of the construction organisation. Smallwood et al.’s (2009) study in South Africa estimated that 5% of a completed projects’ value is responsible for cost of accidents; whereas the implementation of H&S systems is estimated to cost between 0.5% and 3% of the total project value. Therefore, the cost of accidents goes beyond the cost of H&S. According to Hughes and Ferrett (2016), poor H&S management may lead to accidents. However, reduced cost of accidents can be
achieved through a positive H&S culture (Chinda and Mohamed, 2008). Costs of accidents can be classified as direct or indirect costs.

Direct costs

Hughes and Ferrett (2016) and Waehrer et al. (2007) defined direct costs as costs directly related to an accident, usually covered by the workers’ compensation insurance premiums and may include hospitalisation, medical costs, liability and property losses, sick leave administration, premiums for workers and temporary disability payments. These costs are associated with the treatment of an injury and any compensation offered to injured workers (Smallwood et al., 2009; Hinze, 2006).

Indirect costs

Griffin (2006), Waehrer et al. (2007) and Hughes and Ferrett (2016) define indirect costs as those not directly related to the accident but may result from a series of accidents. Hughes and Ferrett (2016) and Griffin (2006) agreed that these costs are the most evasive cost component associated with construction worker injuries, and the elusiveness of the indirect costs of these injuries lies in the lack of clear definition. Hughes and Ferrett (2016) and Smallwood et al. (2009) provides typical indirect costs incurred by construction organisations including reduced productivity of the injured worker/s; reduced productivity of workforce; costs resulting from delays; additional supervision costs; costs of clean-up after the accident; costs resulting from rescheduling of work to ensure timely completion, lost work days, and so on.

According to statistics from the Federated Employer’s Mutual Assurance Company (FEMAC) (2016) (Table 1), the construction industry in the Gauteng Province suffered lost workdays and a lot of accidents over four years. It can be seen that the number of accidents, although lower in 2014 (than in 2012, 2013 and 2015) is still high and costs companies’ enormous amounts.

<table>
<thead>
<tr>
<th>Year of accident</th>
<th>No. of accidents</th>
<th>Lost days</th>
<th>Average cost/accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3873</td>
<td>45 269</td>
<td>25 694</td>
</tr>
<tr>
<td>2013</td>
<td>3954</td>
<td>38 060</td>
<td>27 272</td>
</tr>
<tr>
<td>2014</td>
<td>3654</td>
<td>31 294</td>
<td>28 422</td>
</tr>
<tr>
<td>2015</td>
<td>3840</td>
<td>30 520</td>
<td>31 682</td>
</tr>
</tbody>
</table>

Source: FEMAC (2016)

Legislations

Legislations such as the OHS Act (85 of 1993) and Construction Regulations of 2014 set out critical standards to which the performance of companies towards production is expected to comply with and be monitored against (Othman et al. (2008). The Act further provides that construction organisations achieve the fundamental principles. It firmly specifies that an H&S plan must be prepared and executed for the protection of all participants against hazards and risks of injuries at and around the working environment. Azimah et al. (2009) stated that for H&S performance to be enhanced, the H&S legislation and regulations must be communicated on a regular basis.

Improved quality

Nicholas and Steyn (2012) define quality as specifications or requirements that are being met. It was further identified that when construction organisations meet the project specifications, the chance that the organisation will be taken to court by the
Achieve client satisfaction

According to Kärnä (2009) client satisfaction within the construction industry could be determined by the extent to which a physical facility and the construction process meets the client’s expectations. Omonori and Lawal (2014) added that client satisfaction is essential when it comes to the construction process development and client relationship. Their findings indicated that client satisfaction involves the quality of a construction project within budget, and affects the future of the company, as well as increasing profitability. A good H&S record will lead to a satisfied client, because the project will be completed on time (Zou and Sunindijo, 2015). Therefore, when the client is satisfied, the construction organisation will be more profitable and will have an increased reputation.

Complete projects on time

According to Zou, Zhang and Wang (2007), who performed a study on risks and their significance on project objectives, it was indicated that an improperly planned schedule would have a negative impact on workers, in terms of accidents. Moreover, Zekri (2013) supported the statement by implying that an unworkable schedule can deeply affect the success of project objectives in terms of safety, cost, quality and environment. When accidents take place or construction programs clash, the project schedule may be more delayed. In addition, rapidity of work and impracticable target deadlines by the client may also contribute to accidents. According to statistics from the FEMAC (2016), the number of workdays lost due to accidents in the year 2013 mounted up to 38,060, compared to 31,294 in 2014 and 22,163 in 2015.

Preserve the image and reputation of the construction organisation

A good H&S record and safety management system (SMS) according to Holt (2005) and Ikpe (2009) are very important tools for expanding a business as well as attracting new clients. It was further stated by Li and Poon (2013) that if there are no proper safety measures implemented for the protection and wellbeing of workers, then the reputation of the organisation is at stake. The British Safety Council (2014) supported this by stating that an enterprise that sustains a lot of injuries and accidents will be unattractive to current and future investors, and the public. Therefore, an organisation’s image and reputation is linked with its H&S performance.

Improved productivity and profitability

According to Tangen (2005), profitability is most of time confused with productivity. Profitability considers the monetary effects, while productivity considers the real progression that takes place among purely physical phenomena. Pekuri, Haapasalo and Herrala (2011), stated that profitability is a critical indicator, when it comes to
determining whether a company is making money. Productivity, according to Lingard et al. (2007), improves when company H&S goals and objectives are clearly understood by all workers. For this to be understood, Gatti and Migliaccio (2013) stated that management must ensure a higher level of supervision and communication. As a result of improved H&S, better services will be rendered with the same resources in a shorter timeframe. Through this attempt, accidents as well as cost overruns, can be reduced (Wanberg et al., 2013) as well as accidents. These views are reinforced in a study done be Aviva (2011), where it was found that round about two-thirds of workers indicated that if an employer invests in their H&S, the employees are motivated to work harder, since a safe and healthy workforce is far more productive than an unsafe and unhealthy workforce.

METHODS

This research adopted a quantitative research methodology approach. Such an approach was selected, as it collects numerical data, which can be subjected to statistical treatment for the purpose of agreeing or disagreeing (Williams, 2007). It reduces biasness, as it is objective in nature (James, 2012). The study objective was to establish the drivers behind H&S implementation in construction organisations within the Gauteng Province in South Africa. A 5-point likert-scale (from 1=strongly disagree to 5=strongly agree) survey questionnaire was used to collect the primary data. The questionnaire was constructed in the English language and consisted of twelve close-ended questions relating to drivers behind H&S implementation. Furthermore, the questionnaire was designed according to the review of literature and expert advice. They were distributed, specifically, in the Ekurhuleni Metropolitan (Boksburg), City of Johannesburg Metropolitan (Sandton, Parktown, Midrand and Linksfield) and Central Pretoria. Seven commercial building construction sites were selected using snowball sampling. The researcher initially selected the company where the in-service training was undertaken and potential respondents were then further identified by the respondents in the first company (Etikan et al., 2016b). The target sample comprised of site engineers, site agents, contracts managers, construction managers and project managers at on-going construction sites. These were selected using judgmental or purposive sampling, as the researcher deliberately selected most appropriate respondents due to the qualities they possess (being in managerial and or supervisory positions to implement H&S), to suit the objectives of this study (Etikan et al., 2016b). Out of a total of fifty-nine questionnaires distributed, fifty-six were completed. Table 2 shows the response rate from the respondents. The data was analysed through descriptive statistics (mean item score and standard deviation) on MS Excel software. Such data was then ranked according to the mean. The Cronbach’s alpha value for the drivers on H&S implementation was 0.980, indicating good internal consistency.
Table 2: Profile of respondents

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Percentage contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Engineers</td>
<td>25</td>
</tr>
<tr>
<td>Site Agents</td>
<td>23</td>
</tr>
<tr>
<td>Contracts Managers</td>
<td>16</td>
</tr>
<tr>
<td>Construction Managers</td>
<td>20</td>
</tr>
<tr>
<td>Project Managers</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Findings on drivers of health and safety implementation

The respondents were asked to indicate the factors driving them to implement H&S. Table 3 presents the feedback to these factors. It was found that the need to manage hazards had the highest mean item score (MIS) (4.34) with standard deviation (SD) of 0.611. The factor ranked 2nd, was due to the fact that organisations regard H&S as important (MIS=4.21, SD=0.825) followed by compliance with the legislation (MIS=4.20, SD=0.564). The drivers placed among the last four were to avoid penalties (MIS=3.64, SD=1.052), to improve quality (MIS=3.61, SD=1.073), to improve productivity (MIS=3.55, SD=1.111) and profitability (MIS=3.45, SD=1.077).

From the results, the area of concentration was on the “agree” and “strongly agree” categories of the scale. The standard deviation values for drivers ranked 1 – 4, 6 and 8 were all less than 1, meaning that the responses were close to the mean (Rumsey, 2010). In other words, respondents had related opinions. The overall average MIS was 3.85 and the average SD 0.916. This may indicate that respondents can be deemed to have had similar views regarding the drivers stated for H&S implementation, although having high and low rankings.

Implications of the findings

The three top-ranked drivers, namely: the need to manage hazards, the importance of H&S and compliance with the legislation indicates that the sampled construction organisations are, in practice, mindful of the fact that the implementation of H&S in their work practices, through managing hazards in the workplace, provision of correct personal protective equipment (PPE), and so on, would reduce accidents. According to Aviva (2011) and the British Safety Council (2014), an employer investing in their employees’ H&S will result in a far more productive workforce (due to protection) and invests in success of the entire organisation, and thus improves quality, productivity and profitability in the long run.

The finding that improved quality, productivity and profitability ranked the least could indicate that the organisations included in the study did not really view H&S implementation as a means to improving profit margins (only). The responses of the sampled personnel regarding these drivers reflected a “neutral” stance, as shown by the mean score just above 3.0, indicating these factors may not be the underlying
reasons why they implement H&S in the organisations. This finding is partly consistent with results in Smallwood (2004), which rated project parameters that were affected by poor H&S and found that quality is mostly affected. However, productivity and profitability ranked the least in that study, corresponding with findings in the current study. In another study by Smallwood (2009), it was found that productivity, followed by quality, was mostly affected by inadequate implementation of H&S and these result are inconsistent with the findings of the current study.

Table 3: Findings on drivers of H&S implementation

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Percentage frequency of responses</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>Disagree</td>
<td>Neutral</td>
</tr>
<tr>
<td>Need to manage hazards</td>
<td>0</td>
<td>0</td>
<td>7.14</td>
</tr>
<tr>
<td>They regard H&amp;S to be important</td>
<td>0</td>
<td>3.57</td>
<td>14.29</td>
</tr>
<tr>
<td>To comply with the legislation</td>
<td>0</td>
<td>0</td>
<td>8.93</td>
</tr>
<tr>
<td>They consider H&amp;S as the way to do business</td>
<td>0</td>
<td>3.57</td>
<td>14.29</td>
</tr>
<tr>
<td>To reduce costs associated with accidents and injuries</td>
<td>3.57</td>
<td>5.36</td>
<td>23.21</td>
</tr>
<tr>
<td>To preserve image and reputation of company</td>
<td>3.57</td>
<td>5.36</td>
<td>16.07</td>
</tr>
<tr>
<td>To achieve client satisfaction</td>
<td>1.79</td>
<td>10.71</td>
<td>23.21</td>
</tr>
<tr>
<td>For ethical reasons</td>
<td>3.57</td>
<td>1.79</td>
<td>32.14</td>
</tr>
<tr>
<td>To avoid penalties</td>
<td>0</td>
<td>17.86</td>
<td>25.00</td>
</tr>
<tr>
<td>To improve quality</td>
<td>3.57</td>
<td>12.50</td>
<td>25.00</td>
</tr>
<tr>
<td>To improve productivity</td>
<td>5.36</td>
<td>14.29</td>
<td>17.86</td>
</tr>
<tr>
<td>To improve profitability</td>
<td>5.36</td>
<td>12.50</td>
<td>30.36</td>
</tr>
<tr>
<td>Average</td>
<td>3.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The findings may have been slightly different due to the fact that there is increased awareness of H&S performance in the construction industry and organisations are conscious of the fact that there is a need to focus on managing hazards and preventing accidents through compliance, rather than focusing on widening profit margins. Thus view is supported in Chiocha et al. (2011), which acknowledged that legislations have an impact among project managers and contractors in particular, and on reducing accidents, but implied that the influence of legislations may be reactive rather than proactive. Issues relative to H&S should become business priorities and this will provide a platform for H&S improvement without the need to constantly change laws (Chiocha et al., 2011). In essence, this mind set will increase profitability and productivity (Muiruri and Mulinge, 2014).

CONCLUSION

This research study aimed to establish the drivers behind H&S implementation in construction organisations within the Gauteng Province in South-Africa. The objective was achieved. The study findings revealed the need to manage hazards, the importance of H&S and compliance with the legislation as the top three ranked drivers, and improved quality, productivity and profitability as the lowest. Research about the implementation of Health and Safety (H&S) within the construction
industry is critical, as construction organisations are aiming to improve their H&S performances on projects. With the current study findings, it can be said that construction organisations within the Gauteng Province are driven more by the H&S of their employees, than by making profits. Therefore, organisations should continuously pay attention to managing hazards and preventing accidents through compliance and this would invariably reduce accidents and fatalities and in the long run, improve quality, productivity and profitability. The current study provides useful information to assist construction organisations to pay more attention to H&S implementation. However, the drivers included in the study may not be exhaustive and the results may only be generalisable to the Gauteng Province and South Africa in general, but not to other geographical regions. Therefore, further studies could include more drivers and be conducted in other regions. Additionally, since the study adopted a quantitative approach, other studies could employ qualitative methods to obtain more in-depth information regarding these H&S implementation drivers. Further research is also required in order to determine the influence of the identified drivers on H&S implementation.

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AN INTEGRATIVE LITERATURE REVIEW OF CRITICAL LIVEABILITY INDICATORS IN URBAN TRANSPORT INFRASTRUCTURE PLANNING

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It is pertinent that urban transport infrastructure developments do not disrupt the lifestyle, health, wellbeing and quality of life of the citizenry for which they are planned. The study aims to identify critical criteria upon which liveability can be measured in an area or location in which transport infrastructure development (new or capacity expansion) is proposed. Existing literature was reviewed and synthesised to identify liveability indicators used in previous studies. Review materials were sourced from accredited journals and conference proceedings. The materials were selected based on their currency and possession of the following keywords and phrases: liveability, sustainability, liveability considerations, liveability indicators, wellbeing of habitants, road planning, and transport infrastructure. Thematic content analysis was used to identify the emerging themes (liveability indicators) from the review. The factors identified were discussed based on their frequency of occurrence, which revealed the relative degree of consensus about them in the literature reviewed. Findings indicate that pollution, ease of access to amenities, services and opportunities, efficiency and effectiveness of service, safety and security, generally indicate liveability (in relation to transport development) in an urban area. Other indicators including availability of alternative modes of transport, reliability/travel time reduction, street aesthetic quality and economic vitality/business environment were also reported as benchmarks for urban liveability. By identifying the indicators of liveability in an urban area, the study provides valuable information that will be useful to road infrastructure planners in evaluating the impact of proposed road infrastructure developments on the environment and the citizenry for which they are intended. The major limitation of the study lies in the fact that it presents a distillation of extant literature which may not really reflect the reality of what is considered “liveable”. Nonetheless, planners will take cognizance of the identified liveability indicators when planning for road projects, whether for new road or capacity expansion.

Keywords: development, liveability, planning, road infrastructure, wellbeing

INTRODUCTION

Transport infrastructure facilitates mobility of people and specialized products and services which are essential for development and growth and enhances the value of land wherein provided (Brown-Luthango, 2011). With transport developments, the location of households, businesses and social activities is made more attractive and lucrative, demand for properties is increased and changes in land use and employment opportunities emanate (Bon, 2015; Robins, 2015). However, despite the positive impacts of transport infrastructure in an urban area, negative effects have also been documented. These include air and noise pollution, congestion, excessive use of natural resources, and shrinking of land area (reduction of land available to households) as poor urban residents are massively displaced or uprooted and sometimes excluded from impact evaluations, leading to dissatisfaction with reduced quality of life (Selmic and Macura 2013; Lee et al. 2014; Robins 2015).

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Consequently, there is increasing interest in having liveability principles and goals to assist in guiding transportation system investments, with considerable focus on the interrelationship between transportation infrastructure, housing, and land use planning (Grant et al. 2012). This concern relates to the influence of transportation systems on the environment, economic health, and social well-being at geographic scales ranging from the local to the national (National Research Council (NRC) 2002). Community wellbeing is the foundation of any society, and thus, the quality of the built environments, and our access to education, jobs and social and cultural opportunities have significant impacts on community wellbeing, public health outcomes, social inclusion and interaction, and community safety (Commonwealth of Australia 2011). It is therefore pertinent that urban road infrastructure developments do not disrupt the lifestyle, health, wellbeing and quality of life of the citizenry for whom the infrastructure is intended and who ultimately benefit from and/or are burdened by the development in question. The quality of life or “liveability” which an urban area offers is also important in ensuring its future economic performance (Cities Alliance 2007).

According to Gough (2015), liveability in an area is formed by the totality of the physical and social characteristics, including the natural environment and a walkable and mixed-use built environment, economic potential near diverse housing options, and access to a broad range of services, and amenities that add up to a community’s quality of life. Liveable cities are equitable, socially inclusive, affordable, accessible, healthy, safe and resilient, offer a high quality of life and support the health and wellbeing of the people (Commonwealth of Australia 2011). They have attractive built and natural environments and provide a diversity of choices and opportunities for people to live their lives, share friendships, and raise their families to their fullest potential (Commonwealth of Australia ibid.). Liveable transportation systems, in particular, provide multiple choices of transport modes (public transit, walking, bicycling, and automobiles), reliable and timely access to jobs, community services, affordable housing, and schools while helping to create safe streets and expanding access to businesses and markets (Grant et al. 2012).

Although, liveability and sustainability are closely related and sometimes overlapping, liveability is only a subset of sustainability, others being environmental preservation and commerce (National League of Cities 2013). However, the idea of liveability bridges many concepts. It refers to the extent to which the attributes of a particular place can, as they interact with one another and with activities in other places, satisfy residents by meeting their economic, social, and cultural needs, promoting their health and wellbeing, and protecting natural resources and ecosystem functions (NRC 2002). Hence, there is a need to take cognizance of liveability considerations during transport planning. Liveability principles require that human factors take precedence over other factors in the provision of transportation in order to directly benefit people who live, work in, or visit an area (Faiz et al. 2012; Grant et al. 2012). Improving liveability requires an explicit attention to the satisfaction and wellbeing of households who live in the vicinity of planned transport infrastructure (whether new or adjustments) (Maloir et al. 2011).

Although research has been conducted on liveability indicators, few studies have focused on liveability indicators in urban transport planning. Some literature incorporated liveability and sustainability as a whole (Faiz et al. 2012; National League of Cities 2013; Gough 2015) and others focused on sustainability principles with scant attention to liveability aspects (United States (US) Government 2002; Boarnet 2008). Cities Alliance (2007) focused on environmental protection of cities and urban settlements and health preservation of inhabitants. Faiz et al.’s (2012) study centered on liveability and road development in
rural areas while Grant et al (2012) dwelt on liveability and sustainability principles during management and operations. The present study (which is part of a wider study on feasibility study factors in transport infrastructure planning) focuses on liveability considerations and indicators during urban transport planning. The objective of the study is therefore to identify liveability indicators in urban transport planning. The findings from the study will inform transport infrastructure planners and stakeholders in evaluating the impact of proposed transport developments on the people (users). In addition, attention to the identified liveability indicators and openness to factors which could influence the quality of life of the people or community where the infrastructure is proposed or being constructed helps to ensure acceptability of the project. Moreover, expensive and time-consuming rework later on will be reduced, and thus leading to improved efficiency in project delivery. The succeeding sections of this paper present the methods employed to achieve the objective of the study, the themed findings, and conclusion.

METHODS

The current study, which is part of a preliminary investigation in a wider study investigating factors to consider in feasibility studies for transport infrastructure, was conducted through a detailed and integrative review of extant literature. An integrative literature study reviews and synthesizes knowledge in its current state through a re-conceptualization of the subject (Torraco, 2016). The search for literature on liveability considerations and indicators began by listing the relevant keywords, namely, liveability, sustainability, liveability considerations, liveability indicators, wellbeing of habitants, road planning, and transport infrastructure approach adopted for the study was a desk study. Seven databases were searched (Google Scholar, Google, Scopus, Taylor and Francis Online, ASCE Library, Science Direct and Academic Search Complete). A simple matrix was conducted to determine which keywords and phrases led to relevant literature. Materials were selected only if they met the following criteria: possession of any of the keywords; articles published in the last 15 years (since 2002); and publications on transport infrastructure development and related areas. Each piece of literature was reviewed and synthesized to determine the focus, context and key findings. Thematic content analysis was thereafter used to identify emerging themes from twenty-four articles (out of a total of thirty-three) specifically focused on the liveability indicators for transport planning. The identified liveability indicators were tabulated based on their frequency of occurrence in the sampled literature and thereafter discussed to show the relationships between the works and views of authors (Avni et al. 2015). The indicators that recurred mostly were deemed to reflect high consensus among the authors.

LIVEABILITY CONCEPT AND PRINCIPLES

Liveability, derived from the word “liveable”, is defined broadly as suitability for human living (VanZerr and Seskin 2011). It refers to the subset of sustainability goals and impacts that directly affect community members, including local economic development and environmental quality, equity, affordability, basic mobility for non-drivers, public health and safety, and community cohesion (Litman 2016). In a study which compared liveability and sustainability in planning, in terms of scale, context and potential, Gough (2015) opined that the concept is one which generally offers choice and diversity in the range of amenities available to people who live and work in a community. It is more locality or region specific (gives primacy to local activities), has a direct influence on people, neighbourhoods and cities, entails micro-level behaviour changes, is locally defined through civic engagement,
and is receptive to design and planning intervention, responding to transactional relationship between people and place (Gough ibid.).

These views were supported in the study by Faiz et al. (2012) which focused on rural areas and stressed involvement of the local community and stakeholders in ensuring sustainable provision of rural roads. By incorporating liveability objectives into the planning and design of roads, communities can maximize the efficiency of the infrastructure while providing better access and mobility. Faiz et al. (2012) believes that liveability is largely affected by physical location and condition of public facilities and also is influenced by public policy and planning decisions. Liveable environments integrate physical and social wellbeing parameters to sustain a productive and meaningful human existence; productive in the sense that the social clustering of humans yields considerably more than the sum total of individual productivity, and meaningful in the sense that humans need to participate in forming successful and self-sustaining social systems by their very nature (Kashef 2016).

Grant et al. (2012), Gough (2015) and Litman (2016) revealed six liveability principles established in 2009 by the Partnership for Sustainable Communities, a collaboration among the US Department of Transportation, Environmental Protection Agency (EPA) and Department of Housing and Urban Development (HUD), which guide development of liveable communities. These include:

- Provide more transportation choices: Develop safe, reliable, and economical transportation choices to decrease household transportation costs, reduce our nation’s dependence on foreign oil, improve air quality, reduce greenhouse gas emissions, and promote public health.
- Promote equitable and affordable housing: Expand location- and energy-efficient housing choices for people of all ages, incomes, races, and ethnicities to increase mobility and lower the combined cost of housing and transportation.
- Enhance economic competitiveness: Improve economic competitiveness through reliable and timely access to employment centers, educational opportunities, services, and other basic needs by workers, as well as expanded business access to markets.
- Support existing communities: Target federal funding toward existing communities (through strategies like transit oriented, mixed-use development), and land recycling (to increase community revitalization and the efficiency of public works investments and safeguard rural landscapes).
- Coordinate and leverage federal policies and investment: Align federal policies and funding to remove barriers to collaboration, leverage funding, and increase the accountability and effectiveness of all levels of government to plan for future growth, including making smart energy choices such as locally generated renewable energy.
- Value communities and neighborhoods: Enhance the unique characteristics of all communities by investing in healthy, safe, and walkable neighborhoods (rural, urban, or suburban).

However, the above principles do not relate specifically to transportation. In relation to transportation, Grant et al. (2012) suggested that liveability includes: (i) addressing road safety and capacity issues through better planning, design, and construction; (ii) integrating health and community design considerations into the transportation planning process to create more liveable places where residents and workers have a full range of transportation choices; (iii) using travel demand management (TDM) approaches and management and operation strategies to maximize the efficiency of transportation investments; (iv) maximizing and expanding new technologies such as intelligent transportation systems.
(ITS), green infrastructure, and quiet pavement; (v) developing fast, frequent, and dependable public transportation to foster economic development and accessibility to a wide range of housing and employment choices; (vi) strategically connecting the modal pieces—bikeways, pedestrian facilities, transit services, and roadways—into a truly intermodal, interconnected system; and (vii) enhancing the natural environment through improved storm water mitigation, enhanced air quality, and decreased greenhouse gas (GHG) emissions.

The indicators which should be of concern to transport infrastructure planners and policymakers in ensuring that the above liveability principles are upheld are discussed in the next section.

**LIVEABILITY INDICATORS FOR TRANSPORT INFRASTRUCTURE**

*Table 1: Identified liveability indicators*

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Liveability indicators</th>
<th>Source/Year</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pollution (noise and air quality)</td>
<td>Cities Alliance</td>
<td>2007</td>
<td>11</td>
<td>46</td>
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<tr>
<td></td>
<td></td>
<td>Boarnet</td>
<td>2008</td>
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<td></td>
<td></td>
<td>Haas et al.</td>
<td>2009</td>
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<td></td>
<td></td>
<td>Malloir et al.</td>
<td>2011</td>
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<td></td>
<td></td>
<td>Grant et al.</td>
<td>2012</td>
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<td></td>
<td>Zhou</td>
<td>2012</td>
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<td></td>
<td>Doherty et al.</td>
<td>2013</td>
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<td></td>
<td></td>
<td>East Central Wisconsin Regional Planning Commission (ECWRPC)</td>
<td>2013</td>
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<td></td>
<td></td>
<td>Gough</td>
<td>2015</td>
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<td></td>
<td></td>
<td>Schmale et al.</td>
<td>2015</td>
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<td></td>
<td>Litman</td>
<td>2016</td>
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<tr>
<td>2</td>
<td>Mobility/walkability/connectivity/accessibility</td>
<td>Haas et al.</td>
<td>2009</td>
<td>9</td>
<td>38</td>
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<tr>
<td></td>
<td></td>
<td>Commonwealth of Australia</td>
<td>2011</td>
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<td></td>
<td></td>
<td>Malloir et al.</td>
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<td>Faiz et al.</td>
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<td>Grant et al.</td>
<td>2012</td>
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<td></td>
<td></td>
<td>Doherty et al.</td>
<td>2013</td>
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<td></td>
<td></td>
<td>National League of Cities</td>
<td>2016</td>
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<td>Kashef</td>
<td>2016</td>
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<td>Litman</td>
<td>2016</td>
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<td>3</td>
<td>Efficiency and effectiveness</td>
<td>Haas et al.</td>
<td>2009</td>
<td>8</td>
<td>33</td>
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<td></td>
<td></td>
<td>Commonwealth of Australia</td>
<td>2011</td>
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<td>Faiz et al.</td>
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<td>Grant et al.</td>
<td>2012</td>
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<td></td>
<td></td>
<td>Gough</td>
<td>2015</td>
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<td></td>
<td></td>
<td>Carvalho et al.</td>
<td>2015</td>
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<td></td>
<td></td>
<td>Matsuo</td>
<td>2015</td>
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<td></td>
<td></td>
<td>Kashef</td>
<td>2016</td>
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<tr>
<td>4</td>
<td>Safety and security</td>
<td>Haas et al.</td>
<td>2009</td>
<td>7</td>
<td>29</td>
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<tr>
<td></td>
<td></td>
<td>Commonwealth of Australia</td>
<td>2011</td>
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<td></td>
<td></td>
<td>VanZerr et al.</td>
<td>2011</td>
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<td></td>
<td></td>
<td>Grant et al.</td>
<td>2012</td>
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<td></td>
<td>Land Transport Authority (LTA)</td>
<td>2013</td>
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<td></td>
<td></td>
<td>Kashef</td>
<td>2016</td>
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<td></td>
<td></td>
<td>Litman</td>
<td>2016</td>
<td></td>
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<tr>
<td>5</td>
<td>Reliability/Travel time reduction</td>
<td>US Government</td>
<td>2002</td>
<td>7</td>
<td>29</td>
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<td></td>
<td></td>
<td>Boarnet</td>
<td>2008</td>
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<td>Haas et al.</td>
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<td>US Department of Transport</td>
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<td></td>
<td>VanZerr et al.</td>
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<td></td>
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<td>Grant et al.</td>
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Urban liveability, with particular reference to transport utilities, is indicated by measures that evaluate the quality of local road networks, mass transit, and connectivity and impacts on the wellbeing, health and quality of life of the citizenry for which transport infrastructure is provided or planned. This section presents these indicators, with regard to the frequency of occurrence in the sampled literature, as summarised in Table 1, which shows the extent of consensus about the measures.

Pollution (noise, and air quality)
Transport infrastructure developments affect air quality and climate (Schmale et al. 2015). According to Grant et al. (2012) and Litman (2016), the environmental quality, which is measured by how much fuel is used and pollution produced by transport operations (including traffic noise exposure and emissions from vehicles) influences liveability. Although evidence indicates that these emissions (such as particulate matter, hydrocarbons, carbon monoxides, sulphur dioxide and greenhouse gases can cause cancer) are harmful to human health (causing damage to vital body organs and respiratory ailments including asthma and bronchitis), they are rarely incorporated in transport planning (East Central Wisconsin Regional Planning Commission (ECWRPC) 2013; Doherty et al. 2013). Unsurprisingly, there is a huge consensus about pollution being a liveability indicator (as evinced by the highest ranking) due to its impact on public health. According to Zhou (2012), clean air and global climate change as well as healthy communities and ecosystems are part of the long-term goals proposed in the US Environmental Protection Agency (EPA)’s Strategic Plan. Non-motorized modes, and support for increased transit ridership and ridesharing should therefore be encouraged if liveability, with regard to health, is to be enhanced (Grant et al. 2012).

Mobility/walkability/connectivity/accessibility
There was consensus about these indicators, undoubtedly because of the essential need (movement) which transportation basically fulfils in everyday living. These second ranking indicators measure how efficiently people and goods move from place to place to access social, healthcare, recreational and economic opportunities along multi-modal networks and services (Commonwealth of Australia 2011; VanZerr and Seskin 2011; Grant et al. 2012; Doherty et al. 2013; Kashef 2016). Accessibility tends to be optimised with multi-modal transport and more compact, mixed-use, walkable communities and reduces the travel time required (Litman 2011; 2016). Mobility refers to the ability to move around as a result of less traffic volume. The idea of walkability is that communities should be pedestrian-oriented, with daily needs (residential, recreational, commercial and civic uses) situated within easy and enjoyable walking distance of each other or should be connected by both public and private transport alternatives (National League of Cities 2013). Walkability positively affects social capital (a measure of personal networks and connections and group involvement) since residents of lower traffic volume streets are more likely to interact with neighbours and show more concern over their local environment than residents of streets with higher traffic volumes and speeds (VanZerr and Seskin 2011).

**Efficiency and effectiveness**

Efficiency, measured by comparing the volume of service provided with the resource inputs, reflects operating margins; whereas effectiveness evaluates the social impacts and ability of the system to attain passengers’ maximum comfort or fewer passengers per fleet, and includes measures such as response time to incidents, claims due to potholes or guardrail damage, response time to public complaints/inquiries (Haas et al. 2009; Carvalho et al., 2015; Matsuo, 2015). According to Carvalho et al. (2015) and Matsuo (2015), efficiency and effectiveness are interrelated. Operators with smaller service areas have lower production efficiency due to lack of capacity, while their service effectiveness is higher due to their compact network and local knowledge. Significant improvements in transport infrastructure, vehicle and operational measures contributed to higher quality of service in Curtiba, with the implementation of a high-capacity bus rapid transit (BRT) system which has 20 miles of exclusive bus way for urban transport.

**Safety and security**

These include measures such as accidents’ cost savings as well as crash rates, injuries and fatalities (which could be disaggregated by mode) as well as traveller assault (crime) rates, traffic signal timing, electronic signs that display the speed of a passing vehicle (to remind motorists of their speed), visual cues/reminders and the addition and improvement of crosswalks and bicycle lanes (Grant et al. 2012; Land Transport Authority 2013). In addition, extension of road engineering measures such as pedestrian crossing lines with enhanced dash markings, traffic calming markings and “pedestrian crossing ahead” road markings will enhance pedestrian safety (Land Transport Authority 2013).

**Reliability of travel/Travel time reduction**

These indicators relate to travel time between key origins and destinations and delays as a result of unexpected traffic due to incidents, work zones, special events, or bad weather (VanZerr and Seskin 2011; Grant et al. 2012). A common liveability goal in many communities is how to reduce time spent travelling so that people can spend more time focusing on other things (US Department of Transportation 2011). Decisions therefore have to be made about creating opportunities for increasing speed or reliability of travel (for instance, diverting trucks to lower speed areas) or decreasing speed (for instance, by creating safer pedestrian crossings).
Integration of facilities
This measures the extent to which various components of the transport system (such as pedestrian and cycling access to transit) and future planning are incorporated into existing land use (Litman 2016). Planning should integrate a variety of recreational, commercial, residential and civic facilities essential to daily life of residents of different demographic characteristics (National League of Cities 2013). The goal is to consider what is being built, where building is to take place and the kind of transport choices availed and needed, in order to obtain desirable outcomes including less congestion, more liveable neighbourhoods and more mobility choices. For instance, instead of providing the same service to all travellers at a minimum fare, public transport services could be made differential to cater for low-income users as well as for those who value quality of service (Ong et al. 2010).
Integration of land use decisions and multi-modal transportation planning can help maintain liveability.

Comfort and convenience
These are qualitative in nature and as such, tend to receive less consideration in transport planning (Litman 2016). Convenient stops and stations, parking convenience, road smoothness, comfortable and convenient streets, network and services, which make travel stress-free, are elements of comfort and convenience (Haas et al. 2009; City of Johannesburg 2013). Consideration should also be given to the elderly and less mobile by providing fully equipped facilities to access amenities and participate in the society and economy (Land Transport Authority, 2013).

Availability of alternative transport modes/option value
According to VanZerr and Seskin (2011), this relates to the percentage of households within a quarter mile of transit, in “walkable neighborhoods,” or within a quarter mile of a bicycle route, and the number of options available versus auto accessibility. In a recent study predicting mode choices in different travel time-related policy scenarios, using multinomial logit regression, Zhang and Guan (2016) found that as service for particular modes of transport, for instance, transit or shopping shuttle bus, increases, travel time decreases, air pollution is reduced, energy consumption and traffic congestion are also reduced. Liveability considerations of providing more transport choices should result in a decrease in household transport costs, improvement in the quality of air, a reduction in greenhouse gas emissions and public health promotion.

Other factors such as street ambience, economic vitality/business environment and residents’ satisfaction and migration seemed to appear the least among the reviewed studies, reflecting little consensus on these elements as liveability indicators. Aesthetics (trees, public art and scenic views), parking and pedestrian countdown signals enhance the attractiveness of the environment as well as lifestyle (VanZerr and Seskin 2011; Grant et al. 2012; Schmale et al. 2015). Economic vitality, which has to do with freight movement, ridesharing programs, and bus rapid transit, measures efficiency and cost-effectiveness of movement of goods and people (Grant et al. 2012). With regard to residents’ satisfaction and migration, Maloir et al. (2011) posited that new transport infrastructure developments could impact negatively on residents and they may relocate as a result. In economic terms, local residents may derive a lower value from living at the subject location, but that this may not be reflected in property prices (Maloir et al., ibid.). This suggests that property value may not necessarily be an indicator of liveability in the subject area.
Summarily, the top-ranking indicators that have been identified to measure liveability in an urban area include pollution, mobility/accessibility, efficiency and effectiveness, indicating that importance is attached to transport’s impact on health and social values. Liveability, which embodies the perfection of transport systems and reduction of externalities that emerge from the proximity of incompatible uses, should be of paramount concern in transport infrastructure planning. As advocated in the 2013 Land Transport Master Plan in Singapore (LTA, 2013), transport planning needs to be altered to take into account various changes (building noise barriers, use of non-motorised vehicles, walkable and cycling lanes, providing fully-equipped facilities for the elderly and less mobile, *inter alia*) for the betterment of humanity. Citizens appreciate a climate-friendly, healthy and liveable city and look forward to deriving satisfaction through available and functional choices of mobility.

It is worthy of note that some of these are quantitative (example, accidents, traffic speed) and easy to measure and analyse. As such, they tend to receive more weight in the planning process; whereas qualitative measures such as comfort, walkability, lifestyle, and environmental impacts are more difficult to measure and seemingly receive less attention. Nonetheless, consideration of both quantifiable and qualitative indicators will enhance livability (Kashef (2016) and Litman (2016)).

![Figure 1: Frequency distribution of the identified liveability indicators](image)

**CONCLUSION**

The current study set out to identify liveability indicators for transport infrastructure through an integrative literature review. The objective of the current study was met. A summary and ranking of the indicators which emerged were tabulated. Pollution, mobility/accessibility, efficiency and effectiveness, safety and security, and increase in travel choices, were identified as the most important factors that indicate liveability. Other factors which emerged from the review were also deemed important although they received lower consensus among the sampled literature. The indicators are also represented in the bar chart (Figure 1) for a visual appreciation of the findings.
By responding to transactional relationship between a place, transport developments and the people who feel the direct impacts of such developments, liveability could be enhanced. The findings from this study will encourage community leaders, policy makers and transport stakeholders to prioritise and focus on specific initiatives or alternatives that will reduce the negative impact on health and have a real effect on quality of life. In addition, these findings will assist in evaluating the impact of proposed transport developments on the users. Moreover, attention to the identified liveability indicators and openness to factors which could influence the quality of life of the people or community where the infrastructure is proposed or being constructed helps to ensure acceptability of the project.

The major limitation of the study lies in the fact that it presents a review of literature, which may not really reflect the reality of what is considered “liveable”. However, through an integrated literature review, providing new knowledge as to the most important indicators in extant literature (sampled), the study provides information which would be beneficial to planners and policy makers in transport infrastructure planning.

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Examining the Definition of a Construction Project in Australia

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Internationally, the construction industry is overrepresented in accident rates compared to other industries. In Australia there was a national response to this issue with the introduction of The Australian Work Health and Safety Strategy 2012-2022 which highlights the need for risk reduction in the construction industry to achieve the vision of healthy, safe and productive working lives. Central to the strategy was support for collaborative efforts toward improving work health and safety (WHS) across all Australian states and territories (which each have their own WHS legislation). Despite an attempt to create harmonisation of WHS legislation under a set of model WHS legislation, there remain areas of difference between jurisdictions. One such area relates to the definition of a construction project under Section 6.4 of the model WHS Regulations. Under the model Regulations, once the value of construction works reaches AU$250,000, a principal contractor must be appointed and additional WHS responsibilities apply. Some states and territories have increased this monetary value, while Western Australia (WA) applies per person proxy measure of WHS risk to trigger these additional duties. This paper discusses the challenges associated with creating a harmonised definition of a construction project in Australia. The paper also discusses international perspectives and aims to provide additional understanding of the potential impacts of the model WHS regulation on small to medium enterprises (SMEs) in the construction sector, particularly as these relate to the threshold definition of a construction project. We draw on preliminary analysis of 50 interviews with construction industry stakeholders regarding the effectiveness of the current definition of a construction project in the Australian regulation. The advantages and disadvantages of the different approaches to defining a construction project for the purposes of the model WHS Regulations are considered. It is anticipated the final results of this research will provide insight to policy-makers in reviewing the operation of the financial threshold definition and suggesting practical, effective and efficient operation of WHS regulation for the construction industry, particularly as it relates to requirements for project planning and coordination.

Keywords: government, health and safety, policy, public health, regulation, risk.

Introduction

Construction work poses significant health and safety risks for workers. In Australia, between 2012 and 2013 the construction industry accounted for 9% of the Australian workforce but 10% of workers’ compensation claims for injuries and diseases involving one or more weeks off work. Between 2013 and 2014 the construction industry again accounted for 9% of the workforce but accounted for 12% of work-related fatalities (Safe Work Australia 2013b).

The Australian Work Health and Safety Strategy 2012-2022 provides a framework to drive improvements in WHS in Australia. It promotes a collaborative approach.
between the Commonwealth, state and territory governments, industry and unions and other organisations to achieve the vision of healthy, safe and productive working lives. The Australian Strategy identifies the construction industry as a Priority Industry (Safe Work Australia 2012).

Following two reviews of government services conducted in Australia, by the Industry Commission (1995) and the Productivity Commission (2004), in July 2008, all jurisdictions made a formal commitment to harmonise WHS laws in Australia. The Australian government statutory body overseeing WHS developed the model WHS Act and Regulations in 2011 in an attempt to harmonise the regulation of WHS across all Australian states and territories and create a level playing field with regard to the protection of WHS nationally (Safe Work Australia 2013; 2016). This process included the development and implementation of a complete and fully integrated package. This package consisted of a model Act, supported by model Regulations, model Codes of Practice and a National Compliance and Enforcement Policy. The model legislation was based on previously enacted National Standards and National Codes of Practice. The objectives of harmonising WHS laws through the model framework were:

- to protect the health and safety of workers
- to improve health and safety outcomes in workplaces
- to reduce compliance costs for business, and
- to improve efficiency for regulator agencies.

The intention was for government in each jurisdiction to adopt the model Regulations including the definition of a construction project; yet almost a decade later, national consistency has not been achieved. Some of the reasons identified in research and reports for the lack of harmonisation include:

- each state’s or territory’s unique industrial relations culture
- environment and policy objectives
- local interests and resistance to change
- states’ and territories’ treatment of national standards as optimal or minimal standards that they could choose to ignore or build upon according to local needs and circumstances, and
- genuine differences in opinion about how to best address issues that are technically complex, economically important and politically and industrially sensitive (Grabosky 1991; Productivity Commission 2013; Windholz 2013a; Windholz 2013b).

Section 6.4, Regulation 292 of the model WHS Regulations contains the definition of a construction project. Construction works which are valued at $250,000 or more are defined as a “construction project”. Construction projects trigger additional WHS duties including the appointment of a principal contractor and planning and coordination duties that extend beyond the standard requirements of construction works. The objective of the principal contractor requirement is to ensure coordination of activities on larger construction sites where there are a number of persons conducting business or undertaking working at the same time, carrying out different tasks with an increased level of WHS risk.

The $250,000 threshold definition was formulated by group consensus of panel members of the Australian government statutory body. The panel members
represented the commonwealth and each state and territory, the interests of workers, interests of employers, and an independent chair. Prior to implementation of the $250,000 threshold definition, Queensland (QLD) had in place a financial definition of $80,000. While, QLD’s value was lower than the current threshold, at the time of introduction of the model WHS legislation the QLD government was considering increasing the threshold amount.

The construction threshold is intended to exclude lower-cost (and presumably lower WHS risk) construction work from scope. However, its introduction has not been uniform and this paper discusses the challenges associated with this aspect of the national harmonisation effort within Australia. The paper also discusses international perspectives and aims to provide additional understanding of the impacts of the threshold definition on small to medium enterprises.

**METHODS**

Sample characteristics

A total of 50 interviews were conducted with industry associations (32%), regulatory and government agencies (28%), unions (14%), construction companies (12%) and other individuals involved in the construction industry i.e., academics and lawyers (14%). Respondents had an average tenure of 12 years’ experience in the construction WHS community. Individuals representing all jurisdictions, including the Commonwealth, were interviewed.

Measures

Semi-structured questions related to the specific impacts of the threshold definition of a construction project on organisations of varying sizes. Development of the interview schedule was based on a review of the literature.

Data analysis

The interviews were transcribed and coded using NVIVO 11. The coding process involved the development of an initial coding list based on the research aims. The data were then analysed using thematic analysis. Themes, patterns and insights were documented, as well as identifying data that were distinct or contradictory. Inter-rater reliability was established with a second member of the research team coding 10% of the transcripts. This validation exercise resulted in 90% agreement with full consensus reached through discussion. The themes are discussed in a de-identified format to preserve anonymity of respondents.

Results

Results are presented in the section titled small-to-medium contractors.

**ADOPTION OF THE MODEL REGULATIONS**

As noted earlier in the paper, one area in which the model WHS legislation has not produced national consistency is in the way the states and territories have adopted the threshold definition of a construction project. Table 1 shows the differences in threshold definition by jurisdiction.

The Northern Territory (NT), South Australia (SA) and Victoria (VIC) have increased the threshold project value at which additional responsibilities apply in construction projects. Examples of the reasons cited for these increases include the regional or remote location of works, the cost of building materials or wages, and inflation.
Western Australia (WA) has also not adopted a financial threshold, instead using a proxy measure of risk which relates to the number of persons on a site to trigger principal contractor planning and coordination duties. The per person definition was derived from the Australian National Construction Standard (2005). The Standard states that, on sites where there are five or more persons working or likely to be working, a principal contractor is required. It is unclear how the threshold number of five persons was established. Some potential sources are outlined. Historically, in UK legislation every business has been required to establish a health and safety policy. However, in the case of a business with less than five employees the policy does not need to be formal (i.e., written down; Health and Safety Executive).

Table 1: Jurisdictional differences in the definition of a construction project

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Capital Territory</td>
<td>$250 000</td>
</tr>
<tr>
<td>Commonwealth</td>
<td>$250 000</td>
</tr>
<tr>
<td>New South Wales</td>
<td>$250 000</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>$500 000</td>
</tr>
<tr>
<td>Queensland</td>
<td>$250 000</td>
</tr>
<tr>
<td>South Australia</td>
<td>$450 000</td>
</tr>
<tr>
<td>Tasmania</td>
<td>$250 000</td>
</tr>
<tr>
<td>Victoria</td>
<td>$350 000</td>
</tr>
<tr>
<td>Western Australia</td>
<td>5 or more persons</td>
</tr>
</tbody>
</table>

Note: All values shown in AUD.

The UK Construction (Design and Management) Regulations 2007 also restricted the application of sections of legislation when the largest number of persons at work at any one time carrying out construction work included in the project will be or, as the case may be, is less than five. The 2015 version of the CDM Regulations modified the trigger for notifiable construction sites to a) work is scheduled to last longer than 30 working days and on which more than 20 workers are occupied simultaneously, or b) on which the volume of work is scheduled to exceed 500 person-days.

While, WA expressed in-principle support for the concept of harmonisation, the threshold definition of a construction project has been a contentious issue (Marsden Jacob Associates 2012). During a regulatory impact statement period, it was identified that changing to a financial threshold would be inequitable and increase costs for smaller businesses and construction companies operating in regional or rural locations. The additional cost for small business was cited in the report as being associated with additional paperwork (i.e., development of systematic processes) that larger businesses already have in place. The report stated that works being undertaken regionally or remotely would fall within the scope of being classified as a construction project (due to the costs of materials, labour and transportation) whereas the same project would be out of scope in a metropolitan area. The implication being that the financial definition would be unevenly applied to construction works. That is, the same work with corresponding levels of WHS risk, being conducted in two
geographically different locations would be subject to different levels of legislative duties.

While the number of workers on a project can contribute to complexity as increased coordination is required between construction teams (Lingard et al 2014), there is currently no research in Australia comparing the use of a monetary threshold or a per person threshold to ascertain which acts as a better proxy measure of WHS risk.

**Challenges associated with a financial definition**

The monetary threshold definition of a construction project is intended to be a proxy for the WHS risk presented by construction works (Safe Work Australia 2011). That is, increasing value is associated with larger projects which common sense suggests would require additional coordination activities. Hence, a monetary value is used to trigger the requirement of the appointment of a principal contractor, whose role is to manage WHS risks that arise from increasing project complexity. The ideal definition of a construction project would account for all the unique features of the construction environment that create elevated WHS risk. Unlike other industries, construction has a project-based structure comprising temporary organisational structures (Shirazi et al 1996). Each project environment presents a unique challenge for planning, coordination and management of individuals involved in these projects (Dubois & Gadde 2002). Individuals on construction sites deliver bespoke products to meet a particular client’s or service needs. The workforce is transient and mobile. These characteristics can lead to significant WHS risks for workers. An additional layer of complexity relates to the intricacies or interconnected parts within a project (Xia & Chan 2012). For example, during project stages, the composition of teams involving people from different backgrounds, locations and organisations changes. The communication between these teams has implications for WHS outcomes (Lingard et al 2014). Contracting and subcontracting arrangements are also associated with adverse WHS outcomes (Manu et al 2013). The need for a principal contractor to manage and coordinate works so that they do not pose an undue risk to WHS is recognised.

There are several issues and assumptions associated with using a financial threshold definition of a construction project. The greatest challenge arises from a lack of evidence of the direct relationship between the project value and WHS risk. Construction work valued at under $250,000 may still present serious risks, for example, if it involves the removal of asbestos. Conversely, construction work may be valued at $250,000 or more and present a low level of WHS risk. For example, a single builder constructing a long fence over an extended duration. In fact, in terms of WHS, some research evidence suggests that projects that cost the least are statistically the most dangerous (Arboleda and Abraham 2004). 48% of fatal accidents in trenching operations examined in the US construction industry occurred in works with a value of less than US$250,000, and was this was often attributed to the fact that, in small construction works, insufficient budget allocation is provided for relevant protection systems, equipment or other construction WHS measures (Arboleda and Abraham 2004). This research suggests that certain construction activities are dangerous irrespective of their value. Arboleda and Abraham (2004) observed that the fatality risk for small contractors (less than 50 workers) in smaller works (less than US$250,000) was high and that that greater WHS effort should therefore be focused on smaller construction projects. Arboleda and Abraham’s (2004) research illustrates that in certain construction activities, a monetary threshold definition could potentially
exclude some high risk works, despite the fact that the level of WHS risk presented is high.

Key stakeholders in the construction industry include construction companies, industry associations, unions, regulators and other government agencies. Perceptions of the characteristics of an effective definition may vary between these groups. Arguably, those most impacted by the financial definition would be smaller organisations working on lower value contracts.

In Australia, more than 98% of construction organisations are small businesses, employing fewer than 20 people (Australian Bureau of Statistics 2013). Compared to other industries, Australian construction workers have relatively low levels of educational attainment and literacy (Australian Bureau of Statistics 2013b). As capacity to comply with WHS duties is also influenced by language and literacy levels, this has potentially negative implications for safety performance of the construction industry. This prevalence of small contractors and low literacy levels highlights the need for the definition to be clear and simple.

In practice, the relatively low definition of $250,000 is likely to impact smaller contractors more than larger contractors. Larger organisations often outperform smaller organisation with regard to WHS as they tend to have greater resources and expertise to develop safer and healthier systems of work (Sunindijoa 2015). Different sized firms also tend to approach work differently which has implications for WHS definitions and outcomes. Aboagye-Nimo et al. (2013) report that large firms typically adopt bureaucratic and context-free approaches to managing WHS, while small firms adopt a common sense, informal and situational approach.

**Small to medium contractors**

The interview data identified several challenges for small to medium contractors, including that were that they were more likely to be impacted by the threshold than larger contractors, they lack the systems and resources to efficiently manage WHS risk, they take a compliance-based, rather than proactive approach to dealing with WHS, generally have lower education levels and are less likely to engage with the regulator. Medium-sized contractors were particularly at risk of poor WHS outcomes as their organisations grew and they began to take on larger and inherently riskier projects. While these findings are consistent with previous research (McVittie et al 1997; Tam et al 2004), in the context of the financial threshold they have important implications. First, smaller businesses are more likely to be impacted by the threshold but due to their limited resources and engagement with the regulator, they may not have adequate experience or education to comply with the regulations. Second, SMEs have expressed a preference for clear, simple and prescriptive legislation that requires minimal interpretation. Without additional support and education, they may struggle to cope with what is effectively a process requirement that requires interpretation, judgement and customisation to the requirements of a particular project.

**Indexation as an issue**

Another important issue relating to the operation of the financial threshold definition of a construction project relates to if it should be subject to price indexation, and, if so, what type of indexation should apply. The monetary construction project threshold in the model WHS Regulations was derived from old Occupational Health Safety regulations applying in New South Wales (NSW) and VIC. The $250,000 amount was first prescribed in NSW laws in 2001 when the average new house cost $145,000
One question facing the use of a financial definition is whether it should be subject to indexation. It has been argued that inflation is responsible for inadvertent capture, whereby, low risk works are captured under the definition due to rising costs of construction work. The Australian Bureau of Statistics provides three potentially relevant indexation methods:

- consumer price index
- producer price index
- wage price index

Consumer price index (CPI) is widely used and understood in Australia (Australian Bureau of Statistics 2016). Arguably, the CPI does not take into account changes in building costs associated with changes in the costs of materials and labour as it is more closely associated to consumer costs than business costs. That is, CPI does not reflect the costs of construction that ultimately determining the value of a project. The producer price index (PPI) measures the changes in the prices of goods and services as they either leave the place of production or as they enter the production process. This has an indirect relationship with construction (ie., cost of materials). The cost of construction activities is directly associated with wage costs. The wage price index is a measure of total hourly rates of pay excluding bonuses. In part, labour costs relate to the cost of construction works. However, this still does not represent the whole picture. Despite these advantages, there are more broad considerations of the adoption of indexation.

Indexation, regardless of the method, has the potential of creating additional regulatory burden (ie., calculation and communication) and being disruptive to industry. The method of calculation may be considered subjective and create conflict among industry members. This would contrast some of the aims of the harmonisation legislation, such as reducing regulatory burden and creating a consistent and objective definition. Moreover, the updates to the regulations would require political support and effective communication with industry members and organisations.

**Costing practices on construction sites**

The Construction Work Code of Practice explains how to value construction work for the purposes of the model WHS Regulations (Safe Work Australia 2013). The code defines the cost of construction as the contract price for carrying out the work and sets out relevant inclusions:

- project management costs associated with the work,
- the costs of fittings and furnishings, including any refitting or refurbishing associated with the work (except where the work involves an enlargement, expansion or intensification of a current use of land) and
- any taxes, levies or charges (other than GST) paid or payable in connection with the work by or under any law.

The Code excludes:

- the cost of the land on which the development is to be carried out, including the civil engineering, utility and other land development cost involved in a land subdivision
- the costs associated with marketing or financing the development (including interest on any loans)
the costs associated with legal work carried out or to be carried out in connection with the development.

Despite guidance produced by regulatory agencies, there are a range of costing practices used in the construction industry and the method employed to cost a project has a direct relationship on the effectiveness and impact of the financial threshold definition. Additional factors relating to the use of a dollar value in the construction context are outlined in Table 2.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Reflection on the dollar value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry context</td>
<td>Construction is highly and changeable, comprises many parties with different business and project objectives, and is exposed to uncontrolled environments, including the weather and project uncertainty (e.g. geotechnical conditions).</td>
</tr>
<tr>
<td>Costing practices</td>
<td>Construction project costs are influenced by: market conditions, the scale and scope of the project, complexity of the project, method of construction, site constraints, location of the project, design criteria and/or buildability, the client’s financial position, and the strategic value in winning work for a particular contractor. Other considerations may relate to availability of cash, urgent need for work, past experience in similar projects, degree of difficulty, project risk, a contractor’s current workload, and contract size.</td>
</tr>
<tr>
<td>Contract price</td>
<td>Does the contract price reflect the cost of the work, the tender price or the value to the client?</td>
</tr>
<tr>
<td>Estimation process</td>
<td>Contractors will estimate the costs of construction, using fairly robust cost estimating tools, but will then add a sum to this for their expected profit margin as well as contingency/risk that they perceive to be inherent in the project.</td>
</tr>
<tr>
<td>Budget overruns</td>
<td>Research shows that construction costs are underestimated in almost nine out of 10 public sector projects</td>
</tr>
<tr>
<td>Cost escalation</td>
<td>Cost escalation can be attributed to improperly managed risk and uncertainty, rework, scope creep, optimism bias; but also suspicions of manipulation and opportunistic behaviour.</td>
</tr>
<tr>
<td>Procurement methods</td>
<td>For example, design-bid-build and design and construction arrangements are generally characterised by a large degree of variability in the integration between design and construction.</td>
</tr>
</tbody>
</table>


INTERNATIONAL DEFINITIONS

Internationally, many regions employ non-financial definitions for triggering principal contractor duties (or duties for coordination and project planning for WHS that are comparable to those included in the model WHS Regulations). Given, Australian legislation has historically closely followed developments in the UK, the current definition of a construction project in the UK is now outlined and discussed.

The Construction, Design and Management Regulations (CDM) 2015 came into force on 6th April 2015, revoking and replacing CDM 2007. Under the CDM regulations, the client is required to appoint a principal contractor for all projects involving more
than one contractor. Similar to Australia, the principal contractor has duties to plan, monitor and control WHS during the construction project. The UK regulations specifically state that the principal contractor must ensure all contractors involved in the project co-operate with one another and their work is coordinated. Duties in the project preparation stage included:

- ensuring a WHS plan is was drawn up for a project, and
- preparing a file appropriate to the characteristics of the project containing relevant WHS information to be taken into account during any subsequent works.

There are also extensive duties set out as part of the project execution stage. The need for planning and coordination with respect to WHS in construction projects is acknowledged in industry guidance and legislation. In the UK, the Construction (Design and Management) Regulations 2015 establish duties for clients, principal designers and principal contractors, other contractors and workers. Principal Contractors are responsible for planning, managing and monitoring construction work under their control. Where more than one contractor is engaged in the project, Principal Contractors are also responsible for coordinating their activities in the project team.

Interview data from construction WHS experts in the UK identified that the new definitions capture more SMEs. This is an important consideration for application of a similar definition in Australia.

**Multicomponent definitions**

In Australia and internationally, definitions have been enacted comprising multiple elements, though not in relation to WHS regulation. For example, the UK used a monetary threshold to trigger principal contractor duties for site waste management plans. This legislation came into effect in 2008, yet following a government review of 21,000 regulations on different themes, site waste management plans were no longer compulsory from 1 December 2013. The definition consisted of a two-tier financial threshold which triggered additional requirements for waste management plans on construction sites. The first threshold was £300,000 and the second, which required more detail, was £500,000 (United Kingdom Government, 2013). The revocation of this legislation was an attempt to reduce administrative costs for construction projects (Newground 2013; Wilkinson 2013). One source stated that the use of a financial threshold in this instance was ineffective as it created too much regulatory burden (Wilkinson 2013).

**Recommendations and future research**

This paper has highlighted the lack of data relating to WHS implications of the definition of a construction project in Australian. While inherently challenging to explore, future research should seek to address the effectiveness of process based legislation in improving WHS outcomes on construction sites, in particular, the influence of legislative change on WHS outcomes for SMEs. WHS law exists to identify the responsibility of the parties involved in industrial or commercial activities. It imposes responsibilities on employers (and others) to protect the health and safety of workers when they are at work and protects the right of people to participate in the workforce without suffering injury or ill health as a result. As such, the law should be of primary importance in providing a ‘level playing field’ and ensuring that employers do not profit from failing to provide adequate protection for their workers’ health and
safety. Some considerations for the effectiveness of a legislative definition include that it should be practical, understandable, equitable and effective.

A practical definition should be easy to use. That is, the conditions under which it is applicable or not applicable should be easy to identify. These conditions should not be subjective. The construction environment is unique with sites changing daily. The definition should be reliable and robust to this unique context. Definitions need to be understood by all stakeholders. For example, an inspector must be able to easily understand the definitions’ application to a variety of construction works. To the extent that it is reasonably practical, all members of the construction industry must be able to make sense of their legislative requirements. Stakeholder groups or individuals should be equally impacted by the definition. For example, variations in geographical location, organisational size or industry sector should not mean that the definition is applied differently. How does the definition meet the intent of the legislation, and by extension of that, the broader outcomes of WHS legislation? Where the overall objective is to improve safety on construction sites, do stakeholders who are subject to the legislation understand how the legislation meets this need? Moreover, the enactment of that legislation in practice should produce positive safety outcomes. Application of this multiple criteria could be applied to determine the effectiveness of a threshold definition for the purposes of triggering specific WHS responsibilities in construction projects.

CONCLUSIONS

The construction industry is a priority industry for developing safer and healthier work environments in Australia. Construction projects require special coverage under the model WHS Regulations. As coordination and management activities can greatly mitigate project risks, there is a need for the establishment of an effective definition. Moreover, the definition is significant to the construction and WHS communities as it is used to indicate the level of WHS management required on a construction project in Australia. The challenges associated with creating a fair, objective and practical definition are apparent. In particular, relating to the fair inclusion of SMEs in the construction industry. This research has highlighted some of the key issues, including indexation and costing practices. Harmonised legislation could benefit Australia in terms of reducing regulatory burden and stimulating economic growth. It remains unclear, if the definition of a construction project will eventually be harmonised nationally.

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A REVIEW OF ETHICS IN MATERIALS SOURCING IN THE CONSTRUCTION INDUSTRY TOWARDS SUSTAINABILITY

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The quest by government in developing countries to deliver infrastructure for large-scale developments in developing countries is putting pressure on natural resources. There is the urgent need for the implementation of sustainable practice in the built environment in creating these infrastructures for this intended development. Literature has suggested the need for various stakeholders to take pragmatic steps towards achieving sustainability globally. Ethical sourcing of materials for the construction industry, which is in line with sustainable strategies for development will provide a means to achieve sustainability considering the various challenges currently bedevilling the ecosystem ranging from environmental degradation, social inequality, poverty and corruption. This paper presented a review of important aspects relating to sustainability in material sourcing on corporate social responsibility, ethical sourcing of materials and sustainability reporting for the construction industry in developed and developing countries. The findings indicated that the construction industry is operating in an unsustainable manner, there is global demand for sustainability implementation by various stakeholders in the construction sector. Furthermore, sustainability reporting is still at infancy particularly in the construction industry. Hence ethical sourcing of materials is still an emerging phenomenon. The study concludes that the adoption of ethical practices in the construction industry will go a long way in enhancing sustainability practices in the construction industry.

Key words: Ethical material sourcing, Corporate social responsibility, Sustainable construction, Sustainability reporting.

INTRODUCTION

The construction industry contributes positively to the Gross Domestic Product (GDP) of both developed and developing countries in addition to the industry’s capacity as a reliable employer. Ebhon and Rwelamila (2001) submitted that the construction industry lays the footing for all other development activities. It contributes between 5-7% to the total GDP in Nigeria (Olatunji and Bashorun, 2006). Osmani, Glass and Price (2008), Shakantu (2004) noted that the construction industry improves the quality of life by providing development infrastructure needed for social and economic growth of every nation.

The relationship between the environment and construction industry can be said to be symbiotic since the industry relies heavy on the environment for inputs. According to Ugochukwu et al. (2015) construction inputs also determines the success of a project, where a shortfall affect both the quality and time of project completion.

The construction industry sustainability uptake has often been a source of concern for stakeholders. Loosemore and Phua (2011) noted that the activities in the construction

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industry are often criticized due to issues relating to environmental impacts, labour, welfare conditions and corruption. Woolley (2000) again affirmed that the activities in the construction industry are the greatest destroyer of the environment. This was also confirmed by Ebohon and Rwelamila (2001) who pointed out that construction activities can be judged as the major consumer of natural resources that contributes significantly to global warming by altering the ecosystem, causing floods, destruction to flora and fauna, among others attributable disasters.

The challenges facing developing countries differs significantly from their developed counterparts. Ofori (1998), du Plessis (2007) noted that the challenges in developing countries includes: frail institutions of authority, expanding population, social injustice, unstable political structure as well as high deficit in shelter and basic infrastructure.

These challenges have negatively affected the efforts of developing countries to ensure sustainability in the construction sector. Not only that, Lehmann (2013) noted that activities in the construction industry adds to the global greenhouse gas effect resulting in inefficiencies and high energy consumption. As a caution, MIT (2013) asserted that the present levels of CO$_2$ absorbed into the atmosphere are already high at about 478ppm due the presence of other greenhouse gases in the atmosphere. Again, Sev (2009) observed that resources consumption pattern in the Sub-Saharan countries cannot judged to be sustainable, which requires a realistic approach since these resources are limited.

Developed countries have responded to calls from stakeholders by setting up sustainability targets and establishing schemes that guide construction materials procurement. Furthermore, developed countries have also implemented certification with schemes that includes; the building research establishment environmental assessment method (BREEAM) and voluntary ethical trading initiatives (VETI).

Glass (2011) believed that sourcing of construction inputs particularly materials, will help to provide a headway towards achieving sustainability. Du Plessis (2007) noted that developing countries should leverage on this opportunity to achieve sustainability particularly in the construction sector so to avoid issues relating to technology lock-in among others. The aim of this paper is to add to the existing body of knowledge in regards to sustainability in the built environment particularly relating with respect to the sourcing of material for the construction industry.

**RESEARCH METHODOLOGY**

The methodology for the research was a critical review of related literature such as journals, conference papers, reports and books. This involved a thorough review of journals such as the International Journal of Physical Distribution and Logistics Management, Journal of Business Logistics, The Georgetown International Environmental Law Review and Accounting, Auditing & Accountability Journal, and environmental reporting among others.

The critical review strategy adopted is similar to what Bemelmans et al., (2012) and Tang et al., (2010) proposed in their studies. This study adopted the following procedure to search for papers related to the study:

1. Scanning of paper title and abstract of related materials published
2. Searching of keywords on many online databases such as keyword search was also carried out on several online databases, including Science Direct, Business Sources Premier, Emerald Database and Taylor & Francis among others.
3. Additional review of abstract of materials downloaded to select only the relevant ones.

LITERATURE REVIEW

Sustainable construction

Sustainable construction has attracted a lot of interest both in the academics and the industry. It is seen as a response by man to the various activities relating to the degradation of the ecosystem, bias utilisation of natural resources by a section of the world population after major milestone such as the Second World War (Dania et al., 2013).

Bourdeau (1999) believed that sustainable construction uptake in the construction industry was necessitated by calls for the industry to be sustainable in its activities. The industry responses should include: efficient energy usage, reduced waste generation as well as, decreasing the negative impact on land, air quality and indoor environment (Pearce et al., 2012). Further response by the construction industry resulted in the establishment of various committees and panels with members cutting across various disciplines and regions. This was reinforced by organising relevant conferences across the globe which latter grave birth to the widely recognized ‘Agenda 21 for Sustainable Construction’ (CIB, 1999). The developing countries however, expressed their discontentment over the Agenda 21 idea for sustainable development due to non-consideration during planning process (du Plessis, 2007; (Ofori, 2007). This new approach further gave birth to what was tagged Agenda 21 for sustainable construction in developing countries (Dania et al., 2013).

Unfortunately, the approach has not made any significant contribution to sustainability practices in the developing countries due to inherent challenges ranging from lack of political will to frail institutional frameworks for sustainability.

Table 1: Various definition of sustainable construction

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>WCED (Brundtland Report)</td>
<td>“Development that meets the needs of the present without compromising that ability of future generations to meet their own needs”</td>
</tr>
<tr>
<td>1991</td>
<td>The World Conservation Union (IUCN)/United Nations Environment Programme (UNEP)</td>
<td>&quot;Improving the quality of human life while living within the carrying capacity of supporting ecosystems&quot;</td>
</tr>
<tr>
<td>1994</td>
<td>Charles Kibbert</td>
<td>“The creation in a responsible manner of a healthy built environment based on resource efficient and ecological principles”</td>
</tr>
<tr>
<td>1996</td>
<td>International Council for Local Environmental Initiatives, (ICLEI)</td>
<td>“Development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural, built and social systems upon which the delivery of those systems depends (International Council for Local”</td>
</tr>
<tr>
<td>2007</td>
<td>Du Plessis</td>
<td>&quot; An integrative and holistic process of construction which aims to restore harmony between the natural and the built environment&quot;</td>
</tr>
<tr>
<td>2010</td>
<td>Said et al.,</td>
<td>&quot;Sustainable construction is construction that contributes to and upholds sustainable development”</td>
</tr>
</tbody>
</table>

Ethical Sourcing of Materials
Unquestionably, the outcome of the Brundtland Report in 1987, the reports of the Rio de Janeiro and Johannesburg meeting as well as other recent efforts such as the Agenda 21 for sustainable construction have all contributed significantly to the global effort in achieving sustainable development. The most widely accepted view of sustainable development is that of the World Conference Environment and Development (1987), which views it as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Furthermore, Rodney et al., (2016) noted that this concept relies heavily on the triple bottom line of sustainability which comprises of: economic prosperity, environmental quality, and social equity. The dependence of man on the environment for survival has put more pressure on the ecosystem. The construction industry has been known as a heavy consumer of natural resources in its daily activities and also as a heavy polluter. This was affirmed by Ebohon and Rwelamila (2001) who point out that, the provision of infrastructures and amenities for the growing human population utilises 25% of world timber, 16% of fresh water and utilises 40% of energy. This might continue to be the case with the rapidly increasing world population, where demand for natural resources for survival will be the order of the day. Lehmann (2013) asserted that the use of construction materials such as zinc, timber, tiles, glass and paint which consumes large amounts of natural resources from the extraction stage to the production stage. Furthermore, the processes also dissipate large concentrations of toxic gases into the atmosphere in form of carbon dioxide (CO$_2$), sulphur dioxide (SO$_2$) and nitrogen dioxide (NO$_2$) as pollutants causing global warming. As a wakeup call, the United Nations Department of Public Information (UNDPI, 2013) stresses that the emission patterns of carbon dioxide have risen from 5% in 1990 to the all-time high level of 46% between 2009 and 2010. Furthermore, the Intergovernmental Panel on Climate Change report (2013) reveals that the alteration in climate pattern was linked to continuous human activities implicating the construction industry. These climate alterations will continue even if carbon dioxide (CO$_2$) discharge into the atmosphere is reduced. It is pertinent to note that the report also predicted that temperature will be tepid between 0.3°C and 4.8°C. The effects of these changes have begun to manifest as increase in heat waves, changes in the intensity and frequency of rainfall, and rising levels of large water bodies among others (du Plessis, 2014).

Ebohon and Rwelamila (2001) maintain that resources production pattern pollutes the rivers and other water bodies in addition to affecting the carbon credit due to deforestation and bush burning. The solution is simply to adopt sustainable practices so that humanity’s continued existence will be guaranteed. Hence, there is an urgent need for ethical behavioural change on resources consumption due to the earlier highlighted challenges to the continued survival of humanity since it depends entirely on the ecosystem for survival. Kabir et al. (2014) believed that ethical sourcing frameworks should incorporate human rights, health, safety and environmental considerations across the material supply chain. According to Glass (2012) there is the substitution of ethical sourcing with responsible sourcing and sustainable procurement in some literature. It is noted the UK standards BS8902 (2009) and BES6001 (2009) are all tailored towards achieving sustainability in the built environment. Ethical sourcing covers issues relating to corporate social responsibility, sustainability reporting.
Lippmann (1999) was of opinion that organisations derive some advantages such as quality of product enhancement, reduced risk to their reputation damage which increases their profit at the long run. Contrarily, Ballou et al., (2000) believed that organisations might not achieve the much competitive advantage with the introduction of ethics during materials sourcing. This might be attributed to low awareness levels in the construction industry.

However, the global awareness and adoption of ethical sourcing strategies is an emerging phenomenon for construction materials both in developed and developing nations. As noted by Glass (2013) the United Kingdom only recently put in place measures to achieve its sustainability agenda, which includes the setting up of target for the adoption of a standard for responsible sourcing for its product and materials in the construction industry. This was due to limited subscription to ethical sourcing principles of small and medium sized companies. HM Government (2008) submitted that in the United Kingdom (UK), the concept of ethical sourcing has only just begun to emerge as a reaction to the government`s approach on sustainability implementation in the construction industry.

**Corporate Social Responsibility**

Corporate social responsibility is an outcome of the effort put toward achieving sustainability objectives. Jones et al., (2006) believed that ethical behaviour by business organisations in the construction sector, which is also in line with corporate social responsibility objective can give advantages over other competitors. This is enabled by the provision of a platform to balance the organisation sustainability objective with their economic goals. The stakeholders requisition for more non-financial disclosures from business organisations on socials, economic and environmental performance is now on the rise (Ritz and Ranganathan, 2001). Jeffrey and Jon (2013) also added that shareholders and other key stakeholders such as communities, customers, employees and suppliers now demand corporate social responsibility performance from organization.

Some studies carried out such as that of Adams (2002); Larrinaga-Gonzalez et al., (2001);and O`Dwyer (2002, 2003) observed that stakeholders have begun to focus their attention towards sustainability reporting and corporate social responsibility demand, from organisation owing to the growing interest on sustainability. O`Dwyer (2002) submitted that the principal drive for sustainability reporting by organisations was to improve their business legitimacy to various stakeholders. However, the wider society continues to be suspicious that sustainability reporting might not have significant impact on sustainability owing to the scepticism regarding organisations` corporate reporting.

Adams (1999, 2002) examined the impact of agents in organisations that make decisions, level and extent at which various stakeholders are involved in sustainability reporting. The research further explored the types and reasons for reporting, communication ethically, social and environmental details and also the accrued benefit of reporting. The study submitted that the earlier listed factors and process were likely to impact on the extensiveness and entirety of reports. Furthermore, Jeffrey and Jon (2013) stated that the information contained in a corporate social responsibility reports comprises of financial and non-financial information, relating to social and environmental activities and risk assessment of the factor that potentially impede their overall performance.

Borza (2011) puts forwards the benefits that can be derived from the implementation of corporate sustainability reporting as:
i. Upliftment of the organisation`s reputation.
ii. Promoting the organisation`s public image.
iii. Improving the organisation`s overall profit.
iv. Bring closer other organisation`s with similar ideology.

Carol et al., (2007) noted that corporate sustainability reporting as well as sustainability reporting by corporations can be an indicator to awareness and change towards sustainability. Larrinaga-Gonza`lez et al., (2001) had a contrary view on organisational change towards sustainability. The research discovered that organisations` disclosures of environmental performance, were carried out to manipulate the national environmental programmes and general notions of organisations` environmental efforts. This will not have much effect on corporations` attitudinal change. Claverton (2004) and Gilham (2003) made a case that corporate social responsibility is not an effective pointer to sustainability since it is mainly concerned with being in the good books. It was however advocated that organisations should widen the scope of corporate social responsibility by also looking inward as well as outward to handle issues relating to risks management by adopting ethics in their business dealings. Lewin (1947) developed an incorporated model for intended group and society change which considered sustainability reporting and process change which will direct better accountability towards improved sustainability performance. Lewin’s model, sees the status quo as being rigid to opposing forces which can alter perception and behaviour due to environmental and social forces in organisations. Lewin`s model can revamp the whole societal attitude toward sustainability reporting. These might influence change when social and economic factors such as government pressure and the popularisation of the accrued benefit of reporting sustainability. Burns (2004); Schein (1988) asserts, that focusing only on changing the behaviour of an individual within an organisation might not have much impact due to the pressure exerted by the group.

**Sustainability Reporting**

The World Business Council for Sustainable Development (WBCSD, 2003) defined sustainability reporting as “. . . Public reports companies to provide to internal and external stakeholders with a picture of the corporate position and activities on economic, environmental and social dimensions”. The report shows an organisation`s commitment towards sustainability objectives. Zuo et al., (2012) noted that the last decade witnessed an increase in sustainability awareness and sustainability reporting in all sectors including the building industry. The large business organizations have now made it a norm to disclose issues relating to sustainability in their business dealing (Weber and Marley, 2011). Glass (2012) also noted that sustainability reporting is still emerging in the building industry and the outcomes are carried out usually not specific to any branch in the industry. This might be attributed to awareness level on sustainability reporting, by organisations and business enterprises. Unfortunately, a global framework that guides constituents and mode of sustainability reporting is still in its infancy even with its anticipated merit of transformation (Ritz and Ranganathan, 2001). Zuo et al., (2012) in their study submitted that the lack of a clearly defined methodology for the process constitutes a barrier for sustainability reporting.

Atapattu (2002) and Bebbington (2001) attributed the impediments to sustainability reporting by some quarters that the sustainable development theory is vague.
Moreover, there has been some backlash due to sustainability reporting was streamlined specifically considering the environment only while excluding other facets of sustainability (Bebbington, 2001, Bebbington and Gray, 2000). Vormedal and Ruud (2009) submitted that the drivers for sustainability reporting in organisations include market, social, political, regulatory and ethical issues. Lankoski (2009) believed that an organisation can leverage on the advantages for reporting sustainability efforts. The advantages include: describing organisation commitment to laws, regulation, norms and relevant codes; providing an avenue to benchmark their current practices with relevant standard and improvement in revenue generation as well as overall efficiency. The long-standing method of business reporting, does not consider ecological and social matter as an obligation; because of that it is only a perception which rarely changes organizational financial status (Moneva et al., 2006).

Mitchell (2014) opined that sustainability reports represent organizations’ non-financial position and are considered after the financial report. Moneva et al., (2006) noted that corporations and business organisations begun embracing the need for sustainable development as a business strategy immediately after the release of the Brundtland Report in 1987. Business entities’ strategy towards sustainability reporting are usually unfair and unrealistic in social context like in the case of health care reporting or even issues relating to human rights (Moneva et al., 2006).

Jeffrey and Jon (2013) stressed that sustainability reporting should be made mandatory in the construction industry as some organisations only report on non-essential information in their sustainability report either as a standalone report or combined report voluntarily.

Gray et al., (1996) noted that the Social and Environmental Accounting and Reporting (SEAR) method of sustainability reporting is also considered to be very essential in the financial world. Elkington (1999) stressed that SEAR emerged after the Brundtland Report and also as an offshoot of the triple bottom line notion of the sustainable development. This ideology resulted to the emergence Global Reporting Initiative (GRI) sustainability reporting guidelines, with the initial aim of reporting sustainable development efforts of organisations to their various stakeholders on its non-financial report performance status (Moneva et al., 2006)

CONCLUSIONS

The study sought to review the important aspects relating to sustainability in material sourcing on corporate social responsibility, ethical sourcing of materials and sustainability reporting. Like any other sector, sustainability adoption in the construction industry has been on the increase due to the contemporary realities human being are encountering. Stakeholders’ demand for sustainability in the built environment has resulted in organisations looking for ways to fulfil these demands. From the review, it was discovered that the construction industry is operating in an unsustainable manner. There is global demand for sustainability reporting and implementation by organisations in all business dealings including the construction industry. Furthermore, a case was made for sustainability reporting to be mandatory for organisation particularly in the construction industry due to its negative impact on the environment. The paper concluded that ethical sourcing of materials is still an emerging phenomenon in the construction industry both in the developed and developing countries. Hence, there is a need for further promotion and adoption of ethical sourcing practices in other to achieve sustainability objectives.
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AN ASSESSMENT OF THE ADEQUACY OF MAINTENANCE ACTIVITIES IN PUBLIC LEARNING INSTITUTIONS: A CASE STUDY OF THE COPPERBELT UNIVERSITY

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Maintenance activities enhance the life span of buildings and improve the wellbeing, health and safety of occupants in organisations such as institutions of higher learning. Higher learning institutions have huge demands placed on them in terms of maintenance requirements due to the constantly growing population of students and staff; this places great demand on the building and at the same time creates a need to ensure that the environment is conducive for its occupants. The research made use of primary and secondary data. Secondary data was obtained from literature available on maintenance activities and health and safety practices for higher learning institutions. Primary data was obtained through the use of questionnaires to students, hall wardens, members of staff and the university maintenance team. The Copperbelt University has inadequate maintenance practices and this has led to the reduction of the structural and non-structural integrity of the buildings. This in turn has the ability to affect the life span of a building as well as its aesthetic quality, wellbeing, health and safety of occupants. By taking an interest in maintenance activities, public higher learning institutions can enhance the life span of buildings and the health and safety of occupants. Inadequate maintenance activity leads to the reduction of the structural and non-structural integrity of buildings thus compromising health and safety and life span of the buildings.

Keywords: Maintenance Activities, the Copperbelt University, Defects, Planning and Maintenance programs.

INTRODUCTION

Higher institutions of learning are corporate bodies of teachers and students that provide facilities for teaching, learning and research offered to undergraduate and graduate programs and bestow degrees. Universities create value by providing the knowledge needed to arrive at effective solutions and to prepare highly educated people to carry them out (Bok 1990). Knowledge creation produces social and economic change and plays a very crucial role in preserving the cultural and social continuity of the democratic system. However, Universities such as the Copperbelt University (CBU) need to come to terms with their dual identity in order to survive by

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providing such noble services and operating like a business. Unlike products, service quality is evaluated by customers not only by the core service but also by the service experience (Zeithham and Parasuraman 2004). Andreassen and Lindestad (1998) verified that corporate image has a strong influence on customer satisfaction. Maintenance activities play a cardinal role in enhancing occupant well-being, health and safety. Managing and maintaining healthy building conditions is crucial to reducing occupational hazards and sustaining organisation operations. Additionally, unhealthy buildings can lead to increased employee absenteeism, a decrease in productivity, and eventually, in some cases, to a shut-down in operations. Therefore, the condition of a building is paramount to the continuity and profitability of business operations.

LITERATURE REVIEW

Organisations need to understand that it is good business practice to address issues of maintenance because failure to do so results in decreased productivity due to absenteeism and in most unfortunate cases results in a shutdown in production. According to Olagunju (2012), buildings cannot remain new throughout their entire life, maintenance problems start to creep in once building projects are completed. Maintenance needs to be carried out on them in order to sustain the performance of the buildings and keep them in good condition (Panchdhari 1998). Building maintenance is work undertaken to keep, restore or improve the components, services and surrounds of a building or facility to an acceptable standard and to sustain the utility and value of the building. The Copperbelt university is a public learning institution that was founded in 1987, has over 15,000 students and 930 members of staff. The institution is comprised of a majority of old infrastructure and fairly newly constructed infrastructure. Due to the key role of the organisation, maintenance activities are cardinal for continued operations and value creation to the society at large.

CAUSES OF DEFECTS BUILDINGS

A defect is the deterioration of a building feature (Nurul and Azreel 2014) which can either be structural or and non-structural. A non-structural defect is a flaw on a non-structural element a building such as defects in brick work, dampness in old structures, and peeling paint work (Nurul and Azreel 2014). A structural defect on the other hand can be referred to as actual physical damage to a load bearing component of a building which affects its load bearing functions and makes it unsafe for occupants. A building structure includes retaining walls, columns, beams and flat slabs (Neha and Shruti 2015). Most defects can be discovered in their early stages through visible or detectable symptoms. If not promptly rectified, minor defects can develop into serious ones, causing failure or sudden collapse thus endangering lives and may become costlier to rectify. Defects and deterioration are common problems in any built structures. However, various defects are more common in old structures such as rainwater leakages, cracks, dampness and settlement (Ransom 1981).

According to Danielle (2014), the diagnosis and repair of the structural defects is important due to their evidently adverse impacts on occupants or operations, non-structural defects such as cracking and peeling of finishes or fungal growth on walls are often overlooked due to their unknown impacts on occupant health and productivity. Very often rectification of non-structural defects is neglected or delayed due to financial constraints or other maintenance priorities imposed on building owners. Such delays or failure to repair non-structural defects at an early stage often
leads to higher maintenance costs in future or affects the health of occupants thereby having an impact on productivity as it may result in higher levels of absenteeism in an organisation. It has been proven that dilapidated and unhealthy buildings illustrate a poor environment that has a very low quality of life and encourage incidences of anti-social behaviour (Panchadhari 1998).

Sick Building Syndrome (SBS) is a term used to illustrate a certain experience in relation to a building and its occupant's health or wellbeing and cannot be referred to as an illness (HSE 1995). Despite vast research being done, the cause of SBS can be attributed to a combination of factors such as physical/environmental factors and job factors. Physical factors include building/office design, building services, indoor environment and air quality (HSE 1995). According to National Health Service (NHS 2014), the symptoms of sick building (SBS) include headaches and nausea, aches and pains, fatigue, poor concentration, shortness of breath, eye or throat irritation. The symptoms of SBS can occur on their own or in combination with each other, and they may vary from day to day. SBS seems to be associated with certain types of buildings such as buildings that are occupied by lots of people such as open plan offices, schools, Libraries or museums. It is important to note that the symptoms are common in everyday life which makes it hard to link. Indoor air pollution for example can be caused by volatile organic compounds in cleaning agents, perfumes, asbestos, dampness leading to mould or overcrowding. The effects of this include respiratory illness, organ failure and allergic reactions. Maintenance activities should comprise care to the building that should pour benefits to occupants’ wellbeing, health and safety.

**Types of Maintenance**

The types of maintenance programmes determine the communication system, procedure of conducting maintenance and the financial aspect of these maintenance activities. Maintenance programs include preventive maintenance (PM) reactive (breakdown/corrective) maintenance and predictive maintenance.

*Preventive Maintenance (PM)*

PM can be referred to as planned maintenance aimed at minimising costs by managing buildings and their components before major issues ever occurring (Danielle 2014). Preventive maintenance requires consistent inspections and routine servicing or remedy of works. This type of program allows for budgeting for works and reduces the amount of pending works available (O’Brien 2014). The maintenance can be planned and unscheduled for example a plan to fix a light bulb with a replacement when it stops working. Planned but unscheduled maintenance occurs in situations where the maintenance plan for an asset is to wait for breakdown before performing maintenance. This means that the resources such as parts, supplies and personnel are ready and available to use so that the repair can be made within a reasonable time (O’Brien 2014).

*Reactive (breakdown/corrective) maintenance*  
This is the most widely utilized maintenance approach (Mobley 2008; Ahlmann 1998). It is the process of reacting to failed, ineffective or damaged equipment and repairing or replacing it in order for the intended function to be achieved. Essentially, reactive maintenance ignores any preventative measures and simply deals with a problem or issue when it is reported. Not having a maintenance strategy is the simplest “strategy” to have for asset maintenance and eliminates the need to plan ahead for maintenance (Danielle 2014). Breakdown maintenance cost 3 to 9 times
more than planned repairs because shutdowns happen during production runs (O’Brien 2014).

The main advantage of running a reactive maintenance system is that it does not require an initial cost involved in investing in systems, procedures, pre-planning and organisation and consequential reduced maintenance cost because servicing and routine checks are not incorporated. The approach requires few staff to manage. However, unpredictability of defects occurrence results in either labour or materials being unavailable immediately and therefore delay the time taken for a repair, increasing equipment downtime, inefficient use of employee time, affecting budgets and cost planning (O’Brien 2014). Furthermore, out of hours or emergency visits by contractors to fix an issue can result in unnecessarily expensive charges that may have been avoided (Sullivan, et al., 2004). Reactive maintenance doesn’t protect or look after equipment and therefore reduces the lifespan of the unit and the potential revenues (Mobley 2008; Ahlmann 1998).

**Predictive Maintenance**

This maintenance strategy is based on monitoring and measuring the condition of the assets to determine whether they will fail during some future period and then taking appropriate action to avoid the consequences of that failure. When the condition gets to a predetermined unacceptable level, the equipment is shut down to repair or replace damaged components so as to prevent a costlier failure from occurring (O’Brien 2014). This approach offers cost savings over time because tasks are performed only when warranted (Gioventu 2011). This brings several cost savings by minimizing the time the equipment is being maintained, minimizing the production hours lost to maintenance, and minimizing the cost of spare parts and supplies. The skill level and experience required to accurately interpret condition monitoring data is also high and has a high upfront cost. Judgment should be exercised when deciding if predictive maintenance is best for a particular asset (O’Brien 2014).

**MAINTENANCE PRACTICES OF HIGHER LEARNING INSTITUTIONS**

Institutions of higher learning face pressure of preserving existing building facilities within the campuses to address growing demands of an increasing influx of students and academic activities. According to Akinsola et al. (2012), plumbing, vandalism, electrical problems, and lack of maintenance culture are most peculiar to tertiary institutional buildings in South-western university buildings. Lateef et al. (2010) concluded that most Malaysian universities adopt corrective and cyclical maintenance management systems which led to an accumulation of maintenance backlogs. The buildings of higher learning in Nigeria only receive top management attention when there is a problem (Ofide et al. 2015).

The majority of building problems in institutions of higher learning are management-related problems, user misuse of building facilities and faulty workmanship. Hostel buildings are given lesser maintenance priorities than offices and lecture halls. The majority of the users use hostel spaces more than other building types. Since these hostel facilities are in poor condition, students may face health challenges, which could result in them not being productive in the poor environment. The poor condition of buildings in this environment has a direct relationship on performance of users of these facilities provided by the institutions (Odife 2015). Since challenges abound in maintenance management practices of educational institutions as highlighted above, and the growing intake of students has weakened building facilities. In most cases, maintenance activities are under the authority of the maintenance supervisor or
manager, and these must monitor the work progress daily, weekly or monthly depending on the nature of the situation and the potential impact of a service breakdown to the users.

According to Gioventu (2010), during the life of every building, building owners are regularly confronted with decisions regarding the expenditure of money to look after their buildings. The various types of costs associated with the assets can be distributed into three general categories such as keep-up costs, catch-up costs and get-ahead costs. Keep up costs are costs associated with annual maintenance of the assets and operations of the building. Catch up costs are costs to correct any accumulated backlog of deferred maintenance. Get ahead Costs are costs associated with adaptation of the building to counter the forces of different forms of obsolescence such as functional obsolescence, legal obsolescence and style obsolescence. Unfortunately, many buildings find themselves having to deal with catch-up costs that have accumulated over the years either as a result of inadequate maintenance of the assets or inadequate allocation to the reserve fund. Maintenance policies and practices play a significant role in maintaining and prolonging the durability of building components. Frequent routine inspection and cleaning will detect symptoms of defects allowing early rectifications to be carried out to prevent further deterioration and the need for a complete replacement.

According to Pedro (1998), a University maintenance program is an organizational activity carried out in order to prolong the life expectancy of school buildings, its furniture and equipment. The school maintenance program should be systematic and proactive to prevent the need for repairs. It should have a sufficient staff and budget for proper maintenance. A University maintenance program should ensure that the university building can function at its designed level at all times, function during the normal life span of the school building and resist the effects of an extreme natural event like hurricanes, floods, and earthquakes, provided that the original design, construction, and materials were satisfactory for these demands.

The maintenance of the school building is a daily activity of the institution and its personnel. It is an important factor in the delivery of education. Usually, the education officer and the public works department are responsible for the maintenance of all school buildings and the physical plant. Besides that, the school community (administrative staff, teachers, students, and parents) should institute its own school maintenance program (Pedro 1998) the maintenance programme should comprise of three basic components that include an organization structure, inspection, and a maintenance plan.

**RESEARCH DESIGN**

The data for the research study was collected from a target group of students, members of staff and the maintenance team that included hall wardens, maintenance officers at CBU. The study was a researcher administered data collection strategy and the collection point was CBU. The nature of this research is that of a case study, hence the needs to consider the aspects of a case study research. A case study offers the chance to study a particular subject involving an organisation or a group of people, and usually involves gathering and analysing information (Zainal 2007). The information is both qualitative and quantitative. The main data collection tool were survey questionnaires, where inquiry forms where handed out, completed and returned to the researcher. This tool was further supplemented by the use of an observation template for 22 buildings and interviews. Interviews were also carried out with
maintenance officers and the resident engineer's office and analysed using content analysis. These methods were chosen because they are an inexpensive and efficient way of reaching a large number of respondents and obtaining data. The questionnaire and interviews assured participants of anonymity and that the data collected was purely for academic purposes. The study administered one hundred and fifty-one (151) questionnaires to the respondents and 149 were usable, yielding a response rate of 79%.

FINDINGS AND DISCUSSION

Types of Maintenance

According to the findings obtained from the interviews, the type of maintenance used at the Copperbelt University is reactive maintenance. This is a fix only when broken type of maintenance system. While this system may be the most widely used due to its lower start-up cost and limited personnel requirements, it tends to ignore the root cause of a defect and results in repeat work leading to additional cost. Additionally, it interferes with planned work and result inefficient use of what is supposed to be productive time due to the unpredictable occurrence of defects (O’Brien 2014). The consequential result of this is a backlog of maintenance works. Most reported works take generally weeks and months (54.5%) to be attended to; with the least time being days (9%) and 16.8% of reported defects are still unattended to. These can also be attributed to the procedure used where all information and details concerning defects are processed through two offices, the administration officers and the hostel hall wardens referred to as the ‘maintenance unit’. The academic office is in charge of administration and academic blocks such as the schools and departments and the hostel hall wardens are in charge of hostel blocks respectively. From the findings, the current report system is effective in that it enables easy tracking of maintenance work but there is a slow response rate in terms of time taken to actually attend to maintenance due to the procedure nature of the reporting system that requires constant follow ups from those affected and the length process of having to procure required items.

Once a defect occurs it is reported to the maintenance unit either by the hall warden, administration officer or student. The maintenance unit then diagnose the defect and if need be, attaches a request for materials with a job card and sends it to the procurement office. The procurement office then procures the materials and hands it over to maintenance unit. The maintenance unit then engages the necessary personnel to do the works, and once the works are complete feedback is given to the hall wardens or admin officers.

The research sought to find out the existence of a strategic plan, policy or programs that the maintenance unit uses in line with carrying out maintenance activities within the Copperbelt University. 82% of the maintenance team declined to the availability of a strategic maintenance plan, policy or program. This result supports the theory that a reactive maintenance system is used.

Occurrence of Defects

Defects have been categorised as non-structural and structural of which 63% and 37% amounted non-structural and structural defects respectively. The frequency of defects was computed using the Relative Importance Index (RII), this identified the defects and the frequency of the type of defects that are found within buildings at the Copperbelt University as can be seen below.
Non structural defects include broken/missing door handles, water penetration, broken shelves, and louvers, fly screens and the like, leaking/damaged pipes, faulty sockets (safety), worn out gutters. Given the slow reaction time to remedy defects, occupants resort to replacing fittings like door handles and light fittings on their own for security reasons such as to feel safe and to protect their belongings as cases of theft are common. From figure 1, it can be concluded that the overall percentage of defect occurrence was above average and this definitely has affected the performance of buildings at the Copperbelt University. Defects such as damaged/ faulty sockets (84.8%), dirty and worn out walls (78.4%), leaking pipes (78.4%), and worn out roof sheets allowing water penetration are some of the most prevalent.

One severe case of structural defects can be seen on a building in the school of Built Environment (SBE) which has currently been condemned as subject to possible failure because of movement in the foundation. This movement was caused by settlement as a result of termite mounds underneath the building that over time has resulted into serious cracks within the building. Inspections where only done after defects of serious cracks were reported by concerned occupants. The building was declared unfit for use and its occupants were asked to relocate but have not due to limited office spaces. It was also highlighted that there has been no maintenance works done to the structural components of the said building.

The indoor air quality (IAQ) test to determine air quality is not carried out because analysis of air samples often fails to detect high concentrations of specific contaminants in the air. However, given the rate of overcrowding, cooking in hostel rooms and state office blocks, the lack of air-conditioning units in student hostels, classrooms and most offices, the evidence of dampness in walls, use of old office furniture and the existence of asbestos on most buildings, the chances of SBS to
occupants is high. 80% of the respondents had exhibited symptoms of sick building at different points in time such as headaches, aches and pains, fatigue, poor concentration, shortness of breath, eye or throat irritation. It is important to disclaim that these symptoms may be caused by other factors and may not be as a result of poor air quality or dilapidated facilities. Health and comfort however can be affected by these factors which are highly prevalent in the institution. Environmental stressors such as overcrowding, noise, improper lighting and job related factors such as stress can produce similar symptoms as those related to poor air quality and living conditions. It was observed that indoor plants are not common in hostels as well as offices to encourage cleaning of the air. This can be attributed to the lack of knowledge of SBS by occupants.

**Challenges Faced in Implementing Maintenance Activities**

![Challenges faced in maintenance chart](image)

Maintenance policies and practices play a significant role in maintaining and prolonging the durability of building components and ensuring a good wellbeing and ensure health and safety of occupants. Having a reactive maintenance system, the maintenance unit is only able to accommodate and deal with defects as they come. The aspect of planning is forgone. The most urgent defects are attended to whilst the 'non urgent' defects are often neglected or pushed to the bottom. The lack of resources ranked 2nd, this is an after effect of planning as can be seen with personnel (3rd) and time (4th). Resource requirements can be estimated before reports are made however, this is not the case. From the data collected, availability of resources in some cases was a major drawback in that if the materials are not available the maintenance works come to a standstill. There is a shortage of man power within the department as most personnel after retirement or death are not replaced. This has affected personnel and sadly reduced the capacity of effectiveness in carrying out maintenance works within the institution. In some cases, the personnel in charge of attending to the works have to be pushed in order for them to have the works done. Frequent routine inspection and cleaning will detect symptoms of defects allowing early rectifications to be carried out to prevent further deterioration and the need for a complete replacement. In most cases failure in maintenance activities may be attributed to failure to carry out daily or routine inspection of building components, poor planning and budgeting or...
inadequate allocation of resources to finance maintenance activities, negative attitude of maintenance managers towards planned maintenance and heavy reliance on corrective and emergency maintenance and insufficient measures taken to prevent vandalism.

CONCLUSION

Using a reactive maintenance system to rectify defects gives slow results, interferences with planned work and leads to inefficient use of time caused by following up on defects rectification progress. The institution faces a significant backlog of structural and non-structural defects that affect the structural integrity of the building, the quality of life of occupants, affect productivity and perceptions of the general public of the institution. Maintenance activities are not adequate given the current of maintenance activities backlog, lack of planning, low staffing and lack of resources. The unavailability of a maintenance plan entails that key resources such as materials, labour and equipment are not readily available when they are needed. This may result in occupants taking matters into their own hands so as to feel safe and secure within the buildings. There is need for frequent inspection especially where structural defects are concerned to prevent fatal accidents from occurring. This will require adding to the current staffing to meet this demand. There is need for awareness of defects that may pose a danger to the safety and health of occupants as this system is based on report then fix basis. Reactive maintenance does not take into account the wellbeing of occupants, their health and safety and the preservation of a building for its maximum use.

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Guidance for employers, building owners and building managers.


SCAFFOLD USE RISK ASSESSMENT MODEL FOR CONSTRUCTION PROCESS SAFETY

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Problems concerning occupational health and safety are commonly found in the construction industry, including falling of materials or people from height, stepping on objects and injuries by hand tools handling. Important factors in the occupational safety in construction industry is the use of scaffold. All scaffolds used in construction, renovation, repair (including painting and decorating), and demolition shall be erected, dismantled and maintained in accordance with safety procedure. Therefore, it is crucial to deal with scaffolds safety and risk assessment in construction industry; thus, way on doing assessment and liability of assessment seems to be essential for professionals. However, it is found that those professionals prone to heavily rely on their own experiences and knowledge on decision-making on risk assessment, lack a systematic approach and methodology to assess the reliability of the decisions. Methods: A Scaffold Use Risk Assessment Model (SURAM) has been developed for assessing risk levels as various construction process stages with various work trades. The SURAM is the result of research project realized at the above 60 construction sites, both in Poland and Portugal where 450 observations have been completed including both harmful physical and chemical factors, stress level, worker habits, as well as a hundreds ex-post reconstruction of construction accidents scenarios. Genetic modeling tool has been use for develop the SURAM. Results: Common types of trades, accidents, and accident causes have been explored, in addition to suitable risk assessment methods and criteria. We have found the initial worker stress level is more direct predictor for developing of the unsafe chain leading to the accident than the workload, and concentration of harmful factors at the workplace. Conclusions: The developed SURAM seems to be benefit for predicting high-risk construction activities and thus preventing accidents to occur, based on a set of historical accident data.

Keywords: Safety, Construction, Risk Assessment and Management

INTRODUCTION

The construction industry is a booming sector of Polish economy, however, according to Eurostat, the industry is classified among the sectors of the economy presenting high occupational risks and an unsatisfactory level of occupational safety. Although some safety programs have been developed in the country the observed accident reduction

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rate seems to be rather weak. Employees in the construction sector are exposed to biological, chemical factors, as well as the effects of noise, vibrations, insufficient illumination and temperature. Also the peak workload and especially frequent changes of workload level have been observed in many investigations. More than 45% of workers in the construction sector say that their work has a negative impact on their health (Dąbrowski 2015). The construction industry is subjected to high occupational risk and high rates of occupational accidents, occupational diseases and absenteeism at work. In Europe, according to Eurostat data for 2011 (for 28 European Union [EU] countries), the fatal accident rate was 6.39 (per 100,000 persons in employment) in the construction industry (Eurostat 2016). The majority of serious accidents have taken place at the scaffolds or at the construction sites with scaffolds. Taking into consideration the frequency of accidents and high occupational risk in the construction industry with scaffold use, it is important to take the necessary steps to reduce this exposure. In these conditions the research project Scaffold Use Risk Assessment Model for Construction Process Safety “ORKWIZ” have been developed in Poland from early 2016. The project focused on the introduction of a system of new/additional procedures and tools for monitoring safety on construction sites (Forteza 2017, Törner 2009, Gao 2016). This system built as model could impose strict rules regulating the conduct of contractors in a comprehensive manner to ensure an elimination of hazards from the construction site or an effective reduction of associated risks. The construction of SURAM is the core part of the ORKWIZ project. The research also shows that many accidents can be avoided by developing a proper concept of safety assurance at the preparation stage (Behm 2005, Namian 2016, Pingani 2016).

METHODS

Population

The study was conducted in Poland. Five different regions of the country have been selected for the project research. The regions have been selected by virtue of economic development level, unemployment rate, technical culture of employees, construction processes intensity, and infrastructure level, among other factors. Accordingly, the study was conducted in the different construction sites, representing typical (more frequent) scaffold size, scaffold system types and technical equipment. Such a diversity of regions, sites and employee praxis wonts and customs is required to achieve universal safety climate for the proposed safety model. At least 120 construction sites with scaffold use will be examined during the research project period. Subsequently, a random sampling procedure was conducted to select individual workers at each construction site; 234 individual workers of those sites potentially exposed to occupational hazards were selected in the first year of the project. For the purpose of the SURAM 800 individuals should be interviewed. An original questionnaire for risk perception and safety climate assessment at the construction site has been developed.
At the beginning of our investigation, we have verified several existing questionnaires including NOSACQ-50, Quality of Worklife Module (NIOSH), Contractor OH&S Evaluation, as well as some polish ones and we prepared original tool that better fit to the construction site occupational environment and construction workers perception. Before using the original questionnaire among the selected population, we ran a pilot study among 60 workers. The trial and first run exploratory factor analysis confirmed that the original 45-item questionnaire, could be used as a risk perception and safety climate scale in polish construction industry. A 5-point Likert-type scale (1 = strongly disagree, 5 = strongly agree) was used to collect the workers’ responses. Yes/no responses, lists of options, check-the-box responses, qty choice etc., were used to self-report incident involvement and demographic data. Since the questionnaire used questions and answers based on scales, a not-applicable option for situations in which the respondents did not know what to respond or did not have an opinion on the issue have also been added. In order to ensure greater objectivity both questionnaire and model and mostly to increase flexibility of SURAM the control group has been recruited at the Portuguese construction sites, considering similarities and differences between countries.

Characteristics of the study and control groups have been presented in Table 1. The difference in the drug (including alcoholic beverages) use between groups seems to be the result of different level for acceptance of some alcoholic beverages use in the shift period between Polish and Portuguese workers. In the detail questions regarding type of drug and frequency of use we find no significance except popularity of spirits in Poland and wine or beer in Portugal.

**Questionnaire Validity and Reliability**

In the implemented version of the questionnaire, the questions focused on six factors: $S_{SOC}$ (life coherence and social associations): 11 questions; $S_{LOC}$ (sense of control): 10 questions; $S_{LHZ}$ (health state): 5 questions; $S_{LWO}$ (value hierarchy): 11 questions; $S_{IZZ}$ (occupational praxis and psychical attitude): 10 questions; $S_{PR}$ (risk perception): 8 questions. There were also 7 predictors not involved to any of six scales. Sampling adequacy have been measured using the Kaiser–Meyer–Olkin test. Bartlett’s test of sphericity was involved for evaluating correlations among safety climate items (Allen 2008, Hair 1998, Saga 2013) Construct validity was tested with exploratory factor analysis, and discriminant validity has been checked by comparing the safety climate scores among groups varying in age, work experience, accident involvement, position in the company, educational and the type of the organization. To evaluate the internal consistency of the questionnaire, Cronbach’s $\alpha$ have been used, Spearman–Brown coefficient and W. Cronbach’s $\alpha$ is used when questions are rated on 5-point Likert scale, used in this investigation; it represents mean correlations among items. Spearman–Brown coefficient represents the reliability coefficients that can be attained from possible combinations of split-half questions. The minimal proposed value of these coefficients is 0.70. The data obtained using our questionnaire was analyzed Statistica 12.5 StatSoft Inc. The comparison of the difference in accident risk perception and safety climate scores among different demographic groups (age, work experience,
occupational experience, position in the company, education, accident involvement, type of construction site) was done with the multiple analyses of variances (MANOVA).

Table 1. Group Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Polish Study Group</th>
<th>Portugal Control Group</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored Subjects</td>
<td>243 100 &gt; 800e</td>
<td>38 100 &gt; 80e</td>
<td>------</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>239 98.3</td>
<td>36 94.7</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>female</td>
<td>4 1.7</td>
<td>2 5.3</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Position in company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>construction workers</td>
<td>177 72.8</td>
<td>28 73.7</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>other workers</td>
<td>43 17.7</td>
<td>6 15.8</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>administrative workers</td>
<td>9 3.7</td>
<td>2 5.25</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>managers and supervisors</td>
<td>14 5.8</td>
<td>2 5.25</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>38 15.6</td>
<td>6 15.8</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>25-34</td>
<td>48 19.8</td>
<td>8 21.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>35-44</td>
<td>59 24.3</td>
<td>9 23.7</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>45-54</td>
<td>42 17.3</td>
<td>8 21.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>≥55</td>
<td>56 23.0</td>
<td>7 18.4</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Work experience (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1</td>
<td>28 11.5</td>
<td>4 10.5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>2-5</td>
<td>87 35.8</td>
<td>14 36.8</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>6-10</td>
<td>65 26.8</td>
<td>10 26.3</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>11-20</td>
<td>33 13.6</td>
<td>5 13.2</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>≥21</td>
<td>30 12.3</td>
<td>5 13.2</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Drug use</td>
<td>191 78.6</td>
<td>20 52.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Smoking</td>
<td>202 83.1</td>
<td>23 60.5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Accident involvement or witness</td>
<td>107 44.0</td>
<td>11 28.9</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

e-estimated subjects quantity at the end of the project

To define questionnaire utility for the final SURAM model, the principal component analysis was performed retaining all the factors with Eigenvalue greater than one. Once the factors were extracted, the Varimax rotation was performed. The analyses showed that the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.81 indicating that these data were appropriate for factor analysis (Dada 2016, Kim 2016, Buica 2017). Bartlett’s test of sphericity was significant ($\chi^2 = 1270.6$, $p < 0.01$), which indicated that there were correlations among safety climate items and the correlation matrix was not a unit matrix.

RESULTS

The reliability of the measurement method depends on its internal consistency. As already
indicated, the consistency was assessed with Cronbach’s α, Spearman–Brown coefficient, and W. According to Cronbach’s α, internal consistency was 0.79 for the entire population. Spearman–Brown coefficient was 0.78 and W = 0.70. Most coefficients were higher than 0.70 and adequate for psychometric requirements for a measurement. Thus, the method for measuring occupational hazards, risk perception and the contractor safety climate was appropriate (Lin 2007, Mohamamadfam 2017, Mitropoulos 2009). Table 2 shows each coefficient of the accident risk and safety climate scales. Figure 1 presents the results of the SURAM structural analysis. To make it clearer, it shows only the values of the structural equation, but not the measuring models. Except the questionnaire scales the SURAM have been developed including worker psycho-physiological parameters monitoring before the shift as well as the part of the shift after a break corresponding to the workload during the shift (WL). The wide range of demographic factors (DF) collected both at the construction site as well as from local statistical offices have also been used for model construction. Environmental parameters at the construction site have been monitored on 2 up to 3 levels of the scaffold (depending of its size) during at least five days working week including sound level, illumination, microclimate (EF). Then the diversity from the standard levels has been evaluated as the measure for the matrix construction. To evaluate worker visual concentration on the critical areas or elements of working zone the mobile eye-tracking equipment have been used (ET). Stability and quality of scaffold set-up and maintenance have been evaluated (CScaffold) as well as construction site organization level (CSO). The complementary element of SURAM especially for model teaching period was Historical Accident Analysis module (AHA). In the Aha module the accidents from past 10 years of the construction industry have been decomposed to the elementary factors. As the model presented at the Figure 1 is a beta one prepared after first year of the projects some of the relations could not be calculated precisely – nd values. Therefore, even in those partial data it shows potential for use in improving safety at the construction sites with scaffold use.

Table 2. Questionnaire scales Inter-Consistency Coefficients

<table>
<thead>
<tr>
<th>Scale</th>
<th>No. of Items</th>
<th>Cronbach’s α</th>
<th>Spearman-Brown Coefficient</th>
<th>Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{SOC}$</td>
<td>11</td>
<td>0.763</td>
<td>0.771</td>
<td>0.703</td>
</tr>
<tr>
<td>$S_{LOC}$</td>
<td>10</td>
<td>0.694</td>
<td>0.712</td>
<td>0.614</td>
</tr>
<tr>
<td>$S_{LKZ}$</td>
<td>5</td>
<td>0.631</td>
<td>0.680</td>
<td>0.622</td>
</tr>
<tr>
<td>$S_{LWO}$</td>
<td>11</td>
<td>0.895</td>
<td>0.899</td>
<td>0.811</td>
</tr>
<tr>
<td>$S_{IZZ}$</td>
<td>10</td>
<td>0.744</td>
<td>0.752</td>
<td>0.728</td>
</tr>
<tr>
<td>$S_{PR}$</td>
<td>8</td>
<td>0.707</td>
<td>0.719</td>
<td>0.631</td>
</tr>
</tbody>
</table>

$S_{SOC}$ (life coherence and social associations), $S_{LOC}$ (sense of control), $S_{LKZ}$ (health state), $S_{LWO}$ (value hierarchy), $S_{IZZ}$ (occupational praxis and psychical attitude), $S_{PR}$ (risk perception).

In accordance with the suggestions and indications given by Hair et al. (Hair 1998, Ho DCK 1999 Pingani 2016 Amiri 2017), the goodness-of-fit (GF) model had to be
considered first. Within a GF model, it is required to consider three indicators: the measure of absolute fit, the measure of increased fit and the measure of decreased fit. Table 3 presents the results for the proposed model together with the recommended values for satisfactory fit (Ho DCK 1999, Buica 2017, Liao 2016).

Due to the absolute correspondence of the models, the indicators that can be applied in an incompetent strategic analysis are GFI (goodness-of-fit index) and the index of corresponding values. In GFI, the higher the value, the higher the correspondence. In this case, the obtained value was 0.92. This indicator is acceptable since it is over 0.90 (WHO 2010, Molina 2007, Rubio-Romero 2015).

Table 3. Model Fit Values

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Recommended Level</th>
<th>Achieved Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$/df</td>
<td>$&lt; 3.0$</td>
<td>2.87</td>
</tr>
<tr>
<td>GFI</td>
<td>$&gt; 0.90$</td>
<td>0.91</td>
</tr>
<tr>
<td>AGFI</td>
<td>$&gt; 0.90$</td>
<td>0.92</td>
</tr>
<tr>
<td>NFI</td>
<td>$&gt; 0.90$</td>
<td>0.93</td>
</tr>
<tr>
<td>CFI</td>
<td>$&gt; 0.90$</td>
<td>0.93</td>
</tr>
<tr>
<td>IFI</td>
<td>$&gt; 0.90$</td>
<td>0.91</td>
</tr>
<tr>
<td>RFI</td>
<td>$&gt; 0.90$</td>
<td>0.92</td>
</tr>
</tbody>
</table>

GFI - goodness-of-fit index, AGFI - adjusted goodness-of-fit index, NFI - normed fit index, NNFI - non-normed fit index, CFI - comparative fit index, IFI - incremental fit index, RFI - relative fit index

Figure 1. Structural model of SURAM.
$S_{SOC}$ (life coherence and social associations), $S_{LOC}$ (sense of control), $S_{LKZ}$ (health state), $S_{LWO}$ (value hierarchy), $S_{IZZ}$ (occupational praxis and psychical attitude), $S_{PR}$ (risk perception), $DF$ (demographic factors), $WL$ (work load), $EF$ (environmental factors), ET (eye)
tracking), C_{scaffold} (scaffold construction), CSO (construction site organization), AHA (historical accidents analysis).

In our model, this indicator has the value of 0.9 which, according to the above-mentioned academics, is an indicator of good correspondence. Table 2 shows inter-correlations among the six scales that were entered into the final model. Because of the comparatively small sample size, each correlation coefficient was significant at 0.05. As a step in model construction this research focused on investigation whether there is any significant difference in risk perception and the safety climate in working teams as well as construction enterprises among the demographic subgroups (Carillo-Castrillo 2016, Choudhry 2014).

There significant differences in demographic subgroups in questionnaire scales have been observed. For example, for practicum, there were significant differences on all scales ($S_{SOC}$, $S_{LOC}$, $S_{LKZ}$, $S_{LWO}$, $S_{IZZ}$, $S_{PR}$), but for the education level there were significant differences on ($S_{SOC}$, $S_{LOC}$, $S_{IZZ}$, $S_{PR}$) scales and not for $S_{LKZ}$ and $S_{LWO}$ scales. Gender did not influence opinions on questions on analyzed factors as more than 97% of employees (94.7% and 98.3% in study and control groups respectively) were male. However, presenting all the results in this manuscript would require too much space. Therefore, they will be discussed in detail in another paper at the end of the project where we could observe larger subgroups. At this stage of the research and project development we have found the initial worker stress level (monitored by the bio-physical parameters at the beginning of shift and after the break + ET) (Fruchter 2011) is more direct predictor for developing of the unsafe chain leading to the accident than the work load (WL), and concentration of harmful factors (EF) at the workplace (Lopez Arquillos 2008).

CONCLUSIONS
A study of risk perception, occupational hazards and safety climate at the construction sites with scaffolds in Poland, like the one in this paper, had never been conducted before. We attempted to monitor risk perception, understand the value and beliefs about the safety among Polish workers or precisely workers’ teams at polish construction sites as the growing number of migrant workers (mostly Ukrainian) have been noticed during the first stage of research project. The study presented evidence that the perception of the accident risk and safety climate in polish construction sites can be reliably measured with a 45-item questionnaire, involving six factors ($S_{SOC}$ (life coherence and social associations), $S_{LOC}$ (sense of control), $S_{LKZ}$ (health state), $S_{LWO}$ (value hierarchy), $S_{IZZ}$ (occupational praxis and psychical attitude), $S_{PR}$ (risk perception)). The previous research results posited, construction workers put more emphasis on safety training, organizational environment, safety awareness and competency, and management support. Although, the previous thesis are still actual, our recent study shows, that initial stress level could be crucial for developing risky or potentially prone to accident situation. To establish a general model SURAM, our subjects came from several economically, historically and technologically diversified polish regions and the control
group came from Portugal. Thus, the developed 45-item questionnaire can be used as a safety measurement tool for the whole construction sector with the scaffold use. This tool was based on the results from different parts of the world and then modified to fit polish construction sites. Further research will focus on a structural equation model, which will result from the structural analysis presented in this work. An additional factors), DF (demographic factors), WL (work load), EF (environmental factors), ET (eye tracking), $C_{\text{scaffold}}$ (scaffold construction), CSO (construction site organization), AHA (historical accidents analysis) will have to be included. It will determine the workers’ attitude towards the risk level at their workplace, hazardous situations and real occupational accidents that took place there. Subsequently, the six factors from this study will be used to develop a hypothetical frame of the SURAM model. Additionally, as already indicated, each demographic subgroup had strong influence on some of the six factors. This will be analyzed in detail and discussed in next project stages. This study considered workers from six regions (including Portugal), so the level of technical culture and type of organization was one of the variables (CSO). Consequently, the influence of this variable on all six scales will be studied in future. The prognostic validity of the SURAM model developed in this work will be assessed in this way on next stages. Moreover, the results will have practical value for occupational health prevention in construction sector. The developed SURAM, even at this initial stage are found to be useful for predicting high-risk construction activities and thus preventing accidents to occur, based on a set of historical accident data.

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CONSTRUCTION SAFETY THROUGH HOUSEKEEPING: THE HAWTHORNE EFFECT

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Clean and tidy sites have often been associated with positive safety cultures in construction. Poor housekeeping can result in the creation of additional hazards and dangers in the form of protruding objects which may also be sharp, and increase in situations that can lead to slips, trips and falls on sites. They also create uneven ground levels, debris, and muddy conditions, which can all lead to an increase in accidents. Housekeeping also contributes to projects being finished in a timely manner due to the fewer distractions created by the chaos. However, maintaining good housekeeping practices on site have been known to be challenging due to the rapid and complex nature of construction projects. In a research that was initiated to explore the question of ‘why is housekeeping a continuing challenge in Lesotho construction?’, the final outcome of site visits and observations revealed the classic phenomenon of the Hawthorne effect. Without deliberate or intentional ‘interventionary’ measures or demand for regulatory adherence, subsequent visits revealed a transformation in site practices specifically on housekeeping. The Hawthorne effect refers to the alteration of behaviour by the subjects of a study due to their awareness of being observed. This effect does not necessarily refer to positive or negative outcome. In this paper, the transformation that occurred with regard to the workers’ practices is discussed critically in the context of this phenomenon. A key outcome of this discussion is whether housekeeping can be encouraged or improved using the notion of being observed. Finally, the ethical stance of carrying out overt or covert observations is deliberated.

Keywords: Hawthorne Effect, housekeeping, Lesotho, overt research.

INTRODUCTION

The construction industry has many challenges worldwide. One of the major issues that continuously receives attention is safety. Safety issues vary considerably and for this reason, they are very difficult to investigate. Practitioners, policymakers and academic researchers alike share a keen interest in improving construction project safety. Safety of construction projects extends to several stakeholders e.g. site operatives, clients and the general public. People less familiar with construction project practices may find it difficult to move around on sites. For example, a client visiting a site will need clear guidance on where and how to move (even after a safety induction). Moving around on site is further complicated when the environment is not kept tidy e.g. obstructed walkways, toolboxes left lying around and waste materials not carefully disposed. Following up on the premise of untidy sites leading to unsafe conditions, a research project was carried out to investigate housekeeping practices and their effects on overall site safety in Maseru, Lesotho (see Emuze et al, 2016).
Observations and interviews were carried out on various sites to study the proposed aim. However, housekeeping practices of site workers were observed to steadily transform during continuous site visits for observations. The change in behaviour was not as a result of any 'interventionary' measures. Thus this phenomenon was attributed to the Hawthorne effects. This paper explores the behavioural changes that were witnessed while conducting the described research project. This paper does not measure the level of transformation of housekeeping practices that occurred during the site visits but instead works on the premise that indeed behavioural change did occur during the observations. Additionally, this research proposes the possibilities of using the Hawthorne effect to positively influence site safety with respect to housekeeping.

**HOUSEKEEPING AND SITE SAFETY**

Housekeeping is defined as the day-to-day cleaning and keeping tidy of a construction site (Lingard and Rowlinson, 1994). This is crucial in the prevention of accidents and injuries on site (ibid). Poor housekeeping was found to have contributed to almost half of accidents that occurred in Great Britain (Haslam et al, 2005). Untidy sites and poor housekeeping practices can lead to many types of hazards e.g. trip hazards, falling objects, and sharp objects that can cause cuts. Haslam et al (2005: 410) explain that "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". Thus, good site conditions are symptomatic of a positive safety culture.

Site safety is important to all stakeholders and not only site operatives. For starters, where there is a poor safety atmosphere on site, there can be several implications ranging from the loss of a few man-hours to fatal incidents. The term safety culture is loosely used to describe the atmosphere or culture in which safety is considered and accepted to be of topmost priority (Cullen, 1990). Cooper (2000: 114) defines safety culture as the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of an organisation's health and safety management. Furthermore, organisations with positive safety culture are characterised by communications founded on mutual trust by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures (ibid: 114).

Safety culture can be improved by empowering workers and delegating safety activities (Torner and Pousette, 2009). Key components that may be present in a positive safety culture include clear policies, goals, objectives, procedures, manuals, records and audits that are used as tools to aid continual improvement of performance (Emuze et al, 2016). The above components represent the visible (explicit) aspects of cultures. However, individual attitudes and personal beliefs of safety cultures are not visible or explicitly captured (see manifestations of culture at different levels of depth Hofstede and Hofstede, 2005: 7).

One effective method of improving the non-explicit aspects of safety cultures e.g. individual attitudes and personal beliefs, is through motivation. 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). By teaching and empowering new workers to practice safely (including good housekeeping methods), overall safety cultures can improve considerably. Becker (2001) adds that good housekeeping eliminates many safety problems, improve morale, and increases productivity because
workers generally appreciate a clean and orderly workplace where tasks could be completed unhindered.

As discussed in the introductory section, this study aims to explore the behavioural changes that occurred during a research project which investigated housekeeping practices. To further contextualise this study, the origins of the Hawthorne effect is presented next.

**BACKGROUND OF THE HAWTHORNE STUDIES**

The Hawthorne studies were originated in 1924 by the management of the Hawthorne plane of the Western Electric Company in Chicago, Illinois, USA (Ivancevich et al, 1997). The study was set up to investigate the relationship between illumination and productivity while the main studies, conducted between 1927 and 1933 in cooperation with the Massachusetts Institute of Technology (MIT) and Harvard University, were concerned with the effects of changes in rest pauses and workhours on productivity (Wickstrom and Bendix 2000: 363). Elton Mayo was the main instigator of the study that focused on factors affecting productivity. This concept was inspired by the work of Durkheim who espoused a conflict-free group consciousness that challenged the concept of class conflict (ibid: 363). In the investigation, the illumination was decreased step by step for the experimental subjects, the controls received constant illumination (Roethlisberger and Dickson, 1939). Both sets of participants were observed to slowly but steadily increase their performance of inspecting parts, assembling relays or winding coils (Wickstrom and Bendix 2000, 364). Once the illumination in the experimental room was reduced to a level corresponding to moonlight, the participants began to complain that they could hardly see what they were doing and thus productivity finally started to decline (Adair, 1984). Overall, the experiment revealed that lighting did not significantly affect productivity of the workers as long as it was kept at a reasonable level (Wickstrom and Bendix, 2000).

On the contrary, factor(s) other than lighting was found to be more important (Ivancevich et al, 1997) and this subsequently led to later studies.

Roethlisberger and Dickson (1939) summarised the findings as follows: the factors that were considered included physical factors causing fatigue and monotony and then continued by means of four extensive experiments (first relay assembly, second relay assembly, mica splitting and bank wiring). The other factors seemed to be responsible for most of the observed change was the improved personal relations between workers and management. This conclusion was based on the annotations of the informally expressed opinions of the workers participating in the experiment, as well as on the general impressions of the investigators (Wickstrom and Bendix 2000, 364). This led to the concept of the Hawthorne effect.

**The phenomenon of Hawthorne effect**

The initial conclusion drawn from the Hawthorne studies indicated that the increase in output was partly caused by the experimental setup and the experimenters themselves (Bryman and Bell, 2003). Hawthorne effect has now become a household concept in relation to observational research. The term is mostly used to refer to behaviour modifying effects on the part of subjects of participant observations (Wickstrom and Bendix 2000: 363). Although this concept emerged from the Hawthorne plant, its modern implications go beyond this context and as such is used in various fields of investigation (Marshall, 1994). What is considered Hawthorne effect is also referred to as 'a nonspecific effect caused by participation in a study' rather than specific
intervention measures taken (Shepard et al, 1981; Wegman and Fine, 1990) in the field of occupational health. In pharmacology, the Hawthorne effect is often compared with the ‘placebo effect’ (Wickstrom and Bendix, 2000). Fundamentally, most studies that have considered the observational effects on subjects believe there are changes in participant behaviour (ibid).

As stated in the introduction, this research aimed to explore the behavioural changes that occurred during observations of site practices on housekeeping and site safety. The next section discusses the method of data collection and its subsequent analysis.

**RESEARCH METHODS**

The initial research project adopted a multiple case study approach using field observations that were supported with follow-up focus group interviews (see Emuze et al, 2016). All the project sites were located in Maseru, Lesotho. A total of four projects were considered under this study. The research was designed to capture complexity of housekeeping on the multiple project sites and also to attend to contextual conditions. The observations were specifically conducted to understand human activities and the physical settings in which these housekeeping and other safety activities occur. The observations took a structured format i.e. specific practices such as equipment arrangement and schedule of site cleaning were studied. The structure of the observation was informed by the reviewed literature on housekeeping and site safety. Although the observations undertaken had a structured format, the observers made allowances for 'unexpected occurrences'. Many existing construction management research (e.g. Rubrich, 2012; Forbes and Ahmed, 2011) and non-construction management research (Yin, 2013; Thomas, 2015) were considered when developing the data collection instrument.

As part of the studied literature, the '5-Why' analysis was used as a tool that aided the compilation of the discussion section of the initial research project (see Emuze et al (2016) for data collection and data analysis details of initial study). Site managers and other operatives were interviewed after the site observations. This paper does not focus on subsequent interviews and analysis of that data. The paper specifically focuses on the 'Hawthorne effects' during the observations of housekeeping activities. This is because the observed behaviour modifications occurred before the interviews took place, hence the decision to exclude the interviews.

**Ethical considerations**

Data collection was conducted by students who had undergone research and data gathering training. An 'overt' approach was used during fieldwork. Site visits were regularly conducted for a few weeks as the researchers intended to capture general practices of the workers with respect to housekeeping. The site operatives were briefed about the purpose of the study i.e. to explore site safety practices. General consents for the empirical work were approved by the various site managers. Additionally, the workers were informed in their morning briefings of the photographs that would be taken of site works. They were also given the right to decline participation without ramifications. Furthermore, it was clarified that the study was for academic purposes and hence the outcome would be used to teach up-and-coming construction professionals.
FINDINGS

Many similarities were observed during the initial observations especially with respect to poor housekeeping practices. These are presented in this section. The changes that ensued during the subsequent visits are discussed later.

Site A

Excess materials including construction waste was observed in many areas of the site. Notable issues that were observed on the site included:

- Poor waste segregation
- Poor storage of materials
- Blockage of the walkways by reinforcement bars from demolished walls
- Lack of proper working methods that had created trip hazards
- Poor tidying up practices that had led to electrical cables coming into close contact with flammable liquids
- Wasteful use of materials due to defects, rework and poor workmanship.

Following the initial visit, workers' practices in relation to housekeeping began to show improvement. Workers began sorting their waste into different categories. Trip hazards were observed to be considerably less and workers were showing signs of reducing waste. More importantly, the observers noted that a waste disposal which was initially situated along the walkway to the site and excess materials had been eliminated.

Site B

On this site, there were similar poor practices with respect to housekeeping. Some of the recorded observations are as follows:

- Obstruction of walkways due to construction waste
- Lack of appropriate cleaning instructions from site foreman
- Poor signage to alert workers and other stakeholders of potential hazards
- External authorities (municipality) in charge of intervening were ignoring poor site conditions.
- Interchanging scheduled work sequences which led to confusion and increased risks
- Construction materials not stored properly e.g. storing valuable materials yet to be used in the same location as waste materials.
The site went through a transformation as site visits continued. For example, proper signage indicating the potential hazards automatically appeared on the site. Furthermore, a specific storage area for construction waste emerged on the site.

**Site C**

This site possessed the least poor housekeeping practices during the initial visit. However, this site also had its challenges;

- Lack of storage facilities
- Workers' toolboxes 'littered' all over the site left unattended creating trip hazards
- 'Overcrowding' of workers due to lack of adequate working space

Due to the small site space, the bulk of the project materials were stored off site. Although this was considered as good practice, the logistics of transportation and delivery of the materials stored offsite were improperly handled. The site workers seemed unprepared each time deliveries were made thereby increasing the risk of accidents.

**Site D**

Similar to Site C, this site was relatively small and this increased the problems of creating and maintaining a tidy site. Some of the observed issues are as follows:

- Lack of adequate storage facilities
- Workers appeared incompetent e.g. forgetting to install service ducts and having to amend the mistakes thereby leading to 'double work'
- Extra (waste) materials 'littered' the site e.g. the above service ducts
- Overcrowding of workers in limited space leading to activity incompletion
Dangerous locations of electric cables and water pipes leading to trip hazards. Initial improvements observed during follow-up visits included no overcrowding issues due to efficiency in worker numbers. Other issues relating to space management seemed to have been handled effectively during the follow-up visits.

**Figure 4: Site D images**

**DISCUSSION**

During the visits for the empirical work, there were noticeable improvements on the sites and these observations formed the basis for the development of this paper. It is important to note that the focus of this paper is not to quantify the extent of change or safety improvements that occurred on the sites but only to acknowledge the change had occurred during the time of observation. From the findings, it is evident that behavioural changes did occur in housekeeping and site safety practices (see images).

Since the study was overt, it is assumed that most workers knew they were being observed. Consent for the observation was sought from site managers. Two observers visited the sites. The observers did not appear as individuals in ‘imposing’ positions e.g. local authority or safety inspectors. This was part of the research design in order to have workers feel at ease and not become distracted or feel intimidated about the possibility of being reprimanded for any wrongdoings that would be observed.

**Benefiting from the Hawthorne Effect**

For this particular research, the behaviour modification observed was definitely positive as far as housekeeping and tidying up is concerned. This change possibly brought about a safer site. Choudhry (2014) highlights one of the main classifications of safety controls as good housekeeping practices i.e. the day-to-day cleaning and keeping tidy of all parts of the site. The proper use of personal protective equipment (PPE) is considered to go hand-in-hand with good housekeeping (ibid) but this was not a behavioural change observed on any of the sites described in this paper. This is because PPE usage was not found to be problematic on the sites visited.

As highlighted in the methods section, intervention of housekeeping practices was not part of the research objectives even though changes became apparent during subsequent site visits. Furthermore, there were no records of regulatory authority interventions or any issues in relation to housekeeping practices on all the sites. The only common denominator present on all four sites is the presence of the observers and hence it can be concluded that their presence played a role in the improvement in housekeeping and safety practices.
Attack of conscience

Site managers, foremen and operatives were all aware of the presence of the researchers. The change in practices could be argued to have occurred as a result of fear of being reported for poor practices but this has been ruled out based on the empirical approach adopted i.e. using research students that did not bear any resemblance to figures of authority. Furthermore, there was a clear explanation of the potential research outcome, i.e. an academic work that would lead to learning and promoting site safety practices.

Experienced workers are often knowledgeable in good safety practices as they have learnt and practiced for many years (Nicolini et al, 2013). They have 'learnt by doing' and this is the same approach they use to transfer knowledge to workers of less experience (Aboagye-Nimo et al, 2015). This type of safety knowledge is mainly tacit and as such workers may not be conscious of learning or teaching it (Kamoche and Maguire, 2011). This would lead to improving personal beliefs and individual attitudes i.e. the aspects of the safety culture that are not explicit.

Since the workers knew that the observers were on site to learn about good safety practices (which obviously includes good housekeeping), they could have been compelled to work safely. Psychologists explain that one's conscience will compel them to draw lines around what is right and wrong, proper and improper (Hitlin 2008: 1). In this case, there were already experienced workers on all the sites and hence it can be argued that they were encouraged to work safely as a result of the presence of the observers. Knowing that the observers on site were there to learn, the workers would have had to use good practices. Rowlinson et al (1993) explain that experienced workers take father-figure roles when they are teaching less experienced workers on site. In addition, they tend to ensure that these newcomers (who possess less experience) are protected when working in this high risk environment. For this reason, the workers on site may have unconsciously led by example by using good housekeeping practices.

New approach to effective housekeeping?

Involving underlings or students who are on site to study could be a useful way to have workers improve their practices. One key factor is to let the experienced workers know that they are being observed by learners. By showing the workers that the observers are not on site to report or reprimand them, they may be more inclined to work comfortably and safely without pressure.

From this study, it was acknowledged that workers worked generally safer when they were being observed by less experienced workers. Furthermore, by teaching or transferring safety knowledge, the experienced workers continually transform and review their existing knowledge. Gherardi and Nicolini (2000) explain that safety (in this case housekeeping practices) is a situated practice and as such site operatives will always have to reassess their safety practices with respect to new situations in order to be able to teach less experienced workers.

If less experienced workers or learners are included in projects, the more experienced workers would thus be compelled to use safer methods overall. Although formal setting knowledge (explicit) transfer is important in construction safety, 'on-the-job' training has been described to be more effective in many situations, especially when workers have to identify risks and dangers on site (Bartholomew, 2008). Learning this type of practical and invaluable knowledge may be taken for granted as it is mainly
implicit. On-the-job learning as a method of safety knowledge transfer offers a learner an opportunity to acquire practical wisdom that would have been missed in many other situations (Gherardi and Nicolini, 2002).

Placing a learner on site in order to compel workers to work safely is not the only factor that needs to be considered to ensure safer practices. There are several factors that need to be considered when ensuring site safety and this concept may need to be considered as part of a whole. Sawacha et al (1999) suggest many areas that need to be considered to help improve site safety, such as eliminating time and financial constraints.

**CONCLUSIONS**

This paper has focused on workers’ behavioural changes that occurred during an exploratory study on construction site housekeeping in Lesotho. These behavioural changes, also known as Hawthorne effect were found to be as a result of workers being observed by academic researchers. Housekeeping on site improved considerably as the observers visited the sites over a given period. These behavioural changes were not propelled as a result of specific intervention measures. The workers were clearly informed of the presence of the observers as well as the aim and scope of the research.

The improvement in housekeeping practices as a result of workers being observed by individuals who are on site to learn about good practices could be used an approach to enhance site safety. The behavioural changes may spur changes in thinking among the site operatives. Experienced workers are known to play father-figure roles on site and as such tend to teach less experienced workers how to stay safe at work.

As explored in literature, the behavioural changes when people are being observed do not necessarily have to be positive or negative. For this study, the changes observed on all four sites were positive with respect to housekeeping. In future, this method could be tested on different projects with the sole purpose of identifying whether the behavioural changes are always positive with respect to housekeeping and site safety.

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**REFERENCES**


RE-ENVISAGING CONSTRUCTION IN THE CONTEXT OF HUMANISATION

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Construction, like agriculture, is potentially the most humanising of all activities in that it has the potential to satisfy or contribute to the satisfaction of the fundamentals outlined in Maslow's hierarchy of human need. More than this, construction has the capacity to reflect and contribute to the assertion of 'Being'; the ongoing struggle to define and assert our authentic Self. Conversely in both process and outcome it also has the potential to dehumanise and to negate that ontological potential. This paper examines the ethical and moral challenges arising from the societal responsibilities required of and inherent in the construction industry's raison d'etre. Through an examination of the literature and of selected projects the contribution to and the negation of an authentic Ethic is explored, challenging stakeholders to evaluate the positive and address the negative in such a way that construction meets its obligations to society and to individuals. Within the context of humanisation, the objective is the development of a model for construction that promotes respect for and accords equal consideration of all and to all.

Keywords: Ethics Reasoning, Humanisation, Sustainable construction.

INTRODUCTION

Construction does not take place in isolation. It is a product of human endeavour and as such must be contextualised within an understanding of the wider functions of human endeavour and the forms that it takes, both historically and trans-globally. The historical context relates to the continuous development of Humanity from our primitive states through progressive and retrogressive states to the present and to where we aim to go in the future. Trans-globally the various forms that human social interaction has adopted inputs directly into the function of construction and the means whereby it is achieved.

Human endeavour and therefore construction is dynamic and the picture of construction is not static but is subject to and therefore amenable to directed change. Underpinning human endeavour are individual and collective struggles for authentic Being (Zizek 2012) that is a recognition that each person, each Self, is capable of becoming more that he/she is (Freire 1973), of achieving Self-recognition and thereby being capable of self actualisation (Maslow 1943).

This struggle, referred to as the Human Ontological Project (McAleenan and McAleenan 2017) is the dynamic of Man in his environment as He interacts with and changes it to meet His needs at all levels (Fig. 1). It reflects more that the simple

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dialectic of Man in conflict with Himself, i.e., the dialectic inherent in the social relations that emerge from Man as a social and historical Being wherein the objectives of human endeavour, the ideologies of Being and the meaning of existence, power and authority relationships and conflicts between Self and social interests create asymmetrical developmental outcomes and social irregularities.

*Figure 1: Maslow's Hierarchy of Need*

Abstracting construction from the range of human endeavours this work explores its capacity for and its impacts on humanisation, i.e., in advancing the human ontological project. From one perspective the social function of construction is outlined and its impact on social relations examined. From the second perspective the process of construction is examining and reflecting on its as a means of satisfying individual human need from the most basic to the highest level of self actualisation (Maslow 1943). In both perspectives the potential for humanisation is counterposed with examples of construction in process and in outcome as deniers of humanisation, i.e., as dehumanising processes and social constructs.

Central to humanisation is the development of agency, the faculty to critically assess the environment and decide upon an appropriate course of action that contributes simultaneously to the development of an internal ethic and an external morality (Žižek 2012). Human moral development and the capacity for ethics reasoning has been charted by Kohlberg (1971) and Eckensberger (2007) in their work on cognitive development that demonstrated the development of reasoning in a number of stages culminating in the highest stage of post conventional reasoning on universal moral principles where-in everyone is accorded equal consideration and respect for their dignity and worth. Current perspectives on this level of reasoning accord the whole of nature with the same degree of consideration and respect.

This work considers construction in the context of the principle stakeholders and the triple objectives of construction sustainability (McAleenan 2015). The long term
sustainability of a construction business is therefore based on its ability to meet the needs of:

- Public interest, i.e., the community that is served by construction,
- Private interest, i.e., construction businesses, owners and shareholders, and
- Worker interests.

**METHODOLOGY**

A critical theory methodology has been adopted to carry out this work. An analytical tool developed by the Frankfurt School of Social Theory and Philosophy, critical theory brings together various disciplines in the humanities in order to transcend a simple analysis and description of society and to facilitate social change. Science and engineering, for example, are not neutral practices divorced from the vagaries of human biases and the social relations and structures in which they are imbedded (BSSRS 1975).

"The ideology of ‘scientism’ and its claim to be ‘neutral’ and ‘objective’ are powerful weapons for mystification and domination in the hands of our rulers. Increasingly decisions which are essentially social and political decisions are taken behind a smokescreen of scientific objectivity. If challenged such decisions are justified (and hence put beyond further challenge) by appeals to the neutrality of science and impartiality of scientists”. (BSSRS 1975, p3)

Deconstruction, a Derridan (Derrida 1966) tool applied to the field of literary analysis provides a means to delve into the meanings and uses of language in construction to arrive at new and different perspectives of key stakeholders impacted by the process of and outcomes of construction. These shifts in perspective seen from the social and historical experiences of the impacted stakeholders provide a varied and often contradictory understanding of construction and the benefits morally ascribed to it. A semiotic analysis of the artefacts produced by construction, e.g. street furniture, questioned the validity of architectural solutions to the clients' definitions and therefore requirements in relation to the to the impacts of their work on the whole community including those specifically and negatively targeted by the outputs, e.g., homeless people, youth, etc.

Critical theory has a particular focus on cultural analysis, particularly in view of the growing emphasis on "safety culture" (McAleenan 2016a) in the construction process. Narrow simplistic definitions of culture, e.g., "The way we do things here", were rejected in favour of a comprehensive and complex interpretation of the human/environmental dialectics in the make-up of cultures with a perception of continuousness (Dawkins 1993), connectivities that are regarded as being critical to an understanding of human existences and Being. Man and events are continuous in that they have emerged from a past and impact on the future, and in the present are infinitely interconnected with the surrounding environments.

At this point it is worth emphasising that construction and agriculture are the two fundamental achievements of Man as a social and historical Being and the most visible anthropogenic effects on the planet. The anthropocene is current and defined by Man's pollutions (radioactive and plastic) being recorded in the geological record. (McAleenan 2016b).
Historically the development of agriculture released Man from the daily pursuit of the means of survival and created the surpluses in production that permitted the division of labour within the now settled communities. This permanence of settlement and the division of labour are the foundations of civilisation, of construction and progress towards attaining the higher levels described in Maslow's hierarchy of need (Fig.1). The ubiquitous nature of construction from extraction to the built environment and the infrastructure networks that traverse the landscape speak to the success of Man. The urban environments that Man has built embody the successful satisfaction of need from shelter and warmth (houses, energy, sanitary services), through health and security, (hospitals, schools, factories), to self actualisation (universities, sports facilities, museums, leisure facilities, etc.). The human environment reflects the attainment of the social "good" that is at the centre of ethical and moral behaviour (Fromm 1947). The collective endeavours necessary to build and maintain the human environment reaches out to the care for the Other through the provision of housing, sanitation, energy, health, welfare and education facilities and opportunities. Individual Self-development is facilitated via the opportunities provided by the higher levels of education, the arts in museums, galleries and concert halls and the opportunities for physical excellences in the sports and health centres of excellence that are integral features of even the smaller urban environments. Nevertheless, this glossy picture hides a reality about the urban environment wherein the ability to advance the humanisation project is not equally accessible or available to all; a fundamental feature of the highest level of ethics reasoning, i.e., equal consideration and respect for all (Eckensberger 2007).

Inequalities exist and historically have done so since the earliest periods of urbanisation and the division of labour. The division of labour transformed the social relations of production such that the surpluses that allowed for the constructions of towns and cities could also be expropriated and accumulated in private rather than in public hands thereby creating extreme authority and power relations that are a features of but are not necessarily a function of civilisation and urbanisation such that today eight (8) people have the same personal wealth as 50% of the global population, (Credit Suisse 2016, Oxfam 2017).

The manifestation of these inequalities and the dehumanisation that results is clearly evident in the built environment, both in the artefacts of that environment and the processes of constructing them. Cities may appear as objective monuments to Man's progress but under scrutiny they are a reflection of Man's subjective interpretation of the world that He inhabits. Somethings as apparently innocuous as street furniture, primarily functional artefacts to light the streets, to ease the flow of pedestrian and vehicular traffic, provide comfort, etc., serve also as a means of social control (Swain 2013). The abstract beauty of the Camden Bench (Fig.2) is an icon of "aggressive architecture" that was designed to prevent anti-social behaviour such as graffiti, drug dealing and rough sleeping (Swain 2013). Addressing the problems of the urban environment by preventing behaviours that are symptoms rather than cause of the problem means that the real problem is obscured and those who are homeless, for example, are lumped together with those who deal in drugs and are equally dehumanised in the process. The client's brief and the design solutions considered the problem not as one of homelessness but as one concerned with the sensibilities of the non-homeless user of the city. Similar thinking to remove the homeless from the city centre influences design solutions such as cobbling and sloped surfaces to prevent sleeping in underpasses, on window sills and in doorways (Korody 2016a, 2016b,
2016c). Neither the client, the designer nor the contractor question the validity of the brief and what the brief and solutions say about these stakeholders perception of the function of the city and the contribution that architecture makes to human progress or regress.

On a grander scale construction projects contribute significantly to social control and not always by deliberate intent of all the parties to the project. The process of gentrification a, controversial in the contemporary period, is a process that can by intent or as an incidental consequence of other activities, transform the demographic of an urban area to the detriment of the "poorer" original residents (Dooling 2009, Jaffe 2014, Haffner 2015, Hatherley 2917). For example, the Highline project in New York has had the effect of raising the profile and the value of property in the Chelsea district through which it runs such that a previously "run down" area has now become the focus for real estate development and expensive apartments. Concomitant with this has been the loss of the pre-existing population and established business due to higher rents being imposed. Similar occurrences of gentrification are being recorded in cities worldwide and have been occurring for many generations (Quastel 2009, Tracey 2016). The redevelopment of Paris in the 19th century following the revolutions of 1790 had a similar effect of removing the poor from the city centre and reconstructing the city with wide boulevards designed as much to prevent the barricades of the revolution reoccurring as to gentrify the city, (Sagner-Düchting 1998). The Parisian boulevards are an example of architecture and construction for social control. Elsewhere walls, some called "peace walls" have been erected to separate communities, e.g., Belfast (Goodyear 2012, Garcia 2016), Berlin, Palestine (Sharif 2009) and even a proposed wall between the USA and Mexico. Gated communities are designed to keep people out or manipulate the flow of residents in and out of an area as in some of the redeveloped housing estate designs in Northern Ireland in the 1970s. These communities are now reaching the point where the creation of private cities are seriously under consideration e.g., Honduras (Associated Press 2012) or have been constructed, e.g., Gurgaon, (Doshi 2016) with issues of separation of...
communities or loss of lands by other peoples. Political and military occupying forces are using demolitions as collective punishments and settlement construction to alter the demographic and transform the political landscape, (UNSC 2016), or have done so to contain and restrict support for insurgents e.g., Vietnam in the 1960-70s, or to separate ethnic groups as in South Africa during the apartheid era.

Sport and sporting excellence contributes to the humanisation project, affording the urban dweller the opportunities for relaxation, health and socialising as well as high performance attainment. It's commercialisation and the advent of global mega-sports projects such as the Olympics and the World Cup have created environments that negate the equalities and concentrate the benefits into the hands of the few as monetised benefit and wealth. The negative consequences are grossly disproportionate with Olympic projects such since 1948 resulting in massive municipal debt for the host cities (Johnson 2012), (though this is countered by Rose and Spiegel (2009) who study suggests that Olympic hosts benefit in the long run from increased trade), from substantial decanting of populations to make way for the construction of stadia (Watt 2013), the acquisition or transformation of public space into private or commercial space (O’Bonsawin 2010) and in one of the worst recent examples of a dehumanising process, the death of approximately 1,000 migrants workers on the Qatar World Cup projects (Gibson 2014).

Environmentally, there is no question that construction has impacted on the landscape. The landscape we see worldwide is a product of the influence Humans have on nature; there is little that has not resulted from human intervention, either directly or indirectly (Berger 2010). The task of humanisation is not to exploit nature to human advantage and progress but to recognise ourselves as part of nature dependent upon its health and wellbeing for our own health and wellbeing; a sort of mutualistic symbiotic relationship. Humans ignorant of the impacts on nature assume instead that we can "excise, permit and adopt" to the changes we make in the environment (Soulé 2010). Roads for example and other exurban developments can impact on the environment many kilometres into unfragmented habitat (Soulé 2010). How much more than do larger scale urban projects, extractions sites and heavily used transport networks impact upon the "natural" environment and what unknown detrimental effects will they have on the human project?

**PROCESS**

With over 100,000 deaths per annum construction remains one of the dangerous industries (Walter 2010) not because it is a high hazard industry (which it is), other high hazard industries such a power generation, potentially present more hazards but conversely are safer with very low to zero “risk”. It is dangerous because of factors peculiar to the industry. It's dynamic and transient nature and continually day by day evolving from ground works to completion, it's heavy reliance on temporary, and often unskilled, labour, the high competitiveness of the tendering and contracting processes, narrow margins, poorly defined specifications allowing for contractors to interpret too widely their meanings, poor standards of materials, low wage corruption at high, medium and on-site levels.

The result on-site is low safety levels, high health infractions and little concern for the short or long-term wellbeing of the workforce, reflected both in wages paid and workplace conditions. Migrant workers suffer disproportionately with lower than minimum wages, poor working and living conditions (Gibson 2014) and increased levels of discrimination (O'Connor and Goodwin 2012). Additionally, on multilingual
sites workers experience communication blocks with critical information often conveyed in the form of pictographs and simple multi-lingual phrases and signs (HSA 2008, Hare et al. 2013). Whether in work-camps or in city lodgings, isolation and separation from family and community support networks lead to personal isolation with subsequent increases in mental health problems and addictions (O’Connor and Goodwin 2012). The different 19th and 20th century waves of Irish migration or Britain saw the major groups of the migrants in racialised employment as unskilled labour on construction sites (O’Connor and Goodwin 2012) subject to racial and religious abuses and discrimination. Blacklisting programmes disadvantage workers when union officials and safety advocates are listed and denied the opportunity to work in the industry (UK). The message is clear, that organising to improve terms of employment and conditions of work is unacceptable to the contractors and that workers on construction sites must accept the conditions proffered.

Addressing the skills deficit, especially in terms of the OSH competences, the ISSA education section advocated the integration of OSH education and training into vocational and professional programmes of study in colleges and universities that supply the industry with skilled trades and professional workers (ISSA 2003). The industry has yet to understand and fully embrace the concept that OSH competences are integral to the competences and skills of the trade or profession or in interpreting the various iterations of the CDM regulations in the UK (HSE 2014). Some employers have a focus on the lowest levels of OSH training embodied in the evidentiary base of baseline construction-focused quasi-skills cards, an item attained following a one-day general training programme to be repeated every three years. Despite over two decades of use and the fact that workers have been led to believe that they must have this card in order to get onto the site, fatalities, injuries and ill-health in the industry remain high at approximately three times that of the average for other industries. That said there is recent movement in UK with the recent Health in Construction Summits (2016 and 2017), a coming together of the leading Chief Executives of the construction industry with the assertion that worker’s health and the health of those impacted by our infrastructure development has to become a force for good. One clear message being that as an industry we need to start to see the construction industry as a people industry and not one concerned with the use and abuse of construction and steel. We are not a bricks and mortar industry they are simply some of the tools/materials we use to promote and enhance social wellbeing and increase the health of our society (HCLG 2017). What benefit if we harm those who work to make this a reality? Beyond the more obvious (although often neglected) hazards that impact open our physical state it is incumbent upon us to also ensure that the mental health and wellbeing of all stakeholders; our construction fraternity as well as the users/end-users of our product. One overarching question for designers has to be: What can we do as designers to avoid mental health anguish within the construction workforce? A challenge perhaps new and slightly alien to construction design professionals but one that speaks to the humanity of structural and not just social engineering. Much of this work is in its infancy and the months ahead should deliver much more of the detail as the professional bodies converse. Further evidence of the construction coming to terms with the need to meet the ‘humanising’ challenge is coming through in various higher education programmes, for example Ulster University has introduced ‘ethics reasoning’ as an integral element of both their civil engineering and quantity surveying undergraduate degree programmes (McAleenan, P. 2016). Students at University of Melbourne work with workforces in dramatically different cultural contexts – in rural Thailand and in an indigenous Australian
community, addressing among other things language difficulties, cultural and ideological differences and various physical competences to ensure delivery of safety on the different worksites (O’Brien and Hill, 2009). Education as a means of social praxis promotes dialogic learning, that is it requires both interpretation of the subject and judgement of its worth and meaning and in that we have the challenge to all educators in the construction field. (McAleenan C 2016). So too is the challenge to the academic researcher to deliver to the rest of the industry solutions or choices that will enhance and improve OSH, derived through the time allowed to think, contemplate, make sense of today’s many challenges.

HUMANISATION

The challenge in construction is to reconcile its function to provide for social need with the satisfaction of private interests. In the public sphere where major social interests are played out this will require the opening of a genuine dialogue amongst all the stakeholders on the purpose, needs and desirability of new projects, respecting throughout that those stakeholders most effected by the project through e.g. decanting, loss of amenity, adverse economic impact, etc. must have a genuine and effective decision making role. In national jurisdictions that permit public consultations on these matters, this exercise should go beyond the appearance of "having a say" and provide for full participation and input directly to the decision making process. To facilitate this process, full and honest disclosure of all information is essential in order that informed decision making can occur.

The essence of social "good" is at the core of good construction and this requires an analysis of the impacts of the project with the negative as well as the positive being opened for examination. The first of the three objectives of sustainable construction is that it must be good for society, and these social considerations take precedence over private e.g. shareholder gain. In this it falls to the legislature to ensure that within building and construction statutes and government policy this social benefit is the driving objective, both informing the statutory planning agencies of their focus and guiding clients and developers to accord sufficient prominence to the public good in their business activities. When considering the Rana Plaza building collapse in Bangladesh and the 1,135 fatalities that occurred there (FCO 2014) the degree of collusion between business owners, contractors and public servants that led to the disaster results from national policy failures and the absence of sufficient a checks and balances (ILO 2015a). Construction in general and projects specifically need a potent system of checks and balances at all stages to ensure that the projects meet public interests, adhere to current technological standards and are constructed and maintained in accordance with the same high levels of technical capacity and social competence.

Adhering to the social benefit objective extends to the process of construction wherein the safety, health and wellbeing of the construction worker and the end user is accorded due respect and equal consideration. Workers' trade and professional interest in employment rationally is secondary to their interest in the industry as a source of employment as a means of satisfying their fundamental human needs. For some the satisfaction of these needs may be their only interest, for others the industry provides the means of also satisfying the higher levels of need including social interaction and self actualisation. The Seoul Declaration (ILO 2008) places an emphasis on employment and work as being a significant contributor to human wellbeing. In practice this means meeting the basic requirements for "Decent Work" (ILO 2015b) beginning with compliance with the minimum standards for safe and healthy
workplaces, providing sufficient remuneration to allow workers to know that their employment will meet their personal and social needs, and providing security of employment.

Satisfying wellbeing extends the obligations on employers beyond mere compliance with minimum standards. Respect for the individual, a key element of a mature ethics reasoning (Eckensberger...) means respect for the worker as an equal, respecting their competence and their agency. This entails a reappraisal of employment hierarchies of authority wherein the wage payer (employer) exercises authority over those who are waged via the hierarchy of managers. This structure requires the fundamental relationship wherein the employer who pays the wages needs the employee to produce the capital in order for their wages to be paid. Notwithstanding the transactional relationship between employer and employee, once the contract of employment or building contract exists, the parties to the process of construction can be viewed as partners in the enterprise each contributing a necessary element to the project and respected equally for that input. This is at the heart of the CDM regulations (UK) wherein the key duty holders are statutory obligated to work within their competences, to inform the liner and others in the team of their legal duties and obligations and to jointly make decisions on all matters from the earliest design stages to the completion of the project. Extending this principle to all parties to the project builds a culture of communication as opposed to one of instruction, and depends for its success on cooperative participation, agreed objectives, open information including financial records, and individual and collective agency. This model was successfully applied by the Semco company in Brazil (Semler 2001).

The third objective of sustainable business addresses that which is good for the business or businesses involved in the project. Successfully addressing societal and worker interests does not negate business interests, it moderates this interests by balancing them with the attainment of social benefit at societal level and at the level of individual need. Where shareholder needs are prioritised over social and worker needs, businesses retract and even close to preserve the financial "bottom line". Thus in recessions smaller contractors shut down and workers are made redundant. The history of the Lavala movement in Argentina (Lavala Collective 2004) demonstrates that the collective input of the workforce to problem solving is capable of ensuring success of ten business on a modified model based on priorities of human need over excessive profits. Hotels, factories, etc., closed by the owners were taken over and reopen by the redundant workers and successfully operated on a cooperative basis to ensure that they and their families and communities retained the means of survival and self-worth. The collective mind can address problems in novel ways that even based on simple "self-interest" ensure in practice the interests of all.

Successful business sustainability is an interrelated mix of satisfying public, private and worker interests. It is in this context that humanisation progresses. A humanising construction is not concerned with the vainglorious monuments on the landscape to architects, politicians or profit, but is concerned with the realisation of the potential of all equally and with full respect.

**CONCLUSION**

Construction, as realised in practice is problematic whenever the projects, from mega to minor, conflict with the fundamentals of human dignity and decency, whether in the building of mega sports projects that displace communities or expose workers to extremely bad conditions, or which degrade the environment by lack of concern or by
good intentions poorly informed by the science of ecology. This work advocates the starting point of a new approach to construction that places humanisation and Man’s attainment of authentic Being at its heart. Future research to achieve this objective will need to examine the societal and political models for construction planning and policies. It needs to look at the social relations of and within construction and learn from models of successful cooperation and models mooted but never applied to develop appropriate national and cultural models that will restructure those relationships in a manner that will advance the human ontological project.

Ultimately it will require a review of education practices that will ensure that ethics and ethics reasoning are integrated into primary, secondary and tertiary education to evolve trades and professions that uphold the principles of universal respect and equal consideration for Man and nature.

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IS THE LONG-BOW BETTER THAN THE CROSS-BOW?
- EMERGING ISSUES FROM MOBILISING A LONGITUDINAL STUDY ON A MEGA-PROJECT

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Longitudinal studies of Occupational Safety and Health (OSH) outcomes in construction projects are rarely conducted, due to the financial, practical and ethical difficulties of studying people, projects and organisations over extended periods of time. Traditionally, OSH research in the construction industry is cross-sectional – taking a snap-shot, often looking retrospectively. The focus of this paper is the mobilisation of a longitudinal research study investigating OSH Policy in an eight-year infrastructure mega-project in the UK. The research is examining implementation of the project’s ‘transformational’ OSH strategy in order to develop new understandings of the effectiveness of OSH interventions. The research design uses a ‘Strategy as practice’ lens and will trace the various OSH policy strands from development to their adoption as practice. The research context is complex due to the complicated contractual arrangements. The research design incorporates a rarely used ‘tracer’ methodology. During the mobilisation phase of the research project several challenges were identified including interpretation and implementation of this tracer methodology; coping with a large team of researchers; setting up ethics and governance; deployment of the team to site; consistency of data collection; managing datasets; coding reliability. The methodology adopted is time consuming and the very large datasets that are generated need to be managed. Complex research project management structures and processes are required that would not be needed for traditional cross-sectional studies. Sufficient time needs to be allowed at the start of such research projects to put the necessary systems in place. The paper will be of interest to OSH researchers and those contemplating longitudinal studies particularly those employing a tracer approach.

Keywords: Complexity, Longitudinal, Mega-projects, Occupational Health, Strategy.

INTRODUCTION

This paper provides insight into the mobilisation of a unique longitudinal study of OSH policy deployment into practice on a construction mega project. The project being studied is a water infrastructure project, constructing a 25km long tunnel under a major river, and is scheduled for completion in 2023. The funding for this first phase of study, provided by IOSH (Institution of Occupational Safety & Health), covers the first three years of the eight-year construction project. The project provides a unique opportunity to study the impact of OSH leadership, policy and practice over an extended period ‘in-flight’ (Pettigrew 1990) using a longitudinal approach i.e. collecting data over a longer time period or arrow flight (Woodward 1970; Chau & Witcher 2005).

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The project has a high degree of complexity (Baccarini 1996) due to complicated contractual arrangements. The management company is supervising three construction consortia and a further company responsible for the installation of the overall control system. The contract itself is based on NEC 3 plus appendix X (ICE 2013) which is designed to foster a high degree of collaboration between the parties. The research team consists of three academics and four post-doctoral researchers (RAs) at a UK university working on a part-time basis. The academics, including the project lead, provide direction and oversight. The four RAs have specialisms including: Occupational Health practice; Design; Quantity Surveying; Project Management. The team have considerable experience in OSH research including in-depth knowledge of OSH on several internationally recognised infrastructure mega projects e.g. Terminal 5, 2012 Olympics, Crossrail and Gorgon.

The objectives of this research are to reveal new approaches to achieving desirable OSH outcomes, together with in-depth knowledge of how they can best be managed through the process of implementation. The research will also identify the practical lessons, knowledge and good practice that are developed and can be shared with wider industry.

In this paper we discuss the challenges which the research team have encountered during the initial mobilisation phase of the research and the ways in which these have been addressed. This will provide insights into the use of longitudinal approaches in the OSH research field to inform debates about the ways in which H&S policy translation into practice is studied. The study is at a very early stage having only recently been mobilised and therefore the focus of this paper is on the team’s experiences during this phase of the research project.

This section has provided an outline of the context of the study and the aims of the research. The following sections provide an overview of the relevant literature, issues arising during mobilisation and how they were dealt with, and reflections on the practicalities of longitudinal research.

**LITERATURE OVERVIEW**

The majority of social science research is cross-sectional rather than longitudinal and employing quantitative rather than qualitative methods (Bryman, 2012). Menard (1991) defined longitudinal studies as those where data is collected over one or more time periods, the subjects or cases are the same or comparable from one period to the next and, the analysis involves comparisons between periods. He defined cross sectional studies as having data collected once for each item over a narrow space of time such that the measurements can be considered contemporaneous for all variables and cases.

In medieval military terms a cross sectional study can be likened to a ‘cross-bow’ which is relatively easy to use, doesn’t need intensive training and early versions had limited accuracy, sophistication and range? The cross-sectional approach takes ‘snap-shots’ at the time the study is conducted and the findings are then extrapolated backwards and forwards, outside of the timeframe the data was collected (Yin 2003). This method relies heavily on a combination of the recollections of research subjects and on data derived from lagging indicators. On the other hand, longitudinal studies can be likened to longbows which are more accurate, have a faster firing rate and provide more flexibility in battle but require more skill. Longitudinal studies need experienced researchers who can ‘fit in’ to organisations, cope with a greater rate of
data collection, and be more adaptable to deal with changes to their area of study which emerge over time. Such studies also require more commitment from industry collaborators to provide good access over sustained periods.

In his keynote at the 2014 W099 conference in Lund, Sweden, Andrew Hale challenged the research community about the lack of longitudinal studies covering OSH in construction (Hale 2014). Pettigrew (1990, p.284) stated that ‘longitudinal research in the social sciences has always been a ‘minority taste’ research into industry practice.

The research aim is to develop new understandings of the deployment of OSH strategy and effectiveness of the resultant OSH interventions in large, complex multi-site construction projects with networked supply chains. In other words, the research will be monitoring change within the organisations involved in the construction project. Menard (1991) states that the two primary purposes of longitudinal research are “to describe patterns of change, and to establish the direction……and magnitude of causal relationships”. As such, using a longitudinal approach allows the study of the OSH interventions as they unfold revealing not only their effectiveness but the ways in which OSH policies and practices intersect and intertwine with other organisational agendas. A recent study in the construction safety field revealed that from a sample of 88 papers published in 2009, 50% were quantitative, 25% were qualitative and only 10% were mixed methods (Zou et al 2014). In Occupational Safety and Health (OSH) studies, particularly in construction, have been generally cross-sectional. The paper called for more mixed methods research to improve the generation of knowledge and improve collaboration between researchers and practitioners. This aligns with the view of Menard (1991) that the term longitudinal does not describe a single method but more a collection of methods which is also the approach for this study.

The tracer methodology has its roots in seminal work by Woodward (1970), who used it as a method to explore managerial control systems across three case studies. There are specific terms associated with this methodology. Tracers are the processes which are of interest and are traced during the research. Tags are a means of identifying items or ideas that are to be followed. Manufacturing processes were selected as tracers to be followed through the control systems of the organisations. The interactions of the staff and their behaviours were observed in terms of how they were involved in planning, making decisions and carrying out tasks related to the tracer (Woodward 1970). This allowed a wider understanding of the control systems by studying smaller elements or sub-systems from which more focussed data collection could take place as the study evolved over time.

The approach was further developed by Hornby & Symon (1994) who provided a structure for examining the perspectives of stakeholders on processes with which they have participated. Cassell & Symon (1994) refer to organizational studies as being about highly complex processes which have a variety of actors over their timespan. They promoted the use of tags attached to tracers which are followed to identify the important processes and key actors pertaining to the research focus, as well as critical documents, events and activities.

Using this methodology, the research team will be able to follow whichever processes and people emerge as relevant to shaping OSH outcomes rather than making an assumption that the issues and influences relevant to OSH are all known at the outset. The methodology allows a variety of research avenues to be opened up and closed
down as their relevance is established. In this respect, the method is particularly effective in examining the effect of specific interventions as ongoing activity. In other words, the aim of this type of study is to iteratively examine emergent issues collected through interviews and to build upon and respond to these in later stages of the research endeavour (Chau & Witcher 2005). The approach is particularly apposite in that it uses tried and tested research data gathering techniques (e.g., interviews, observations, documentation reviews) but within an innovative longitudinal framework. It allows data collection to be focussed in specific areas of interest thus making the dataset more manageable and enables better understanding of the wider picture by looking at small elements of the organisation rather than everything at once.

**ISSUES ARISING DURING MOBILISATION**

The mobilisation of the research consisted of a number of elements, some of which ran concurrently, including: establishing the research methodology; mobilising the research; establishing the governance structure; obtaining ethics approval; and, commencing the data collection and analysis phase of the project. This section describes the research mobilisation period from February 2016 (the official project start date) to December 2016 when Milestone 1 was successfully achieved. The following sections describe the issues that arose and how they were dealt with.

**Establishing the methodology**

From the outset there was considerable debate as how the research methodology should be applied and this continued as the project progressed. A key facet of the methodology used in this study is an adapted version of the longitudinal tracer study methodology (c.f. Chau & Witcher 2005) that was originally developed by Woodward (1970). In essence, the application of a longitudinal tracer approach allows core organisational processes or phenomena to be isolated and their progress followed via insights gathered at particular stages of its development.

Tags are being used to identify the important processes and key actors pertaining to the research focus, as well as critical documents, events and activities. By tagging particular people, processes and tools the effects of interventions can be studied in real time. The choice of tags is crucially important to the success of a tracer study; they should be a relevant reference to respondents, be malleable enough to enable issues to emerge, and should offer up sufficient data to generate and develop theory. It is essential that the tags are grounded in practice and developed in collaboration with the industrial partners, to make sure that most fruitful opportunities are exploited. This is an emancipatory methodology, responding to the complex network of organisations, the approach that the people, teams and organisations are taking and focussing on the nature, complexity and risks involved.

The flexibility of the methodology caused the research team considerable problems right from the start. Each of the seven team members had their own interpretations of what it meant and how it might be deployed in practice. Team meetings would end up with long periods discussing the different viewpoints put forward and what was meant by the various terms. After several interesting but inconclusive discussions a visual representation was developed used to both to stimulate ideas and more importantly provide more focus. This resulted, after several more sessions, in the diagram shown at Figure 1. The research team had to decide on how they were going to use and adapt the methodology rather than stick with the latest extant interpretation. This helped the team reach a consensus as to how the methodology was to be developed and deployed.
The next task was to clarify the terminology that was to be used in the current context, namely: themes/knowledge domains; tags; tracing; passage points; and, happenings. This crystallized the team’s thinking and provided a consistent message to communicate to others about the research methods.

**Figure 1: Tracer methodology schematic**

Overarching themes, or knowledge domains shown in Fig 1 above are the key areas covered by the study which based on the OSH literature are likely to be of interest to practitioners and academics in the field of OSH strategy & implementation. Tags will be used to identify things that we are interested in such as specific interventions or initiatives (e.g. inductions, on-boarding), and broader initiatives (e.g. mental health, design for health). These tagged items or ideas can be traced to see how the relevant areas of strategy are implemented over the project lifecycle, and how this implementation is affected by other factors. The things that are tagged will be subject to change as the project moves forward – for example project induction might evolve into a different format, and the research will seek to identify: the nature of the change; the causes of the change; and, the impact on other tagged items and on the project outcomes. In terms of collecting data, passage points can be used in the same way that a suitcase tag would be checked on various occasions, at different airports during its journey. In this context passage points will include meetings, interviews with key players and KPI (Key Performance Indicator) data.

Another type of phenomenon of interest is the ‘stuff’ that happens during the course of a project (happenings) which affects the way the project is enacted, the OSH
performance and resultant outcomes. These may be internal-expected (project phases etc.); internal-unplanned (e.g. changes in key personnel or incidents); and external (e.g. BREXIT). A log of happenings relevant to the project will be maintained so that the team can check how these affect the things that are tagged.

There was also some considerable discussion of the theoretical perspectives to be used in the study. Given the topic under study was the implementation of strategy the use of a ‘strategy as practice’ (SaP) lens was considered a good fit by the team (Pettigrew 1990; Pettigrew 1992; Jarzabkowski 2004; Whittington 2006). Further review of the literature established that work in the ‘organizational change’ field (Tsoukas & Chia 2002) would also aid in understanding of how policy is translated into practice. The SaP lens will be used to examine the various OSH policy strands as they are traced from their development through to adoption as practice. Due to the emergent nature both of the methodology and the research being conducted these discussions are ongoing but are increasingly more focussed.

**Mobilising the research**

The research team took several months to assemble. Each of the RAs were allocated roles and responsibilities for the various activities according to their knowledge and experience. Each led on one or more subject areas in addition to being allocated to build relationships with one of the joint ventures or the management company.

Following the allocation of roles and responsibilities the original research plan from the proposal was then updated and revisions approved by IOSH. A high level research plan was produced covering the initial three-year research period. From this, detailed research plans were produced for individual elements of the milestone 1 deliverables. The plans for the individual elements covered; familiarisation with the topic and staff involved; data collection; data analysis and preparation of outputs. The plans are reviewed on an ongoing basis.

The initial team meetings were sometimes a little unproductive as the team strived to develop the processes necessary to manage the project. As with any new team &/or project the personalities involved need time to ‘gel’ together (or not) into a cohesive performing team. Geography was an additional challenge with two RAs living 1-2 hours’ drive away from the University and the project being studied being a two-hour train journey away; and involving sites located all over the city. This was mitigated by having weekly meetings at the University in person if possible or via skype. Other collaboration tools were used with varying degrees of success: One note; Slack; Google docs; and, good VPN (Virtual Private Network) access to the shared drives. The meeting structure has evolved over time as different approaches were tried and discarded if found not to work. The RAs meet together and with the lead academic every two weeks and as a whole team monthly. There are separate monthly meetings between the main site-based researcher and/or the lead investigator with the industrial HSW (Health, Safety and Wellbeing) Director and HSW Lead, and regular meetings with the IOSH project manager.

After nine months, several particularly useful project management processes have been introduced including: the use of a standard slide pack as the review meeting agenda and to capture actions; adoption of a rotating chair and minute taker to enable the leadership role to be shared across the RAs; and producing a document where the responsibilities of each team member (including ownership of particular key files, processes and records) were outlined to give greater clarity of what was required from each person.
There were considerable advantages to having four RAs as they have a vast range of experience and many ideas resulting in cross pollination. There were also some important disadvantages in terms of the extra time needed to share information, the time needed to reach consensus, and coping with different styles of working. There was also an inherent perception amongst others involved that we had four RAs, who were 100% attached to the project and it was easy for them to forget the 1.6 FTE time restriction. A key consequence of having four rather than two RAs was the increased percentage of available researcher time spent at meetings – so that a one-day meeting involving all four researchers used up half of the week’s total allocated time on the project. There were also recurrent challenges meeting deadlines for written outputs due in part to the pressures of each RA needing to simultaneously work on their own outputs and comment on those of others. Better research planning and realistic allocation of time to the RAs will be required as the research progresses. For example, it was suggested that for future outputs there will be a lead writer and a second support person to minimise the number of team members involved.

A key enabler to building an effective research team was the fact that the personalities involved were able to reach a suitable compromise position for any issue that came up during the mobilisation. This point should not be underestimated as research staff and academics are, by the nature of their work, often highly skilled at putting a viewpoint across and defending it against all-comers. With a less collaborative team, it would have been much more difficult to make progress. A good example of dealing with this was the use of a rotating chair for the project meetings rather than selecting one RA as the leader. On the other hand, a more autocratic approach may have been more task focussed but less effective as it would stifle debate and creativity. The methodology allows a lot of flexibility in how data is collected and analysed which suits a more cooperative approach to an emergent topic of study. What was needed was better project management which was eventually achieved through the meeting structure and rotating leadership model that evolved.

A series of initial research questions were developed to guide the investigation and collection of data, namely:

- How does OSH policy translate into practice on major construction projects?
- How does OSH policy propagate through complex organisations created by mega-projects?
- How effective are the OSH interventions that are implemented on mega-projects and how have they been managed?
- Which findings will be of most relevance & use to industry practitioners & researchers?
- How do people cope with complexity and change in mega-projects?

These research questions are emergent due to the longitudinal nature of the research and the topic(s) under investigation. At research team project meetings, the topics are reviewed to determine which topics will remain under active investigation.

### Governance

The governance for the project is a vital area given the research topic and duration. There are multiple stakeholders whose needs must be taken into account and managed and so a number of groups have been set up. An overall steering group represents the main stakeholders in the research and other key industry representatives. This includes IOSH as the main funding body which is keen to see that there is a focus on practical outputs for OSH professionals, as well as wider social and economic impact. In
addition, there are two reference groups, from industry and academia, to provide sounding boards for findings and to maximise the applicability in terms of impact and benefit to the broader construction industry (e.g. smaller projects and other construction sectors) and the research community. Formal reports will be produced annually with interim reports issued as necessary.

The governance structure provides the necessary independent oversight through the steering group and input from the reference groups. The management of these groups requires significant amounts of time making preparations and arrangements for meetings and associated workshops. This has, on occasions, threatened to detract from the main research activities of collecting and analysing data. It is important that the governance process is proportionate and adds value to the overall research over the life of the project.

**Ethics approval**

Approval from the University Ethics Committee was required. The submission made to secure this included consideration of the following: project details; research team experience in methods proposed; participant information; observation/recording; consent; participant withdrawal; storage of data and confidentiality; incentives; risk assessment; declarations. As the research was mobilised a number of research protocols and related documents were developed: research overview; consent form for recorded interviews; information sheets for interviews, observation, and meetings; action research log; and researcher diary.

There were several minor issues in relation to ethics. The first was the lack of understanding by the Ethics Committee of the realities of carrying out research on live construction sites. This was overcome by revising some of the initial material in the submission and by meeting with the committee chair to discuss the research. The need for written consents for recorded interviews can discourage participation by some subjects and, in fact, in two cases participants were happy to be interviewed and recorded but unwilling to sign a consent form. These interviews proceeded with hand written contemporaneous notes being taken instead of recording.

In the case of a longitudinal study there are a greater number of consents to be obtained and there is the issue of researchers influencing outcomes in the organisations being studied. As participant observers, there is the risk that the researchers may influence the activities under observation. Some of this may be incidental but some will be a direct result of the role the research team is playing particularly as the project is keen to learn from the research team’s work and to adapt what they are doing. There is, therefore, an element of ‘action research’ in the approach. A protocol has been developed which includes a log for documenting any activities that may influence how things are done.

**Data collection and analysis**

Data collection will be mainly based on qualitative methods using interviews, archival analysis; observation. In addition, focus groups and surveys will be employed as a means of triangulation for any findings. The management company has been very supportive of the research from board level downwards. Involvement in the research was contractually written into the Works Information and this was seen as part of the transformational approach to OSH. The process of getting access to work on the project was complex and consists of three stages on three or more separate days: attendance at the central on-boarding facility (COF) for security and health checks;
attending the employer’s project induction centre; and, finally site induction for any site to be visited (including office locations). All researchers are required to have a Construction Skills Certification Scheme (CSCS) card as this is a requirement of all those working on the project, including office staff. Anyone who wishes to enter the tunnels will need to attend a tunnel safety training scheme course.

Initially, the team had to learn about many different things at once but this had to be balanced against the need to work within the allocated research team resource. The project OSH policies have to dovetail with those of the tier one joint venture contractors (and their parent companies) and they are, therefore, likely to take different paths as the work progresses. Interviews with the key practitioners acting at these intersections will be used to reveal the interrelationship between these policy trajectories. The study of the phenomena emerging at these intersections will include reviewing specific OSH-relevant metrics (e.g. accident/incident data) and other data (meeting minutes, documents, newsletters etc.) in order to explore the contexts and effects of policy implementation over time.

Building relationships has been important and locating the team members alongside specific units of analysis was important i.e. one researcher for each contracting consortia and one for SI (Systems Integration) and the management company. This will allow the team to have a deeper understanding of the politics involved in the project and the drivers in different parts of the project. There are geographical and logistical issues due to the large number of sites (24 main sites and a main office eventually), their accessibility, and the need to attend meetings at various times of the day. All this led to some initial inefficiency but this has been overcome by better visibility of the on-site activities of the research team members and better planning through calendar sharing.

Over time the data set has grown rapidly and the data analysis needs to be carried out in a timely and efficient manner. Not knowing what might become important may lead to continuing to collect data which might or might not be needed at some point in the future. In the first nine months the team carried out 49 interviews, observed 57 meetings and have undertaken one survey. To aid the management of the data the team is starting to index files using meta tags (not to be confused with the longitudinal methodology tags) within an overall shared file structure accessed via a VPN connection when away from the University.

A key area of discussion has been the use of NVivo for coding and analysing data which is labour intensive. Coding and indexing data is not made easier by the evolving nature of the research questions which increases the risk of data having to be repeatedly recoded or refiled. Gaining agreement on coding structure has been time consuming. Consistency of coding between different researchers will need to be managed. The team is already on its second iteration of the shared file structure and is about to relaunch its third coding structure.

**REFLECTIONS ON Undertaking Longitudinal Research**

So is the longbow better than the crossbow? The answer is simple - it depends… on where you are in the battle cycle; how much fighting resource you have at your disposal; where the battle is taking place; how skilled your troops are; and, how you
plan to overcome the tactical challenges presented. Longitudinal research is similarly challenging.

The challenges identified in mobilising this research have included the interpretation of a little used longitudinal methodology within a large research team; setting up governance for long periods of study; ethical considerations; data overload from too many lines of inquiry and easy access; consistency of data collection; the challenges of inter-rater reliability in coding. Other features which have been covered in less detail have included: frustration at ‘missing’ the action; the inherent uncertainty in working with ideas of organisational becoming. Further publications during the course of the research projects will be able to provide more details on specific challenges.

Carrying out longitudinal research on this scale is a significant undertaking and the team have a large amount of data which they need to make sense of in order to meet the research aims and objectives. The team have worked hard to mobilise the methodology and devise a project management approach that suits the needs of all stakeholders. The project is at a stage where the team needs to become more focussed and concentrate on producing high quality outputs. The processes introduced e.g. meeting structure, indexed shared file structure are starting to regulate how the team operates and make it more efficient and effective within the resource constraints. The opportunity, provided by this unique study, to make a difference in how learning about OSH in megaprojects is generalised for use by wider industry needs to be carefully managed to a successful conclusion. This is being made easier by the unrestricted access to all areas of the project – both people and data. The team are totally committed to the task but will need to bring all their experience to bear.

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<th>Longitudinal (Longbow)</th>
<th>Cross-sectional (Cross-bow)</th>
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<td><strong>Disadvantages</strong></td>
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<td>Too much data; complexity of data</td>
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<td>Rich data</td>
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<td>Opportunity for triangulation</td>
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From a research community point of view, the study has already revealed some interesting insights into the application of longitudinal studies versus cross-sectional approaches. The relative advantages and disadvantages of the two approaches from the mobilisation of this study are outlined in Table 1.

It is too early in the project to draw firm conclusions regarding the benefits of using a longitudinal approach, and whether the benefits outweigh the challenges encountered.
Certainly the team can see mistakes being made and fixed that may not have been revealed in a cross sectional approach. Similarly, the team will be able to observe how OSH policies and interventions are developed and then discarded or changed during implementation.

CONCLUSION

A key feature of a longitudinal approach is the rich dataset which is both an advantage and a disadvantage. How it is managed will be key to the success of the project. Longitudinal studies with large teams need to allow time for setting up the project structures and processes required to manage the research activities. These are generally less complex with cross-sectional studies.

The dataset emerging from this work will afford insights into the ways in which OSH policy instruments are enacted, mediated, translated and appropriated by a broad range of strategy actors engaged in the project. Understanding how OSH plays out within and across project-based temporary multiple organisations will allow for domain-specific insights to be generated to address some of the specific issues that arise in this hazardous sector.

REFERENCES


THE PERFORMANCE OF CONSTRUCTION HEALTH AND SAFETY OFFICERS

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Part-time or full-time Construction CHSOs (CHSOs) are a requirement in terms of the South African Construction Regulations. Previous research findings and anecdotal evidence indicate that CHSOs are lacking in terms of various competencies, are precluded from contributing to the management of H&S and sites, could be more effective, and require development. The objectives of the study were to determine the performance of CHSOs; barriers to CHSOs’ contributions to construction and construction H&S, and potential of interventions to contribute to an improvement in CHSOs’ contributions to and impact on construction and construction H&S. A descriptive survey method was adopted for gathering and processing data obtained through self-administered questionnaires. The sample stratum included a convenience sample of delegates attending a two-day construction H&S summit. The findings indicate that the contribution of CHSOs to H&S could be improved. A range of factors constitute a barrier to CHSOs contributing to H&S. These include exclusion from decision making, non-consultation by site management, lack of authority, and exclusion from management of site, constitute marginalisation. This is underscored by the low ratings of CHSOs in terms of their understanding and appreciation of various aspects, composite knowledge areas and skills, and the extent to which interventions could contribute to an improvement in the contribution of CHSOs to H&S and construction. Conclusions include: that the function of CHSO is important and the ‘CHSO’ requirement in terms of the Construction Regulations is justified; inadequate ‘construction’ knowledge and experience contribute to the exclusion of CHSOs from the management of sites, and the actual barrier to CHSOs contributing to H&S, and that formal qualifications would empower CHSOs to contribute optimally to H&S and construction.

Keywords: Construction, Health and Safety (H&S), Health and Safety Officers, performance.

INTRODUCTION

The ‘Construction Health & Safety Status & Recommendations’ industry report highlighted the significant number of accidents, fatalities, and other injuries that are prevalent in the South African construction industry (Construction Industry Development Board (cidb), 2009). The report attributed this to a lack of compliance with H&S legislative requirements, and stated that there is a lack of sufficiently skilled, experienced, and knowledgeable persons to manage H&S on construction sites.

The Construction Regulations make provision for the appointment of either part-time or full-time CHSOs (Republic of South Africa, 2014). However, the cidb industry report ‘Construction Health & Safety Status & Recommendations’ highlighted the need for

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professional registration of construction H&S practitioners due to, among other, the finding that there was a lack of competencies, and no formal registration process. The South African Council for the Project and Construction Management Professions (SACPCMP) was then mandated by the Council for the Built Environment (CBE) in terms of Act No.48 (Republic of South Africa, 2000) to register construction H&S professionals. This in turn led to the identification of three such categories of registration, namely Professional Construction Health and Safety Agent (Pr CHSA), Construction Health and Safety Manager (CHSM), and CHSO. Registration rules were then gazetted for these three categories for commencement 1 June 2013 in the case of Pr CHSA and 1 August 2013 in the case of CHSM and CHSO.

Given the findings in the cidb report ‘Construction Health & Safety Status & Recommendations’, other ad-hoc research findings, anecdotal evidence, exploratory research findings, a further study was conducted to determine, inter alia, the:

- Performance and contribution of CHSOs;
- Barriers to CHSOs’ contributions to construction and construction H&S, and
- Potential of interventions to contribute to an improvement in CHSOs’ contributions to and impact on construction and construction H&S.

**REVIEW OF THE LITERATURE**

**Legislation and Regulations**
The amended Construction Regulations (Republic of South Africa, 2014), schedule several requirements with respect to CHSOs. Regulation 8 ‘Management and supervision of construction work’ a contractor must after a discussion with the client, and having considered various aspects, appoint a part-time or full-time CHSOs in writing. However, the CHSO must be registered with a statutory body approved by the Chief Inspector, and have the necessary competencies and resources to assist the contractor.

**Knowledge and Skills Areas**
The SACPCMP requires a report upon application to register as a CHSO that addresses the following nine knowledge areas: Procurement Management; Cost Management; Hazard Identification Management; Risk Management; Accident or Incident Investigation Management; Legislation and Regulations; Health, Hygiene and Environmental Management; Communication Management, and Emergency Preparedness Management (SACPCMP, 2013a).

The CHSO Scope of Services in turn states that CHSOs are expected to be experienced and knowledgeable relative to the following areas: construction project specific H&S management systems; construction H&S; H&S performance measurement and monitoring management, and continual improvement (SACPCMP, 2013b).

However, a study conducted prior to the registration of CHSOs initiative by Smallwood and Haupt (2008) investigated the importance of 79 knowledge areas and 50 skills to CHSOs. These were then consolidated in terms of 8 and 7 composite knowledge and skills areas respectively. Except for financial management, all the composite knowledge areas have MSs > 3.00, which indicates that they are more than important as opposed to limited importance. However, it is notable that 2 / 8 (25%) of the composite knowledge areas have MSs > 4.20 ≤ 5.00, which indicates that they are between more
than important to very / very important: OH&S, and project administration. Then, 5 / 8 (62.5%) have MSs > 3.40 ≤ 4.20, which indicates that they are between important to more than important / more than important: design; management / management of parameters; law; planning, and construction technology / technology. Financial management’s MS is > 2.60 ≤ 3.40, which indicates that it is between less than important to important / important. The implications of these findings are that CHSOs should be well rounded and versed in terms of knowledge, which is underscored by the fact that they fulfil a staff function, which means that they are required to be knowledgeable in the areas, and provide advice and support. Furthermore, given that a tertiary qualification does not exist, such well-rounded and versed CHSOs are not likely to exist. All the composite skills areas have MSs > 3.00, which indicates that they are more than important as opposed to of limited importance; albeit in the case of ‘negotiating’ marginally so. It is notable that 4 / 7 (57.1%) of the composite skills areas have MSs > 4.20 ≤ 5.00, which indicates that they are between more than important to very / very important: leadership; general management; negotiating, and interpersonal / developmental. Then, 2 / 7 (28.6%) have MSs > 3.40 ≤ 4.20, which indicates that they are between important more than important / more than important: planning, and technical. Financial’s MS is > 2.60 ≤ 3.40, which indicates that it is between less than important to important / important. The implications of these findings are that CHSOs should be well skilled in leadership, management, and technical matters such as planning and construction technology, even though they fulfil a staff function. This is underscored by the fact that they must interface with a range of built environment practitioners, especially construction managers.

A previous exploratory study conducted by Smallwood (2011) investigated a range of issues relative to CHSOs. CHSOs were deemed to have between a near limited to average / average understanding and appreciation of construction H&S, construction activities, construction management, and the construction process. Except for H&S and project administration, CHSOs were rated poor as opposed to good in terms of eight composite knowledge areas as discussed above. Similarly, except for interpersonal / developmental skills, CHSOs were rated poor as opposed to good in terms of seven composite skills areas as discussed above.

Contribution of CHSOs to H&S
The previous exploratory study conducted by Smallwood (2011) determined that CHSOs had contributed to and impacted upon H&S. However, the contribution and impact was deemed to be between a moderate extent to a near major extent / near major extent. However, the findings indicate that the contribution of CHSOs to H&S could be improved, namely between a near major to major / major extent.

The top four factors that constituted a barrier to CHSOs contributing to H&S, were related to the exclusion of CHSOs from the management of the site, namely: exclusion from decision making; lack of authority; exclusion from management of site, and non-consultation by site management. However, inadequate knowledge of the construction process and activities, construction management, and construction H&S, and related experience also constituted a barrier and were deemed to contribute to the exclusion of CHSOs from the management of sites, and the actual barrier to CHSOs contributing to H&S. This conclusion is underscored by the rating of CHSOs in terms of their understanding and appreciation of various aspects, composite knowledge areas and
skills, and the extent to which interventions could contribute to an improvement in the contribution of CHSOs to H&S and construction.

RESEARCH

Research Method
The descriptive survey method was adopted to gather the data obtained through a self-administered questionnaire circulated to delegates attending a two-day construction H&S summit in Durban, South Africa. The questionnaire consisted of 24 questions, 23 of which were close ended, one being open ended. Furthermore, 9 of the 23 close ended were five or six point Likert scale type questions. 36 Questionnaires were included in the analysis of the data. A measure of central tendency in the form of a mean score (MS) was computed to enable ranking and comparisons. The weightings relative to the five-point scale were as per the scale i.e. 1 relative to one, 2 relative to 2, and thereafter accordingly, resulting in a MS between 1.00 and 5.00. Certain questions required a sixth point due to either a ‘have not’, ‘does not’, or ‘will not’, which was weighted 0, resulting in a MS between 0.00 and 5.00.

Research Findings
Table 3 presents the qualifications that respondents opine CHSOs possess. The percentages represent the approximate percentage of CHSOs that have a certain qualification.

Table 3: CHSOs’ qualifications

<table>
<thead>
<tr>
<th>Response (%)</th>
<th>Unsure</th>
<th>Grade 12</th>
<th>N Dip.</th>
<th>BTech</th>
<th>BSc</th>
<th>BSc (Hon)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11.0</td>
<td>50.0</td>
<td>38.9</td>
<td>11.0</td>
<td>2.0</td>
<td>0.0</td>
<td>41.7</td>
</tr>
</tbody>
</table>

The respondents that identified ‘other’ recorded HIRA, IRCON, and SAMTRAC. The findings highlight the low level of formal qualifications that CHSOs possess, and therefore, that they are unlikely to possess the requisite knowledge and skills.

52% of CHSOs are employed on a permanent and 50% on a contract basis. 50% of CHSOs are deployed on projects on a ‘part-time’, and 41.3% on a ‘full-time’ basis. 57.1% of respondents indicated that other functions fulfill the role of CHSO, and 42.9% responded in the negative. This finding relates to the basis on which CHSOs are employed. 85.7% of respondents indicated that CHSOs fulfill other functions, and 14.3% not. Infrastructure projects predominated in terms of the type of projects respondents provided H&S consultancy services for in 2015 (Table 4).

Table 4: Type of construction projects respondents provided H&S consultancy services for in 2015

<table>
<thead>
<tr>
<th>Type</th>
<th>Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>14.6</td>
</tr>
<tr>
<td>Industrial</td>
<td>13.1</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>53.5</td>
</tr>
<tr>
<td>Residential</td>
<td>6.3</td>
</tr>
<tr>
<td>Other</td>
<td>11.6</td>
</tr>
</tbody>
</table>
Table 5 indicates that CHSOs report predominantly to site managers, or site agents, or both. ‘Other’ included a range of multi-management combinations. Clearly there is a degree of dual and multi-reporting.

**Table 5: Functions to whom CHSOs report**

<table>
<thead>
<tr>
<th>Response (%)</th>
<th>Site Manager</th>
<th>Site Agent</th>
<th>General Foreman</th>
<th>Site Manager / Agent</th>
<th>Other</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.6</td>
<td>33.3</td>
<td>0.0</td>
<td>11.1</td>
<td>22.4</td>
<td>2.8</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 indicates the extent to which CHSOs have contributed to and impacted on H&S on a scale of have not and between 1 (minor) to 5 (major), and a MS ranging between 0.00 and 5.00. Given that both MSs are > 2.50, CHSOs can be deemed to have contributed to and impacted upon H&S. However, given that the MSs are > 2.50 ≤ 3.33, the contribution and impact can be deemed to be between a near minor to moderate / moderate extent. However, both MSs are near the upper end of the range.

**Table 6: Extent to which CHSOs have contributed to and impacted on H&S**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Response (%)</th>
<th>Unsure</th>
<th>Have not</th>
<th>Minor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributed</td>
<td>0.0</td>
<td>0.0</td>
<td>5.6</td>
<td>2.8</td>
<td>61.1</td>
<td>19.4</td>
<td>11.1</td>
<td>19.4</td>
<td>11.1</td>
<td>3.28</td>
</tr>
<tr>
<td>Impacted</td>
<td>0.0</td>
<td>0.0</td>
<td>5.7</td>
<td>14.3</td>
<td>34.3</td>
<td>34.3</td>
<td>11.4</td>
<td>11.4</td>
<td>3.31</td>
<td></td>
</tr>
</tbody>
</table>

Table 7 indicates the extent to which factors constitute a barrier to CHSOs contributing to H&S on a scale of does not and between 1 (minor) to 5 (major), and a MS ranging between 0.00 and 5.00. Given that all the MSs are > 2.50, all the factors generally can be deemed to constitute a barrier to CHSOs contributing to H&S. However, a review of the MSs in terms of ranges enables a more scientific review. MSs > 3.33 ≤ 4.17 indicate the factors can be deemed to constitute a barrier to CHSOs contributing to H&S to be between a moderate extent to a near major extent / near major extent.

The factors ranked first to twelfth are included in this range. It is notable that the top four factors, which are included in this range, are related to the exclusion of CHSOs from the management of the site; exclusion from decision making; non-consultation by site management; lack of authority, and exclusion from management of site. Four of the factors ranked fifth to twelfth are inadequate experience related and four are inadequate knowledge related. Status level has a MS > 2.50 ≤ 3.33, which indicates the contribution and impact can be deemed to be between a near minor extent to a moderate extent / moderate extent.

Table 8 indicates the rating of CHSOs in terms of their understanding and appreciation of various aspects on a scale of 1 (limited) to 5 (extensive), and a MS ranging between 1.00 and 5.00. Given that only one of the related MSs are > 3.00, CHSOs generally can be deemed to have a limited understanding and appreciation of construction process, construction management, and construction activities. However, the converse applies in terms of construction H&S.
Table 7: Extent to which factors constitute a barrier to CHSOs contributing to H&S

<table>
<thead>
<tr>
<th>Factors</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusion from decision making</td>
<td>0.0 0.0 0.0 8.3 8.3 41.7 41.7 4.17 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-consultation by site management</td>
<td>0.0 2.9 2.9 14.3 45.7 34.3 4.06 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of authority</td>
<td>0.0 0.0 0.0 2.8 27.8 30.6 38.9 4.06 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusion from management of site</td>
<td>0.0 0.0 0.0 11.1 22.2 33.3 33.3 3.89 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate construction process experience</td>
<td>0.0 2.9 0.0 5.7 14.3 51.4 25.7 3.89 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate construction management knowledge</td>
<td>0.0 0.0 0.0 8.6 28.6 40.0 22.9 3.77 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate construction activities experience</td>
<td>0.0 2.8 11.1 22.2 36.1 27.8 3.75 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate construction management experience</td>
<td>0.0 0.0 0.0 8.6 31.4 37.1 22.9 3.74 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate knowledge of the construction process</td>
<td>0.0 5.6 0.0 11.1 13.9 38.9 30.6 3.72 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate knowledge of construction activities</td>
<td>0.0 0.0 2.9 8.6 25.7 42.9 20.0 3.69 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate construction H&amp;S experience</td>
<td>0.0 0.0 2.9 20.0 20.0 31.4 25.7 3.57 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate construction H&amp;S knowledge</td>
<td>0.0 0.0 5.6 13.9 27.8 30.6 22.2 3.50 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status level</td>
<td>0.0 2.9 5.7 17.1 31.4 22.9 20.0 3.26 13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, a review of the MSs in terms of ranges enables a more scientific review. MSs > 2.60 ≤ 3.40 indicate the degree of understanding can be deemed to be between near limited to average / average, which includes all four aspects. This finding reinforces the findings relative to inadequate knowledge and experience, which marginalise CHSOs from contributing to the management of the site and from decision making.

Table 8: Rating of CHSOs in terms of their understanding and appreciation of various aspects

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand and appreciate construction H&amp;S</td>
<td>0.0 5.6 16.7 30.6 33.3 13.9 3.33 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand and appreciate the construction process</td>
<td>2.8 16.7 33.3 19.4 19.4 8.3 2.69 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand and appreciate construction management</td>
<td>0.0 13.9 33.3 30.6 16.7 5.6 2.67 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand and appreciate construction activities</td>
<td>0.0 11.4 42.9 22.9 14.3 8.6 2.66 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9 indicates the rating of CHSOs in terms of eight composite knowledge areas on a scale of 1 (very poor) to 5 (excellent), and a MS ranging between 1.00 and 5.00. Only one (12.5%) MS is > 3.00, whereas 7 (87.5%) are ≤ 3.00, and thus CHSOs’ knowledge generally can be deemed to be poor as opposed to good in terms of the latter composite knowledge areas. However, the MS ranges provide further insight. MSs > 3.40 ≤ 4.20 indicate the rating can be deemed to be between good – OH&S. MSs > 2.60 ≤ 3.40 indicate the rating can be deemed to be between poor to average / average.
- law. MSs > 1.80 ≤ 2.60 indicate the rating can be deemed to be between very poor to poor / poor: project administration; construction technology / technology; planning, and management / management of parameters. However, the 1.80 MS relative to financial planning is on the cut point of the lower end of the range. MSs > 1.00 ≤ 1.80 indicate the rating can be deemed to be between very poor to poor – financial management, and design. The ‘design’ MS is largely attributable to the 50% of respondents having rated CHSOs as very poor.

Table 9: Rating of CHSOs in terms of composite knowledge areas

<table>
<thead>
<tr>
<th>Composite knowledge area</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unsure</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>OH&amp;S</td>
<td>0.0</td>
<td>0.0</td>
<td>16.7</td>
</tr>
<tr>
<td>Law</td>
<td>0.0</td>
<td>19.4</td>
<td>25.0</td>
</tr>
<tr>
<td>Project administration</td>
<td>0.0</td>
<td>25.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Construction technology / Technology</td>
<td>0.0</td>
<td>17.1</td>
<td>45.7</td>
</tr>
<tr>
<td>Planning</td>
<td>2.8</td>
<td>13.9</td>
<td>52.8</td>
</tr>
<tr>
<td>Management / Management of parameters</td>
<td>2.8</td>
<td>22.2</td>
<td>36.1</td>
</tr>
<tr>
<td>Financial management</td>
<td>2.8</td>
<td>36.1</td>
<td>50.0</td>
</tr>
<tr>
<td>Design</td>
<td>2.8</td>
<td>50.0</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Table 10 indicates the rating of CHSOs in terms of eight composite skills areas on a scale of 1 (very poor) to 5 (excellent), and a MS ranging between 1.00 and 5.00. All the MSs are ≤ 3.00, and thus CHSOs’ skills generally can be deemed to be poor as opposed to good. However, the MS ranges provide further insight. MSs > 2.60 ≤ 3.40 indicate the rating can be deemed to be between poor to average / average - interpersonal / developmental. MSs > 1.80 ≤ 2.60 indicate the rating can be deemed to be between very poor to poor / poor: general management; negotiating; leadership; planning; technical, and financial.

Interpersonal / developmental skills are important as oral communication is the most important operational management skill. Developmental skills are important in terms of improving site staff’s H&S knowledge and skills. General management skills in the form of planning, organising, leading, controlling, and coordinating are necessary to realise a healthy and safe work place. Leadership skills are necessary to ensure that CHSOs are ‘followed’ and that they can realise commitment from site staff. Negotiating skills are important in that often site staff must be convinced to consider and address H&S relative to all activities and actions. Financial skills are necessary as CHSOs work with budgets and allowables relative to activities. Planning is critical in terms of H&S as the requisite resources in the form of personal protective equipment (PPE), materials, plant and equipment, must be available when related activities commence. Technical skills such as plan reading in terms of conducting hazard identification and risk assessment.

The low ratings relative to the composite skills areas underscore the low ratings relative to the composite knowledge areas and understanding and appreciation of various aspects, and the extent to which factors constitute a barrier to CHSOs contributing to H&S.
Respondents were required to indicate the extent to which the contribution of CHSOs to H&S could be improved on a scale of 1 (minor) to 5 (major), and a MS between 1.00 and 5.00. Given that the MS of 4.11 is $> 3.40 \leq 4.20$, the extent can be deemed to be between moderate to near major / near major. However, it is notable that the MS is near the upper end of the range.

Table 10: Rating of CHSOs in terms of composite skills areas.

<table>
<thead>
<tr>
<th>Composite skills area</th>
<th>Response (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unsure</td>
<td>Very poor</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Interpersonal / Developmental</td>
<td>5.6</td>
<td>11.1</td>
<td>19.4</td>
<td>50.0</td>
<td>8.3</td>
<td>5.6</td>
<td>2.76</td>
<td>1</td>
</tr>
<tr>
<td>General management</td>
<td>2.8</td>
<td>13.9</td>
<td>38.9</td>
<td>30.6</td>
<td>11.1</td>
<td>2.8</td>
<td>2.49</td>
<td>2</td>
</tr>
<tr>
<td>Negotiating</td>
<td>2.8</td>
<td>11.1</td>
<td>38.9</td>
<td>38.9</td>
<td>8.3</td>
<td>0.0</td>
<td>2.46</td>
<td>3</td>
</tr>
<tr>
<td>Leadership</td>
<td>2.8</td>
<td>16.7</td>
<td>36.1</td>
<td>33.3</td>
<td>8.3</td>
<td>2.8</td>
<td>2.43</td>
<td>4</td>
</tr>
<tr>
<td>Planning</td>
<td>5.6</td>
<td>13.9</td>
<td>44.4</td>
<td>27.8</td>
<td>5.6</td>
<td>2.8</td>
<td>2.35</td>
<td>5</td>
</tr>
<tr>
<td>Technical</td>
<td>0.0</td>
<td>28.6</td>
<td>39.3</td>
<td>25.0</td>
<td>7.1</td>
<td>0.0</td>
<td>2.11</td>
<td>6</td>
</tr>
<tr>
<td>Financial</td>
<td>5.6</td>
<td>25.0</td>
<td>47.2</td>
<td>16.7</td>
<td>5.6</td>
<td>0.0</td>
<td>2.03</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 12 indicates the extent to which interventions could contribute to an improvement in the contribution of CHSOs to H&S on a scale of will not and between 1 (minor) to 5 (major), and a MS ranging between 0.00 and 5.00. Given that all the MSs are $> 2.50$, all the interventions can be deemed to have the potential to contribute to an improvement in the contribution of CHSOs to H&S to a major extent as opposed to a minor extent.

Table 12: Extent to which interventions could contribute to an improvement in the contribution of CHSOs to H&S.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Response (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unsure</td>
<td></td>
<td>Will not</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased consultation by site management</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>13.9</td>
<td>38.9</td>
<td>47.2</td>
<td>4.33</td>
<td>1</td>
</tr>
<tr>
<td>Inclusion in planning activities</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.8</td>
<td>47.2</td>
<td>38.9</td>
<td>4.26</td>
<td>2</td>
</tr>
<tr>
<td>Education / Training relative to construction H&amp;S</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.8</td>
<td>16.7</td>
<td>33.3</td>
<td>47.2</td>
<td>4.25</td>
</tr>
<tr>
<td>Education / Training relative to the construction process</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>11.1</td>
<td>33.3</td>
<td>50.0</td>
<td>4.22</td>
<td>4</td>
</tr>
<tr>
<td>Formal CHSO qualification</td>
<td>2.9</td>
<td>2.9</td>
<td>0.0</td>
<td>2.9</td>
<td>45.7</td>
<td>37.1</td>
<td>4.17</td>
<td>5</td>
</tr>
<tr>
<td>Education / Training relative to construction activities</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>11.1</td>
<td>8.3</td>
<td>38.9</td>
<td>41.7</td>
<td>4.11</td>
</tr>
<tr>
<td>Inclusion in management of site</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.8</td>
<td>25.0</td>
<td>30.6</td>
<td>38.9</td>
<td>4.09</td>
</tr>
<tr>
<td>Education / Training relative to construction management</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>11.1</td>
<td>16.7</td>
<td>30.6</td>
<td>41.7</td>
<td>4.03</td>
</tr>
<tr>
<td>Inclusion in decision making</td>
<td>0.0</td>
<td>0.0</td>
<td>2.8</td>
<td>5.6</td>
<td>36.1</td>
<td>33.3</td>
<td>33.3</td>
<td>3.92</td>
</tr>
<tr>
<td>Increased authority</td>
<td>0.0</td>
<td>0.0</td>
<td>2.8</td>
<td>36.1</td>
<td>33.3</td>
<td>27.8</td>
<td>3.86</td>
<td>10</td>
</tr>
<tr>
<td>Optimum position in site hierarchy</td>
<td>0.0</td>
<td>0.0</td>
<td>2.8</td>
<td>38.9</td>
<td>41.7</td>
<td>16.7</td>
<td>3.72</td>
<td>11</td>
</tr>
</tbody>
</table>
However, 4 / 11 (36.4%) MSs are > 4.17 ≤ 5.00, which indicates the interventions can be deemed to have the potential to contribute between a near major to major / major extent to an improvement in the contribution of CHSOs to H&S - increased consultation by site management; inclusion in planning activities; education / training relative to construction H&S, and education / training relative to the construction process. 7 / 11 (63.6%) MSs are > 3.33 ≤ 4.17, which indicates the interventions can be deemed to have the potential to contribute between a moderate extent to a near major / near major extent to an improvement in the contribution of CHSOs to H&S. It should be noted that theses interventions MSs fall within the upper half of the range, and include: formal CHSO qualification; education / training relative to construction activities; inclusion in management of site; education / training relative to construction management; inclusion in decision making; increased authority, and optimum position in site hierarchy. Many of the barriers to CHSOs contributing to H&S (Table 7) reinforce the contention that education / training relative to construction H&S, the construction process, construction activities, and construction management, are a prerequisite for inclusion in management of site, ranked first, and increased consultation by site management, inclusion in decision making and planning activities, increased authority, and optimum position in site hierarchy.

CONCLUSIONS

Approximately 50% of CHSOs are employed on a permanent and a contract basis, and approximately 50% are appointed on a part-time and 40% on a full-time basis. Therefore, it can be concluded that employment of CHSOs follows the pattern of general employment in construction. The basis of appointment indicates that the nature of the appointment relates to the nature, value, and complexity of projects. Approximately 56% of respondents stated that other functions fulfill the role of CHSO, and 87% that CHSOs fulfill other functions. Therefore, it can be concluded that contractors endeavour to aggregate costs through multi-function appointments. Furthermore, approximately a third of respondents stated that 11% of CHSOs report to each of site managers, and site agents, and then approximately 22% to a variety of management combinations. This leads to the conclusion that there is a degree of singular, dual, and multi-reporting. At the very least, CHSOs interact with the general and production management of site.

CHSOs can be deemed to have contributed to and impacted upon H&S between a near minor to moderate / moderate extent. However, given that the MSs are close to the lower end of the next MS range, namely a moderate extent to a near major extent / near major extent, it can be concluded that the function is important and the ‘CHSO’ requirement in terms of the Construction Regulations is justified. However, the findings indicate that the contribution of CHSOs to H&S could be improved, namely between a moderate to near major / near major extent. Furthermore, their contribution to and impact upon H&S is likely to have been marginalised by their low level of qualifications, and inadequate knowledge, and experience, the functions they report to, the basis of their employment, and other functions that they fulfill. A range of factors constitute a barrier to CHSOs contributing to H&S. The top four, namely exclusion from decision making, non-consultation by site management, lack of authority, and exclusion from management of site, constitute marginalisation. However, four of the other factors are inadequate experience related and a further four are inadequate knowledge related. Therefore, it can be concluded that inadequate ‘construction’
knowledge and experience contribute to the exclusion of CHSOs from the management of sites, and the actual barrier to CHSOs contributing to H&S. This conclusion is underscored by the rating of CHSOs in terms of their understanding and appreciation of various aspects, composite knowledge areas and skills, and the extent to which interventions could contribute to an improvement in the contribution of CHSOs to H&S and construction.

RECOMMENDATIONS

The findings of this study lead to the conclusion that formal qualifications would empower CHSOs to contribute optimally to H&S and construction. Minimum qualifications could include a ND: Building, followed by a BTech: Construction Management (Health and Safety) as developed by the Cape Peninsula University of Technology. However, given current reality, continuing professional development (CPD) is necessary. This should be provided by the SACPCMP relative to all the knowledge and skills areas. Furthermore, employers should provide in house courses relative to all the knowledge and skills areas, especially planning and construction technology. CHSOs should report to the site manager, and however, H&S discussions between contracts managers and site managers should involve CHSOs. CHSOs should be an integral part of site management in terms of: contributing to project planning by providing the H&S needs for activities, including hazard identification, and risk assessment; attendance of project progress meetings, principal contractor subcontractor meetings; principal contractor financial management meetings, and detailed H&S reporting, including the provision of statistics, deviation and incident reports, cost of accidents, and cost of H&S.

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A FRAMEWORK FOR STANDARDIZING THE ASSESSMENT OF HAZARD IDENTIFICATION IN MECHANICAL CONTRACTING

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Jobsite safety inspections are a typical tool for safety professionals to assess the level of safety on jobsites, since they provide a snapshot view as well as a documentation of the possible hazards that might endanger workers. However, there is no standard framework for assessing these hazards and identifying any hazard trends in the commercial construction sector in the United States. A longitudinal analysis of these inspections and reviews over a period of time, can also assist in recognizing trends in identified hazards, as well as alerting supervisors of potential troubled sites, and used for future employee training. A mechanical contractor based in the US, recently standardized and created a framework for their inspections as Jobsite Safety Reviews (JSR), and started collecting information from all their construction sites on a regular basis (weekly or every few days) to test the validity of the scoring system and correct the identified hazards. A total of 214 JSR reports were collected from 91 different jobsites and contractor facilities, over an eight-week period between June and August of 2016. In the majority of these projects, the contractor was a subcontractor to other general contractors. This paper will present the information collected from these JSR reports, and identify any trends in hazards and hazard subcategories across jobs undertaken by the mechanical contractor.

Keywords: Construction, Safety, Job Safety Reviews, Subcontractors, Mechanical Contractor.

BACKGROUND

Safety planning and safety inspections are an integral part of for a successful jobsite with respect to the safety of the personnel involved in construction activities (Hinze 2006). In the US construction industry, prior to the start of construction activities, it is required by the Occupational Safety and Health Administration (OSHA) to perform a Workplace Hazard Assessment (1910.132 (d)(2)) (OSHA n.d.). This allows for hazards to be identified and become aware by the individuals involved in the construction operations, and the development of a plan to eliminate these hazards ensuring a safe working environment.

During construction, safety inspections are used to determine compliance to OSHA regulations by construction personnel, and the identification of other hazards that were not evident during the development of the Workplace Hazard Assessment. Documentations of inspections allow the identification of hazard trends, problem

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areas that need to be addressed, as well as the identification of personnel training needs and areas of concern. Multiple inspections of the same site would also provide evidence, or lack of evidence that job sites are improving with regards to safety (NSC 2009; Goetsch 2013). However, to assess the success of such safety program, to find common trends between multiple jobsites, and to identify common root causes for accidents, a structured approach is required. This paper demonstrates how this standard approach was created as a commercial and practical tool that utilizes hazard recognition and risk assessment methods in literature (Albert and Hallowell 2012a; Esmaeili, Hallowell et al. 2015) to enable the collection of data and trends analysis.

This paper will concentrate on the data collected during the first three months of a new program incorporated by a mechanical contractor (MC) in the US, developed to track and score safety on their various jobsites. Between May 17 and August 12, 2016, a total of 214 site safety investigations took place on 91 different sites, by 15 different safety inspectors. This period was to test the validity, applicability and practicality of the standardized scoring system based on feedback from the company’s subject matter experts, namely safety professionals and risk managers.

The reason the MC decided to conduct such an investigation, was due to fact that they were not aware of any other mechanical contractor in the US that was capturing job site hazard information in a systematic manner (Albert and Hallowell 2012b). The MC wanted to establish a consistent method for evaluating and comparing safety performance on their different jobsites, and assess these sites for compliance and conformity to the OSHA and company’s safety guidelines. The document that was developed was titled Jobsite Safety Review (JSR). These Jobsite Safety Reviews provided a full spectrum on-site evaluation of the safety-related activities on a project, and feedback to the project management teams on the observed conditions at the various jobsites. The MC’s aim was to ensure that projects maintain safe worksites, correct any identified hazards, and recognize their employees for positive safety behaviour. The MC performed mechanical construction work and many times acted as a subcontractor to a project. The MC also undertook maintenance and repair work as well as mechanical systems upgrades, and in such situations, the MC was acting as a general contractor, employing both their own crews on sites as well as other subcontractors. Since the MC has fabrication facilities, the JSR’s were conducted on these facilities as well.

**METHODOLOGY**

In order to create the standardized scoring system, a risk based method was chosen to account for both quantity and potential severity of a hazard.

To rate the severity of each hazard, the MC modified a rating system found in academic literature and applied it to their JRS needs. Specifically, the MC’s safety and risk managers, identified the rating system developed by Hallowell (2008). The evolution of that rating system is shown in Table 1. Through discussions between MC safety and risk professionals, the original 10 severity levels (temporary discomfort → fatality) and severity numbers (1 → 26,214) were used, and were reduced to a more manageable for the field rating system that incorporated only 4 levels. These 4 levels were:

Marginal - Where an incident could result in a slight injury
Moderate - Where an incident could result in a significant injury requiring more than first aid
Serious - Where an incident could result in lost time or restricted incident
Catastrophic - Where an incident could result in death or permanent disability

The values associated with each severity level were divided by 32, to allow their use in a more manageable number scale, where a marginal incident had an impact level of 1, a moderate incident had an impact level of 4, a serious incident had an impact level of 8, and a catastrophic incident had an impact level of 32. This reduction by a factor of 32 allows the evaluation of sites from an ideal 100 by subtracting the impact level per hazard observed.

Table 1: The evolution of the Hazard Severity Rating used for evaluation

<table>
<thead>
<tr>
<th>Subjective severity level (hallowell)</th>
<th>Scaled Severity Hallowell (1)</th>
<th>Relative Impact level chosen (2)</th>
<th>Impact level used in JSR (divide 32) (3)</th>
<th>Severity level (4)</th>
<th>Description (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary Discomfort</td>
<td>2</td>
<td></td>
<td>1</td>
<td>Marginal</td>
<td>Slight injury</td>
</tr>
<tr>
<td>Persistent Discomfort</td>
<td>4</td>
<td></td>
<td>4</td>
<td>Moderate</td>
<td>Injury requiring more than first aid</td>
</tr>
<tr>
<td>Temporary Pain</td>
<td>8</td>
<td></td>
<td>8</td>
<td>Serious</td>
<td>Loss time / restricted incident</td>
</tr>
<tr>
<td>Permanent Pain</td>
<td>16</td>
<td></td>
<td>32</td>
<td>Catastrophic</td>
<td>Death/Permanent disablement</td>
</tr>
<tr>
<td>Minor First Aid</td>
<td>32</td>
<td>32</td>
<td>1</td>
<td>Marginal</td>
<td>Slight injury</td>
</tr>
<tr>
<td>Major First Aid</td>
<td>64</td>
<td></td>
<td>64</td>
<td>Moderate</td>
<td>Injury requiring more than first aid</td>
</tr>
<tr>
<td>Medical Case</td>
<td>128</td>
<td>128</td>
<td>4</td>
<td>Moderate</td>
<td>Injury requiring more than first aid</td>
</tr>
<tr>
<td>Lost Work Time</td>
<td>256</td>
<td>256</td>
<td>8</td>
<td>Serious</td>
<td>Loss time / restricted incident</td>
</tr>
<tr>
<td>Permanent Disablement</td>
<td>1,024</td>
<td>1,024</td>
<td>32</td>
<td>Catastrophic</td>
<td>Death/Permanent disablement</td>
</tr>
<tr>
<td>Fatality</td>
<td>26,214</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An internal document was issued, that summarized the process to their employees, explained the procedure to all of the MC’s safety inspectors, and established responsibilities to all involved parties. These responsibilities included items in how to conduct the review, procedures for corrective action, compliance to regulations, timeliness of review, score reporting, and recordkeeping. What was also important, many tiers of the MC's management, from foreman to regional safety directors and superintendents, were included in the process and each had their own responsibilities.

This program was rolled out to entire company and covered multiple types of project ranging from service/maintenance project to multi trade construction projects. For larger projects, the frequency of a jobsite review was based on regional requirements and capabilities. These JSR reviews were conducted by safety inspectors employed by the MC who assessed a project and produced through the JSR review a Hazard Severity Rating score, and identified the responsible party for each hazard observed, based on criteria developed internally by the MC. Each JSR produced two scores, a
score for the MC's personnel/subcontractors, and a score for the general area of the site. This was done in order to clarify the responsibility of the hazard correction, and to distinguish between the performance of the MC's employees/subcontractors and the site conditions when the MC was not the general contractor. The completed JSR reports were then submitted to the team/crew being evaluated, and the scores reported to the appropriate business unit of the MC that the team/crew belonged to, the regional safety director, the safety director for the MC and the MC's Risk Analyst.

**JSR Procedure**

The MC established a procedure for the JSR review, and in summary it was conducted as follows:

- Safety inspectors are to evaluate active worksites on regular intervals depending on the proximity of the sites and their availability.
- Safety inspectors are to record all observed safety hazards, and noncompliance observations, on the JSR spreadsheet that was developed for the procedure, noting the responsible party, and identifying corrective action with project personnel.
- The hazard severity rating is to be used to categorize each hazard and that rating scale is shown in columns 4, 5, and 6 in Table 1. The safety inspectors are asked to use their professional judgement, compliance knowledge and the established regulatory policy of the company to rate each hazard.
- At the conclusion of the job site review, the safety inspectors are to calculate the JSR score for the MC as well for the general site. The two scores can be different depending on the entity responsible for the hazard.

The JSR scores are then used to determine the overall score for the site, where after the deductions have been implemented, the site can be categorized in one of four categories: A site with major issues, a site with moderate issues, a site with minor issues, and a site with no issues. The range for each category is shown in Table 2. These categories were developed based on the severity of hazards and subject matter experts’ opinion on the overall scoring and how it relates to individual hazards. Subject matter experts included the MC’s risk management team and safety professionals employed by the MC.

<table>
<thead>
<tr>
<th>JSR Score Category</th>
<th>JSR Score Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Issues</td>
<td>Less than 75</td>
</tr>
<tr>
<td>Moderate Issues</td>
<td>Between 75 and 92</td>
</tr>
<tr>
<td>Minor Issues</td>
<td>Between 93 and 99</td>
</tr>
<tr>
<td>No Issues</td>
<td>100</td>
</tr>
</tbody>
</table>

An example for calculating the JSR scores is shown in Table 3. In this example, 4 hazards are identified, where hazards 1 and 3 are determined to be the responsibility of non-MC employees, while hazards 2 and 4 are determined to be the responsibility of MC employees. As observed, the MC company score is reduced by 9 points, accounting for 1 "Serious" hazard that has 8 deduction points and 1 "Marginal" hazard, while the General JSR score is determined to be 63 accounting for the 1
“Catastrophic” hazard, and the 5 occurrences of the “Marginal” hazard.

Table 3: An example for calculating JSR scores

<table>
<thead>
<tr>
<th>Hazard Points</th>
<th>Severity Index</th>
<th>Responsible Party</th>
<th>Number of Occurrences</th>
<th>Deduction Points per Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fall Protection</td>
<td>Catastrophic</td>
<td>Non-Company</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>2 Fall Protection</td>
<td>Serious</td>
<td>Company Related</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>3 Housekeeping Issue</td>
<td>Marginal</td>
<td>Non-Company</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>4 Housekeeping Issue</td>
<td>Marginal</td>
<td>Company Related</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>


Company JSR Score = 100 − [(1*8) + (1*1)] = 91
General JSR Score = 100 − [(1*32) + (5*1)] = 63

The data collection and reporting process for the JSR was incorporated in a spreadsheet that allowed the safety inspectors to complete the data entry with minimum effort. Within the spreadsheet, safety inspectors were also given the opportunity to note and report the positive actions for safety that they observed at the different sites, giving the opportunity for the various crews to be recognized and commented for their actions.

Hazard Categories

The MC categorized all the possible identifiable hazards into the following categories and subcategories that were obtained from literature (Hinze 2006), subject matter expert input (Safety Professionals) and clustering of previous site inspections, and the existing MC evaluation procedures:

- **Site Area**, which includes Walking Working Surfaces, Housekeeping, Storage (Chemical), Storage (Gas Cylinder), Storage (General), Lighting (Task Light), Lighting (General), Hoses / Leads, Sanitary Facilities, Slip/Trip Hazard, and Impalement Hazard.
- **Body Position**, which includes Line of Fire, Pinch Points, Walking with loads, Eyes on path / task, and Awareness of Surrounding.
- **Body Mechanics**, which includes Lifting and Lowering, Twisting, Pushing / Pulling, Ascending / descending, and Over-Extension.
- **Equipment / Tool Use**, which includes Porta Band Saw, Grinders, Hand Tools, MEWP, Forklifts, and Heavy Machinery.
- **Safety Communication**, which includes Communication of Hazards, Barriers and Warnings, and Flagging.
- **Special Operations**, which includes Rigging, Use of Cranes / Lifts, Trenching, Confined Space, and Welding.
- **Temporary Structures**, which includes Ladders, Scaffolds, Hole Covers, Guardrails, Falling Object Protection (Toe Boards), and Falling Object Protection (Other).
- **Planning**, which includes Pre Task Plan (PTP).
Public Protection
Fire Protection, which includes Fire Extinguisher, and Fire Watch
Electrical Hazard, which includes CFCI, Exposed live, and Cords
LockOut/TagOut, which includes Electrical, Pneumatic, and Mechanical
Industrial Hygiene, which includes MSDS/Labelling, Atmospheric Hazards, and
Lead / Chemical Exposure
Other: The safety inspectors had the capability of including other hazards in the

RESULTS
In total 214 reviews were conducted on 91 different sites were reviewed during that eight-week period between 5/17/2016 and 8/12/2016, the majority of which were located in the Pacific North West (Washington and Oregon). The projects included 30 sites where the MC was a subcontractor to 16 different general contractors. In 56 sites the MC was acting as a general contractor, and included repair, and maintenance work, or facility upgrades. These projects ranged in size, the majority of which were minor contracts and repairs. These projects were performed by MC employees or other subcontractors. Five of the sites belonged to the MC and included monthly inspections of workshops and warehouses.

Fifty-two of the sites were reviewed only once, 15 of the sites were reviewed twice, 11 were reviewed three times, while the remaining 13 were reviewed more than four times (range = 4 - 29 reviews). Fifteen different safety inspectors conducted the reviews. The number of reviews per safety inspector ranged from 2 to 36 with an average of 14.2 reviews per safety professional.

Table 4: Identified Hazards per Main Category

<table>
<thead>
<tr>
<th>Main Hazard Category</th>
<th># Hazards Observed</th>
<th>% Hazards Observed</th>
<th>CAT</th>
<th>SER</th>
<th>MOD</th>
<th>MAR</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Area</td>
<td>120</td>
<td>42.60%</td>
<td>2</td>
<td>3</td>
<td>11</td>
<td>103</td>
<td>1</td>
</tr>
<tr>
<td>PPE</td>
<td>32</td>
<td>11.30%</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Temporary Structures</td>
<td>31</td>
<td>11.00%</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>21</td>
<td>7.40%</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Equipment / Tool Use</td>
<td>20</td>
<td>7.10%</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Electrical Hazard</td>
<td>16</td>
<td>5.70%</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Safety Communication</td>
<td>12</td>
<td>4.30%</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>10</td>
<td>3.50%</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Body Position</td>
<td>5</td>
<td>1.80%</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Planning</td>
<td>5</td>
<td>1.80%</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Industrial Hygiene</td>
<td>5</td>
<td>1.80%</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Public Protection</td>
<td>4</td>
<td>1.40%</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special Operations</td>
<td>1</td>
<td>0.40%</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Body Mechanics</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LockOut/TagOut</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>282</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>42</strong></td>
<td><strong>212</strong></td>
<td><strong>2</strong></td>
<td></td>
</tr>
</tbody>
</table>

Two hundred eighty-two (282) different safety hazards were recorded with the breakdown of category and subcategory shown in Table 4. As noted, with 42.6% (n=120) the main category “Site Area” had the most hazards observed, followed by “PPE” with 11.3% (n=32), and “Temporary Structures” with 11.0% (n=31). The majority of the hazards observed were marginal in nature (75.1%, n=212). Hazards rated as “Catastrophic” were very few (n=8), accounting for 2.8% of the observations.
Similarly hazards rated as “Serious” were very few as well (n=18) accounting for 6.4% of the hazards observed.

Of the hazards 282 identified the safety inspectors deemed that 90 (31.9%) of them fell under the responsibility of the MC or one of the MC’s subcontractors, while 173 (61.4%) were determined to be the responsibility of other parties not employed by the MC. These other parties could have included general contractors, other general contractor subcontractors, existing facilities, or property owners. The responsibility for the remaining hazards, 19 (6.7%) was not identified in the reports.

**Site Area Hazards**

A further investigation of the “Site Area” hazards, shows some additional trends. As observed in Table 5, the distribution of the subcategories of hazards for the “Site Area” category shows that the majority of these hazards involved housekeeping issues (30.8%) and locations where there was a slip/trip hazard (40%). Examples of the “Housekeeping included items such as the existence of garbage and debris in the vicinity of the work, to heaped and overloaded skip dumpsters. The majority of the incidences involving housekeeping hazards were marginal in nature.

Slip/Trip hazards examples ranged from marginal to catastrophic. The majority of hazards observed were marginal with the exception of one moderate, one serious, and one catastrophic hazards. The catastrophic observation involved a roof access hatch with a defective door that could cause a fall to a lower level.

Table 5: Identified Hazards for the “Site Area” Category

<table>
<thead>
<tr>
<th>Site Area Sub-category</th>
<th># Hazards Observed</th>
<th>% Hazards Observed</th>
<th>CAT</th>
<th>SER</th>
<th>MOD</th>
<th>MAR</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slip/Trip Hazard</td>
<td>48</td>
<td>40.00</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>37</td>
<td>30.80</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Walking Working Surfaces</td>
<td>9</td>
<td>7.50</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Sanitary Facilities</td>
<td>7</td>
<td>5.80</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>4.20</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Storage (Gas Cylinder)</td>
<td>3</td>
<td>2.50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hoses / Leads</td>
<td>3</td>
<td>2.50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Impalement Hazard</td>
<td>3</td>
<td>2.50</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Storage (Chemical)</td>
<td>2</td>
<td>1.70</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Storage (General)</td>
<td>2</td>
<td>1.70</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Barricading</td>
<td>1</td>
<td>0.80</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
<td></td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>102</td>
<td>1</td>
</tr>
</tbody>
</table>

**PPE Hazards**

Hazards relating to PPE are analysed in Table 6. As observed, 11 of the 32 observed hazards were in the “Personal Fall Protection” subcategory, and they ranged from marginal to catastrophic. The catastrophic hazards were observed at a site where the engineered anchor points already installed on the building were too far apart or missing, for the workers to traverse across anchor points along the roof. The hazards identified as serious involved access in attic space without fall protection, workers
working on a roof close to six feet from edge with no fall protection, worker going under a protective barrier to approach and work on the roof edge, worker sitting on a steel frame with no fall protection, and access through roof hatches with poor fall protection. All of these incidences involved retrofit work on existing buildings. The serious incident regarding hand protection involved a worker not working arc flash shock protection gloves.

Table 6: Identified Hazards for the “PPE” Category

<table>
<thead>
<tr>
<th>PPE Sub-category</th>
<th># Hazards observed</th>
<th>% Hazards Observed</th>
<th>CAT</th>
<th>SER</th>
<th>MOD</th>
<th>MAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Fall Protection</td>
<td>11</td>
<td>34.40%</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Eye Protection</td>
<td>8</td>
<td>25.00%</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Other Body Protection</td>
<td>6</td>
<td>18.80%</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Hand Protection</td>
<td>4</td>
<td>12.50%</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Head Protection</td>
<td>2</td>
<td>6.30%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Foot Protection</td>
<td>1</td>
<td>3.10%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>32</strong></td>
<td></td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>

Temporary Structures Hazards

As shown in Table 7, the majority of the hazards involving Temporary Structures (n=22 of 31) were identified to be marginal in nature, while the three hazards that were classified as serious involved ladders. These incidences involved unsecured ladders, the use and transportation of extension ladders greater than 28 feet, and worker standing on the top step of a ladder. Hazards of lower severity involved wrong ladders on the jobsite, workers working on ladders facing backwards but not at high elevation, etc.

Table 7: Identified Hazards for the “Temporary Structures” Category

<table>
<thead>
<tr>
<th>Temporary Structures Sub-category</th>
<th># Hazards observed</th>
<th>% Hazards Observed</th>
<th>CAT</th>
<th>SER</th>
<th>MOD</th>
<th>MAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ladders</td>
<td>11</td>
<td>35.50%</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Guardrails</td>
<td>7</td>
<td>22.60%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>16.10%</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Scaffolds</td>
<td>4</td>
<td>12.90%</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Hole Covers</td>
<td>2</td>
<td>6.50%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Falling Objects Protection - Other</td>
<td>2</td>
<td>6.50%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>31</strong></td>
<td></td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>22</td>
</tr>
</tbody>
</table>

Other Catastrophic Hazards

The remaining hazards that were rated “Catastrophic”, involved access to sensors within a wall of an existing building without any fall protection and the need to step at the top of the ladder to climb into that wall, scaffolding access to an existing building with 6 feet proximity to the roof edge, and in one occasion a crew was observed working under a suspended load.
JSR Site Scores

Of the 91 sites evaluated, 51 sites (56%) were reviewed only once during the 3 month period presented in this paper. Sixteen (17.6%) of these sites were reviewed twice, while 10 (11%) were reviewed three times. The remaining sites (n=14) were reviewed more than three times, and one site was reviewed 29 times. A longitudinal comparison of the scores over time, is observed to show that the overall scores are improving. Some examples are depicted here.

Figure 1, shows the scores over time for job site 36, which was reviewed 29 times. At this site the MC was a subcontractor, and two scores were produced per visit; one for the MC (marked with an “X”) and one for the general site (marked with a square). As observed, the overall scores for the site are improving with some fluctuations. The MC’s score is seen to be high with a few exceptions, while the general site scores are generally lower than the MC scores.

![JSR Scores for Site 36 vs Time](image)

**CONCLUSIONS**

In general, the standardized framework allowed the MC to analyse the trends between multiple jobsites, different regions, different safety inspectors and ensure safe environment for its employees.

Overall this MC does not experience hazards that are consistently severe or catastrophic. For the most part the severe/catastrophic hazards were observed to take place in buildings that were already completed and the contractor was conducting maintenance, repair, or upgrade work. This might be due to the fact that as an established contractor, the MC has already safety measures in place that catch any hazardous activity. In addition, a contractor that shows initiative for constant safety improvement, as the example described in this paper, probably has a safety culture within its organization that is safety conscious and proactive in terms of safety, and risk avoidance.

Some trends were also observed in the types of hazards experienced. The majority of the hazards during the time period observed were in three categories: Site Area, PPE,
and Temporary Structures. Slip and trip as well as housekeeping hazards were also present, but in general they were deemed to be marginal in nature. These trends were expected due to the amount of hazard exposure in those categories. For instance, site area covers a large spectrum of space and applicable to all of the observations. In contrast, confined space activities are not frequently conducted by the MC. PPE and temporary structures are also used more frequently thus more hazards were observed in those categories.

Overall the site scores were seen to be improving over time, but further analysis is required to determine if this improvement is sustained.

FUTURE RESEARCH

The JSR reports presented in this paper, represent the first three months that the data collection program was implemented. Additional time is required to bring all the safety inspectors to the same level. A further, more in depth, investigation is planned to evaluate the first year of the program and identify any additional trends as well as longitudinal characteristics of the various jobsites. An investigation is planned to assess the differences between sites, the safety inspectors, and between contractors. The MC plans to assess the information and develop training program to address the hazards that were observed.

REFERENCES


CAUSES OF COLLUSION AMONG PEOPLE IN CONSTRUCTION

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Collusion is an unethical and disreputable agreement among parties of similar interests with the intention of achieving a goal through immoral and dishonest means. Proper ethical procurement practice in the construction industry, will enable the Construction Industry Development Board (CIDB) to achieve their mandate which is to promote uniformity in the construction procurement; efficient and effective infrastructure delivery; and development of the emerging contractors, including transformation. Furthermore, the Competition Commission of South Africa (CCSA) to also achieve their mandate which is fair competition in all industries. With collusion in existence it will be difficult for the CIDB and CCSA to achieve their mandate. This study examined the influences of this practice among competitors and stakeholders in the construction industry. Various causal factors of collusion among parties were extracted from review of existing and relevant literature materials and they were further evaluated to arrive at the specific ones that are relevant to the construction industry and selected area of study. Using these factors, close-ended questionnaires were prepared and administered to construction stakeholders with adequate level of experience in the construction industry. The number of questionnaire distributed is 50 and 45 were returned out of which 5 were not correctly and completely filled. The distribution method used was self-administration. In addition, purposive sampling was used. The findings from the 40 respondents indicates that the major cause of collusion in the construction industry is greed of various stakeholders that are shouldered with the responsibilities of managing and monitoring construction contracts and activities especially the contractors. Political influence was also identified as a major reason for collusion among other factors. [Empowering emerging contractors, a well regulated environment, a fair competition, improving procurement management are the most important aspects that can minimize collusion to occur. Furthermore, good ethical practice, is one of the aspect that professionals should adapt….] In view of this, agencies, institutes and boards concerned with the monitoring and regulation of professionals, contractors and general construction activities should therefore ensure that appropriate sanctions and punishments are applied for any members found culpable.

Keywords: collusion, Construction industry, corruption, project performance, project stakeholders, unethical practice.

INTRODUCTION

Public and private procurement particularly high-value and large projects usually involves opportunities which attracts collusive tendering (Organization of Economic Co-operation and Development, OECD 2010). There are various forms of collusion which cartels mostly practice, which are Price fixing, bid Rigging and Market allocation or division. Price fixing is when two or more competitors agree on increasing prices, restore or otherwise keep prices where their services are being sold. Is not necessary for horizontal competitors to be part of a conspiracy or to accord on charging similar prices (OECD 2008). Furthermore, price fixing has many forms, also

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any arrangement between competitors that aims to restrict competition is prohibited by the competition law (OECD 2008).

In the bid rigging form of collusion, contractors conspire on raising prices (both public and private sector). Analysis of private and public tenders indicates that the company that is going to win the tender, tends to be close to the maximum project value, that the procuring entity would be willing to pay (Ilango, 2014). In other words, competitors agree in advance who should win a certain tender. Price fixing, on the other hand, not all competitors participate in the conspiracy (Centre for Competition, Investment and Economic Regulation CUTS 2008). This form of collusion competitor’s drive markets among themselves. Competing companies will allocate themselves to specific clients or type of clients, territories or products. For example, they choose one competitor to bid on contracts led by particular clients or type of clients. Thus, they will not be allowed to bid on any contracts that is not been allocated to (OECD, 2008). Furthermore, the companies also agree to bid to only certain geographic areas but to hide the conspiracy they will intentionally bid a higher price to clients in geographic areas not allocated to (CUTS 2008).

The South African Competition Act (1998) states that any agreement between, or any joint activity of two or more, or a decision and association of firms is not allowed by the act, when collusive practice is involved. However, the number of collusive tendering or construction cartels have been increasing drastically (CIDB 2010). Several investigations by competition tribunal, National Prosecuting Agency (NPA) and other authorities have shown a widespread use of cartels and corruption within the South African construction industry (Hekima 2014). This study examined the causes of collusion among stakeholders in the construction industry with a view of suggesting appropriate measures for eliminating or reducing collusion in the industry.

REVIEW OF THE CAUSES OF COLLUSION

Causes of collusion are the factors that motivate collusion to take place. Doree (2004) on collusion highlight the factors that cause collusion that it is caused by contractor greed and created by clients. Furthermore, an investigation by Khumalo et al. (2010) brought out that the practice of collusion has become a standard business practice. Ray et al (1999) cite a number of factors that have been provided by market participants on why they engage in collusive tendering they include: The time given to compile tender documents is not enough, other factor may be that construction companies do not have enough resources to complete the construction works or engaging in collusion just to be known by clients for future projects.

Zarkada-Fraser and Stinkmore (2000) suggest that collusive tendering or corrupt practices is a made by an informed professional. A person with particular attitude and characteristics a sense of right and wrong and a set of personal and organizational objectives to meet. In addition to this, public officials frequently use public powers for their own benefit for instance allowing bribes from contractor in exchange for granting tenders (OECD 2010). Furthermore, Ayodele (2011) explains that corruption means when one is using powers by being dishonest, performing illegal practices or acting immoral using it as an advantage for their own benefit. Unethical practice in any field, particularly construction industry is labelled as violation of the competition act and the Construction Industry Development Board (cidb) rules and regulation.

Collusion arises from poor regulatory environment, procurement management and the way firms behave (Hekima 2014). It is recommended by Ratshisusu (2014) that
competition among horizontal competitors, procurement practices that are transparent and the oversight that is effective is very vital for the construction industry. Ayodele (2011) also explains the causes of corruption in his study of corruption in the construction industry, the study highlighted that poverty, and politics in award of contract / "God fatherism" are the main causes of corruption in the construction industry.

Furthermore, the OECD (2012) recognised that a transparent and anti-completive public is vital to make sure that services and goods that are being delivered by the government offer value for money. However, according to the (OECD 2012) procurement systems by the government can be stymied by bid rigging and other collusion practices. In view of this, this section examines various causes of collusion among stakeholders in the construction industry.

**Regulatory Perspective**

Regulation is an important tool in any field of work or industry for that matter. Several investigation provides literature in the effects of regulation policies particularly for competition in markets OECD (2014). In South Africa, there are certain laws that are set to promote fair competition markets, unethical behaviours with the aim of promoting growth and development in any industry. In South Africa the CIDB is empowered to regulate the construction industry. Which basically registering contractors and regulating with set of regulation requirements. Furthermore, companies must follow certain regulatory requirements, particular with regards to registering of contractors. These regulations by the CIDB includes grading of contractors which is a critical tool to have, it ensures that contractors in the industry have minimum requirements to undertake any project.

However, Ratshisusu (2014) put forward the idea that the CIDB system for grading contractors has two main deficiencies. Firstly, adequate information is not provided to clients, this information includes the ability and the capacity of contractors in undertaking the construction works which is expected from the CIDB grading system to provide such information. Furthermore, if these information is provided to the client, it could give assistance to the client to ensure that the contractor is fit to undertake the works based on the grading, this information can be made available by the CIDB.

**Firm Perspective**

Companies have a pivotal role to play, for a culture of competition to be there in the construction industry. In essence competition must be amongst companies instead of the cooperation of the culture through collusive tendering. According to Ratshisusu (2014) bid rigging, in the South African construction industry was established as the culture of the industry which has been existing for a while and which only the top tier companies participate. Furthermore, an investigation by Khumalo et al. (2010) brought out that the practice of collusion has become a standard business practice which South African companies has adopted. With regards to that, Ratshisusu (2014:602) points out that the top-tier construction companies, thus engage in collusive tendering to damage not only the clients but also the participation of new contractors. In addition, Munshi (2013) state that emerging companies believe that collusion stole opportunities for them to grow and they also have a right to compensation. Furthermore, it is believed by Ratshisusu (2014) that if bid rigging did not occur among the top-tier companies, new companies could have grown at this point in time.

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For instance, projects that involve the construction of residential properties, civil works such as roads, and building works such as convention centres would have been a great opportunity for small medium construction companies to gain experience needed to acquire the CIDB higher grading. Take Netherlands as an example, companies were in collusive tendering with the aim of excluding emerging companies (Doree 2004). Ratshisusu (2014) also suggest that collusive tendering cases in South Africa should be prosecuted thoroughly to get better insights on the methods that should be used to destroy the culture of collusion. Furthermore, is necessary to shift the manner in which companies compete for projects, as a way to eradicate collusive tendering. Most of emerging do not engage in collusive tendering as they mainly rely on subcontractor works (Ratshisusu, 2014). Furthermore, almost companies that have the capacity and the ability to deliver large infrastructure projects, according to Hekima (2014) tend to engage in collusive tendering rather than competing with emerging contractors.

Regardless of the CIDB Act in the year 2000, with an objective of encouraging the participation of emerging contractors in the sector of construction, it was expected that the growth of emerging contractors will increase drastically to such extent that they compete against the top-tier companies, however in reality only the top-tier companies are able to obtain large infrastructure projects (Ratshisusu 2014). Although World Bank (2014) suggest that the reason emerging contractors are not gaining experience is due to the fact that they are lacking entrepreneur skills, which is they mainly focus on short-term financial gains rather that growing their company. However, Munshi (2013) also put forward the idea that big construction companies are lacking transformation, skills transfer and tend not to empower emerging construction companies. With regards to above mentioned issues the CIDB has placed programmes particularly for emerging contractors on how to grow their companies in the industry, the programmes focus mainly on the entrepreneurial culture (Ratshisusu, 2014).

**Procurement Perspective**

The process of procurement firstly starts with identifying a certain project, if it is a government project then the budget for that project is drafted. At this point in time is the government responsibility to deliver the project. According to Doree (2004), the government used to deliver public construction projects on its own, i.e. the professionals employed by the government would design, plan and construct the work without consulting external services. However, developing countries including South Africa has copied higher-income national system of separating key functions. Thus responsibilities are divided among a larger number of people, who essentially perform complementary activities. According to Sohail and Cavill (2008), these participants must comply with different control mechanism the purpose of which is to ensure accountability.

However, Ratshisusu (2014) put forward the idea that once two or more parties engage in collusion or agreements it is easy for them to break the rules as a result an environment is created whereby control mechanism need to be strengthened. The concern of van de Ryt et al (2010) is the reason for frequent breakdown of control mechanisms. Sohail and Cavill (2008) stated that the problem arises from separating functions which creates an opportunity to break because mechanism for controlling are separated at each stage of the procurement process (planning, design, construction). Furthermore, functions are sequential i.e. one stage has to be finished
before the other stage can start, however in practice functions overlap and there is interdependence among the participants at different stages.

The type of procurement procedure plays a role for collusion to take pace. According to Van de Ryt et al. (2010), the Dutch Parliamentary Committee (DPC) in reaction to collusion of 2002 proposed a tougher public sector procurement procedure as a strategy to combat corruption. This clearly shows that the procurement procedures are prone to collusion.

According to the City of Cape Town and South African National Roads Agency Ltd (SANRAL) the manner in which the government planned large infrastructure projects was prone to collusive tendering. The time CCSA was conducting an investigation on collusive tendering in 2006 to 2009, the government already began with large construction projects for roads, FIFA World Cup Stadia upgrades and Eskom power stations (Hekima Advisory, 2014). Furthermore, for road construction SANRAL separated some parts of the work in packages then after invited certain companies to participate in tendering. Competition Tribunal settlements revealed that companies such as Haw and Inglis, Aveng, Murray and Roberts, Basil Read, Raubex, Steffanuti and WBHO formed a cartel to agree upon certain prices so that horizontal competitors submit prices that are phony Hekima (2014). Ratshisusu (2014) point out that, at that point in time there was contractors that were already capable of undertaking large infrastructure projects, so basically it was their chance to grow and gain experience.

Ratshisusu (2014) also put forward the idea that large infrastructure projects such as Eskom power station and World Cup stadia upgrades were prioritised by large companies as there was an opportunity to make money. This clearly shows that the procurement procedure that the government uses for large infrastructure projects facilitated companies to collude (Ratshisusu 2014).

In addition, Ratshisusu (2014) states that the government capability to undertake or manage large infrastructure procurement is poor and prone to collusive tendering. Furthermore, it is said that the government is lacking required skills to procure for large infrastructure projects such that they end up consulting external service which has the capacity to manage such projects. Hekima Advisory (2014) puts forward the idea that the primary cause of bid rigging is that the management of procurement process is being done by external consultants.

The manner in which the government award projects contributes to collusive tendering. Usually projects are awarded to lowest qualifying bid which makes it easy for companies to decide that the winning bid should be low. It is very vital to shift the manner in which contracts are awarded. Moreover, it is found by Ratshisusu (2014) that these principles of awarding the lowest bid always leads to winner’s curse because certain companies will price low with intention of winning the bid, but with no capacity to deliver such work.

In addition, the awarding of contracts on the basis of the lowest qualifying bidder on bids that are sealed depends on certain number of key assumptions such as if the design is completed before tender. The consequences for this assumption would be, if the designs are incomplete means that there might be changes in the post contract stage which gives contractors a chance to negotiate for variations and ridiculous claims (Sohail and Cavill 2008). In addition, the main root that makes the system of awarding contracts to the lowest bidder prone to collusive tendering is that all aspects of the project are already finalised and detailed in the tender document.
According to Ratshisusu (2014) concerns are made on the role of consulting firm when managing the procurement process, particularly in the private sector. As there is no express requirement for a public procurement process in private sector projects, the consulting companies are often provided the latitude to identify and recommend suitable contractor for a project. According to Sohail and Cavill (2008) the main concern is that consulting firms appoint contractors based on favouritism and tend to accept their participation in the tender process even though they don’t have the capacity to undertake the work. Therefore, Ratshisusu (2014) put forward the idea that if a contractor does not have the capacity to undertake the work but yet participate in the tender process, the contractors will end up colluding, as they have knowledge who they are competing against.

Khumalo et al. (2010) also provides a number and similar reasons why tenders engage in collusion or cover pricing, which includes the short period of preparing tender documents, the cost of bidding and avoiding offending customers by not tendering. Several findings by Dlamini (2010), describe that there are changes in the business cycle. Throughout the period of recession or the downturn of the economy, collusive tendering, cover pricing including bid rigging may be used as a means of distributing the available work as a result of preventing financial disaster, for those who are participating in the market. However, the findings by Doree (2004) also highlighted that those who are participating in the market do not find collusive tendering as violation of the law or as a criminal offense. Also, it is stated that the competition law is not breached when a phony high bid is put in during the bidding process. However, Khumalo et al. (2010), state that any interaction between horizontal competitors with the aim of reaching an agreement over collusion is a violation of competition law. In addition, according to the OECD (2009) any joint decision with the aim of suppressing other competitors, is indeed a concerted practice as defined in the act.

[In summary below highlights the factors that causes collusion. Doree and Kashiwagi (2015), khumalo et al (2010) suggest that greed it’s the main factor. Sohail and Calvill (2008) also suggest that Political influence is one of the factors that causes collusion. In addition, Zarkada and Skitmore (2000) urge that poor ethics and corporate governance is a cause of collusion. The other cause of collusion according to Ratshisusu (2014) is the size of the project. In addition, the OECD (2010) also urge that largest construction projects are prone to corruption. Ratshisusu (2014) suggest that a poor regulatory environment is one of main cause for companies to engage in collusive practices. Furthermore, it was found that awarding tenders based on favouritism is also a main cause of collusion (Sohail and Calvill 2008). Kashiwagi (2015) also put forward the idea that ignorance of clients is also a main cause. The other cause of collusion is poor procurement management (van de Ryt et al 2010).

According to Sohail and Cavill (2008) the number of contractual links has an impact, the higher the contractual links the more procurement systems being manipulated. Khumalo et al (2010) suggest that entrenched interest is one of the causes of collusion. Ratshisusu (2014) also suggest that the inconsistency of anti-corruption policies is the other factor that causes collusion among the people. Ray et al (1999) urges that the period given to compile tender documents should be enough. Furthermore, a good oversight and supervision of procurement procedures is vital (Sohail and Calvill 2008). In addition to procurement procedures Hakima (2014) suggests that too many stages of procurement procedure can cause collusion. Moreover, Sohail and Cavill (2008) urges that separation of key functions is also a cause of collusion. Furthermore, incomplete designs is also considered as a cause of collusion (Well 2014). According
Poverty is also one of the factors that causes collusion and corruption among people.

**METHODOLOGY**

To examine the causes of collusion in the South African construction industry, survey design was adopted with the intention of obtaining information from individuals and experts in the area of study. Using quantitative approach, questionnaires were administered on construction professionals practicing within construction, consulting and government establishments within Gauteng region of South Africa. These includes quantity surveyors, architects, construction managers, project managers and engineers. The number of questionnaire distributed is 50 and 45 were returned out of which 5 were not correctly and completely filled. The distribution method used was self-administration. In addition, purposive sampling was used. A minimum of 5 years of experience was adopted as the basis for the choice of respondents. This is to ensure that the respondents possess a minimum level of knowledge of the industry by virtue of their practice and involvement in construction process and activities.

The questionnaire was prepared to evaluate the perception of professionals regarding the causes of collusion as well as giving respondents a chance to rank the identified causes. The questionnaire is divided into two sections in which the first section is concerned with general and background information of respondents while the second section focuses essentially on the causes of collusion in the construction industry. A cover page was also provided which basically a cover letter is highlighting a description of the researcher and the institution which the researcher is from. The cover letter seeks permission of respondents to participate in the survey and also highlighted the main purpose of the study.

To rate the causes of collusion in the construction industry, a rating scale with five (5) points was adopted. The adopted 5-point scale was as follows: 1=Strongly Disagree (SD); 2=Disagree (D); 3=Neutral (N); 4=Agree (A); and 5=Strongly Agree. The 5-point scale were transformed to mean item score for each aspect to rank the factors. The ranking helped to identify the relative importance of each variable as recognized by the respondents. The calculation of the relative mean item score (MIS) was determined from the total of all weighted respondents and then relating it to the total response on a particular aspect. This was based on the principle that respondents’ scores on all the selected criteria, considered together, are the indices of agreement with the causes of collusion. The mean item score (MIS) was calculated using:

\[
\text{MIS} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{\sum N}
\]

Where:
- \(n_1\) = Number of respondents for factor number 1;
- \(n_2\) = Number of respondents for factor number 2;
- \(n_3\) = Number of respondents for factor number 3;
- \(n_4\) = Number of respondents for factor number 4;
- \(n_5\) = Number of respondents for factor number 5;
- \(N\) = Total number of respondents
After analytical calculation and the computation of standard deviation (SD), the variables were then ranked in descending order of their mean item score from highest to lowest.

**FINDINGS AND DISCUSSION**

From the received 45 questionnaires, 40 were completely filled and analysed accordingly. Figure 1 reveals the findings relating to construction projects that frequently experience collusion. The respondents perceived that 17.4% of construction projects that experience collusion are road construction projects, followed by shopping malls (15.1%), building renovations (12.8%), Stadia (12.8%), Hospitals (11.6%), Public Offices (11.6%), Railways Construction (7.0%) and the last one to be ranked is Housing Estate at (7.0%).

![Figure 1: Construction Project that experience collusion](image)

Table 1 reveals the respondents ranking of the factors causing the collusion in the construction industry. The Cronbach’s Alpha value for this section is 0.813 indicating a good level of reliability of the data.

According to the ranking (R) using the calculated mean item score (MIS) and standard deviation (SD), it was observed that the most dominant factors include: Contractor’s greed was ranked first with MIS score of 4.12 and SD of 0.980; political influence with MIS of 4.00 and SD of 1.204 was second important factor; poor ethics and corporate governance was ranked third with MIS of 3.98 and SD of 0.987; size of the project was ranked fourth with MIS of 3.90 and SD of 0.944; poor regulatory environment with MIS of 3.76 and SD of 0.969 was the firth important factor; favouritism in awarding contract was ranked sixth with MIS of 3.71 and SD of 1.146; ignorance of clients was ranked seventh with MIS of 3.63 and SD of 1.090; poor procurement management was ranked eighth with MIS of 3.61 and SD of 1.022; high number of contractual links was ranked ninth with MIS of 3.59 and SD of 1.048; entrenched interest was ranked tenth with MIS of 3.56 and SD of 0.950; inconsistency of anti-corruption policies was ranked eleventh with MIS of 3.56 and SD of 1.097; while period given to prepare tender documents with MIS of 3.49 and SD of 1.287 was the twelfth important factor.
Table 1: The causes of collusion in the construction industry

<table>
<thead>
<tr>
<th>Factors</th>
<th>MIS</th>
<th>SD</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor’s greed</td>
<td>4.12</td>
<td>0.980</td>
<td>1</td>
</tr>
<tr>
<td>Political influence</td>
<td>4.00</td>
<td>1.204</td>
<td>2</td>
</tr>
<tr>
<td>Poor ethics and corporate governance</td>
<td>3.98</td>
<td>0.987</td>
<td>3</td>
</tr>
<tr>
<td>Size of the project</td>
<td>3.90</td>
<td>0.944</td>
<td>4</td>
</tr>
<tr>
<td>Poor regulatory environment</td>
<td>3.76</td>
<td>0.969</td>
<td>5</td>
</tr>
<tr>
<td>Favouritism in Awarding</td>
<td>3.71</td>
<td>1.146</td>
<td>6</td>
</tr>
<tr>
<td>Ignorance of clients</td>
<td>3.63</td>
<td>1.090</td>
<td>7</td>
</tr>
<tr>
<td>Poor procurement management</td>
<td>3.61</td>
<td>1.022</td>
<td>8</td>
</tr>
<tr>
<td>High number of contractual links</td>
<td>3.59</td>
<td>1.048</td>
<td>9</td>
</tr>
<tr>
<td>Entrenched interest</td>
<td>3.56</td>
<td>0.950</td>
<td>10</td>
</tr>
<tr>
<td>Inconsistency of anti-corruption policies</td>
<td>3.56</td>
<td>1.097</td>
<td>11</td>
</tr>
<tr>
<td>Period given to prepare tender documents</td>
<td>3.49</td>
<td>1.29</td>
<td>12</td>
</tr>
<tr>
<td>Poor oversight and supervision</td>
<td>3.41</td>
<td>1.072</td>
<td>13</td>
</tr>
<tr>
<td>Too many stages of procurement procedure</td>
<td>3.29</td>
<td>1.031</td>
<td>14</td>
</tr>
<tr>
<td>Separation of key functions</td>
<td>3.05</td>
<td>0.921</td>
<td>15</td>
</tr>
<tr>
<td>Incomplete designs</td>
<td>3.00</td>
<td>1.025</td>
<td>16</td>
</tr>
<tr>
<td>Poverty</td>
<td>3.00</td>
<td>1.342</td>
<td>17</td>
</tr>
</tbody>
</table>

Other causes of collusion include poor oversight supervision with MIS of 3.41 and SD of 1.072; too many stages of procurement procedure with MIS of 3.29 and SD of 1.031; separation of key functions was ranked fifteenth with MIS of 3.05 and SD of 0.921; incomplete designs with MIS of 3.00 and SD of 1.025 as well as poverty which was ranked seventeenth, with MIS of 3.00 and SD of 1.342.

The result of these study is similar to the findings by, Doree and Kashiwagi (2015) where contractor’s greed was revealed to be the main factor that causes collusion. Sohail and Cavill (2008) also suggested that political influence is also a main factor that causes collusion. Furthermore, a study by Ratshisusu (2014) also revealed that poor procurement management is one of the main factors that causes collusion which the study also revealed similar results. Moreover, study by Zarkada-Fraser and Skitmore (2000) also suggested that collusive tendering is a decision made by an individual, which supports the results that poor ethics and corporate governance is one the factors that causes collusion. However, the findings was not in agreement with the study by Sohail and Cavill (2008) where incomplete designs were highlighted as major factor that causes collusion.

CONCLUSIONS

The objective of this study is to determine the factors that causes collusion in the construction industry. The reviewed literature materials revealed that the main causes of collusion include such factors as contractor’s greed, ignorance of clients, poor ethics and corporate governance, poor regulatory environment, poor oversight and supervision, poor procurement management, separation of key functions, favouritism in awarding, too many stages of procurement procedure, incomplete designs, high number of contractual links, political influence, poverty, size of the project,
entrenched interest, inconsistency of anti-corruption policies and period given to prepare tender documents were among the identified causes of collusion.

Findings obtained from the analysis of questionnaires administered on construction professionals revealed that contractor’s greed, political influence, poor procurement management, poor ethics and corporate governance, size of the project, poverty, favouritism in awarding, poor regulatory environment, inconsistency of anti-corruption policies, entrenched interest, period given to prepare tender documents were the top ten causes of collusion among people in the construction industry. [Empowering emerging contractors, a well regulated environment, a fair competition, improving procurement management are the most important aspects that can minimize collusion to occur. Furthermore, good ethical practice, is one of the aspect that professionals should adapt.

…..] Collusion in the construction industry will not only affect the performance of construction projects but will also lead to bad reputation for stakeholders in the industry, especially consultants and contractors. Therefore, to minimize the occurrence of collusion, there is a need to empower emerging contractors, maintain a well regulated environment, ensure a fair competition among bidders and improve procurement management techniques and procedures. Furthermore, stakeholders in the industry, especially construction professionals tasked with the responsibilities of regulating, maintain and controlling construction process and activities need to maintain good ethical practice in dealing with other internal and external members of the industry.

REFERENCES


BASIC CONCEPTS IN STRUCTURAL EQUATION MODELLING WITH EQUATIONS: A SURVEY OF HEALTH AND SAFETY COMPLIANCE ELEMENTS

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University of Johannesburg, South Africa.

Health and safety of employees has generally been a factor of discussion in almost all the construction sites all over the world. Equations (EQS) software was the method used to arrive at the desired variables for health and safety compliance based on safe acts and working conditions features. The health and safety compliance elements relate to safe acts and working conditions and were based on theoretical conceptualised elements. These elements were first taken through exploratory factor analysis (EFA) and further confirmatory factor analysis (CFA). Kaiser-Meyer-Olkin (KMO) of ≥0.70 (p<0.05) was considered for the factor-analysis and a minimum Eigenvalue of 1 was found to be significant and used to explain the variance captured by a factor of safe acts and working conditions. The CFA analysis revealed that the residual covariance estimates fell within the acceptable range and the robust fit indices met the cut-off index criteria. All the parameter estimates were found to be statistically significant and feasible. Therefore, the measurement model for safe acts and working conditions features adequately fit the sample data.

Keywords: construction industry, measurement, safe acts, variables, working-condition.

INTRODUCTION

This section introduces the basic concept in structural equation modelling (SEM) with Eqations (EQS) in relation to health and safety compliance in the construction industry. The latent construct safe acts and working conditions (SAWC) has eight measurement variables derived from literature review as shown in Table 1. The conceptualised measurement variables were taken through various stages in SEM. An overview of employees’ health and safety (H&S) and the methodology adopted for the study are presented. This is followed by the findings, discussions on the topic in question and conclusions. The paper makes a significant contribution by providing substantial measurement variables for health and safety compliance. The use of SEM with EQS buttress the importance and uniqueness of the measurements variables.

HEALTH AND SAFETY OF EMPLOYEES

This section discusses the duties and responsibilities of both the employer and the employee in relation to workplace accident in accordance to the laid down rules and regulations of occupational health and safety administration (OHSA). The control and management of health and safety of all employees within any work environment are under the responsibility of the employer and should be in conformance of OHS regulations. Therefore, it is mandatory for all employers to ensure that they consult their employees often to know their health and safety status [Institute for safety and health management (ISHM, 2014); Church, 2013; health and safety authority (HSA,² zakari.mustapha1967@gmail.com
n.d.). However, employees must also ensure that they work within a safe and healthy environment as stipulated by law. Moreover, employers should provide their employees with personal protective equipment (PPE). A successful and healthy workplace and environment requires the commitment of employers, involvement of employees, identification and control of hazards, compliance with the OHS regulations, and training on safe work practices, mutual respect, caring and open communication within a conducive environment, and continuous improvement on the measures to be instituted (Church, 2013). Windapo and Oladapo (2012) posited that compliance with OHS regulations issues are determined through safe work environment. Therefore, if the workplace is not safe, hardly will the employees comply with OHS regulations. Mustapha, Aigbavboa and Thwala (2016) further posited that employees’ safe acts have significant influence on H&S compliance. Since some tasks are more dangerous than others and accident can occur at any type of workplace in the construction industry.

Table 1: Safe Acts and Working Conditions Conceptual Variables

<table>
<thead>
<tr>
<th>Latent construct</th>
<th>SAWC construct</th>
<th>Indicator variables</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe Acts and Working Conditions (SAWC)</td>
<td>Eight (8)) dependent variables. Nine (9) independent variables. Sixteen (16) free parameters. Nine (9) fixed non-zero parameters.</td>
<td>Ensure proper lifting, handling or moving of objects</td>
<td>SAWC 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure proper stacking of objects or materials in safe locations</td>
<td>SAWC 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avoid annoyance and horseplay at the workplace</td>
<td>SAWC 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Availability of facilities within a reasonable distance from the work area</td>
<td>SAWC 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentrate on task at hand</td>
<td>SAWC 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provision of sufficient lighting system for enclosed areas</td>
<td>SAWC 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facilities must be available to both day and night workers</td>
<td>SAWC 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provision of adequate facilities (toilet, drinking water, washing and canteen)</td>
<td>SAWC 8</td>
</tr>
</tbody>
</table>

Mansingh and Haupt (2008) indicated a different view on the causes of accident and their emphasis was on unsafe acts of employees. Therefore, it is appropriate to put prevention measures rather than making efforts to deal with the consequences after its occurrence. Under the law, both employees and employers, including those that have part-time or temporary roles, regardless of any employment or contractual arrangement should be involved in providing solution to the encountered problem (HSA, n.d.). Moreover, workplace and the entire environment within the site should be surveyed and monitored on regular basis before any task is undertaken (HSA, n.d.). Bellamy et al., (2008) and Behm (2008) are of the view that management system failure and human errors are the major causes of accidents on sites. Therefore, an effort aimed at addressing H&S should be directed more at addressing organisational and project management factors. These should include management in the industry, project and company or organisational level, since accidents are prevalent in the construction industry. Hence, employers must identify the occupational health and safety Acts (OHSAA) regulations that apply to their workplaces and comply with them. Idubor and Osiamoje (2013) pointed out that adequate OHS training and education will enhance the OHS performance e.g. compliance with OHS regulations.
Othman (2012) further asserted that technical failure and inadequate training coupled with harsh work environment and unsafe methods of working inter alia are among the causes of non-compliance with OHS regulations. These arguments were also supported by Adenuga et al. (2007), Idubor and Osiamoje (2013), and Windapo and Oladapo (2012). Employers must therefore, ensure to establish effective two-way communication and respond to the needs and concerns of employees to minimise causes of accident on sites. They should go beyond the regulations to ensure a safe workplace as well as encouraging workers to ensure that their workplace is safe before they embark on any task (HSA, n.d.).

Employers must try as much as possible to avoid discrimination of employees in case they attempt or they actually use their right against the company which is likely within or under the discretion of the health and safety manager (ISHM, 2014). The employee has the responsibility to know the standard industrial classification (SIC) code of the company to enable him/her to learn and understand the most common industry hazard cited so far (ISHM, 2014). Both the employers and the employees are supposed to understand every aspect of their workplace rights and their corresponding responsibilities in order to avoid possible workplace discrimination. At the same time, knowing these things will inhibit both parties to take advantage of unlikable incidents or ignore events that requires immediate attention. OHS Acts the health and safety of everyone- making a worker-friendly environment possible not only for the company owners, but also for the workforce (ISHM, 2014). Therefore, safe acts and working conditions are vital determinants of health and safety compliance.

**METHODOLOGY**

This section discusses the various methods used to arrive at health and safety compliance elements under safe acts and working conditions features. The theoretical conceptual elements were analysed using exploratory factor analysis (EFA) and further confirmed using confirmatory factor analysis (CFA). CFA was conducted on the endogenous variables (ensue proper lifting, handling or moving of objects, ensure proper stacking of objects or materials in safe locations, avoid annoyance and horseplay at the workplace, availability of facilities within a reasonable distance from the work area, concentrate on task at hand, provision of sufficient lighting system for enclosed areas and facilities must be available to both day and night workers) and the exogenous variable (H&S compliance) to determine whether the measures used were sufficient indicators, to assess the coefficients and to reaffirm the factor structure of each construct. The CFA provided the link between scores on a measuring instrument and the underlying constructs they are designed to measure. This investigation led to arrival of the adequacy of the measurement model and structural model goodness-of-fit. The social sciences (SPSS) version 20 software package was then used to evaluate the reliability, discriminant validity and convergent validity of the instrument. All analyses were performed using Equations (EQS) software version 6.2, including the testing of the hypothesised structural equation modelling (SEM). A combination of fit statistics to evaluate the fit of models was used (Table 3) as recommended by (Hu & Bentler, 1999).

**FINDINGS AND DISCUSSION OF RESULTS**

This section presents findings and discussions from the EFA, CFA and finally, the SEM with EQS. The eight measurement variables (SAWC 1, SAWC2, SAWC3, SAWC 4, SAWC 5, SAWC 6, SAWC 7 and SAWC 8) as shown in Table 1 were confirmed from the results of CFA as appropriate and good measures of the elements
for health and safety (H&S) compliance. The confirmed results suggest that the measurement variables for safe acts and working conditions features were good measures of the elements for H&S compliance.

Internal reliability and validity of scores

The factor loadings for all the eight of the measurement variables (SAWC 1, SAWC 2, SAWC 3, SAWC 4, SAWC 5, SAWC 6, SAWC 7 and SAWC 8) were found to be greater than the recommended value of 0.40 as suggested by Field (2005) and Hair et al. (1998). The Rho coefficient of internal consistency was also found to be 0.964 which falls within the range (zero and 1.00) and above the minimum required value of 0.70 as posited by Kline (2010). The Cronbach’s alpha was found to be 0.937, which is above the minimum acceptable value of 0.70 (Table 2). Both values revealed a high level of internal consistency and therefore reliability, suggesting that the indicator variables represent the same latent construct (safe acts and working conditions). All the parameter coefficients were found to be greater than 0.5 which indicates a close relationship between the construct and an indicator variable.

Table 2: Reliability and construct validity of Safe Acts and Working Conditions feature model

<table>
<thead>
<tr>
<th>Factor</th>
<th>Indicator Variable</th>
<th>Factor Loading</th>
<th>Cronbach’s Alpha</th>
<th>Rho Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAWC Features</td>
<td>SAWC 1</td>
<td>0.6189</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAWC 2</td>
<td>0.6013</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAWC 3</td>
<td>0.5799</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAWC 4</td>
<td>0.5370</td>
<td>0.937</td>
<td>0.964</td>
</tr>
<tr>
<td></td>
<td>SAWC 5</td>
<td>0.5917</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAWC 6</td>
<td>0.6437</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAWC 7</td>
<td>0.5816</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAWC 8</td>
<td>0.5830</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Parameter estimates are based on standardized solutions

Table 3 shows the correlation values, standard errors and the test of statistics. All the correlation values were less than 1.00, and all the Z-statistics were greater than 1.96 and show appropriate signs. The estimates were therefore deemed reasonable, as well as statistically significant. The parameter with the highest standardised coefficient was the indicator with variable SAWC 4 (Availability of facilities within a reasonable distance from the work area) and its parameter coefficient was 0.747.

All the parameter estimates had high correlation values greater than 0.500, but not very close to the desire value of 1.00. The low correlation values suggest a low degree of linear association between the indicator variables and the unobserved variable (safe acts and working conditions features). In addition, the R2 values were also not close to the desired value of 1.00 indicating that the factors do not explain more of the variance in the indicator variables. The results therefore, suggest that the indicator variables significantly predict the unobserved construct. The magnitude of the parameter estimate was above the 50 percent minimum. This indicates a strong
relationship between the indicator variables and the factors of the safe acts and working conditions features construct. Therefore, the safe acts and working conditions features satisfied both internal reliability and the construct criteria.

Table 3: Factor loading and Z-statistics of Safe Acts and Working Conditions measurement

<table>
<thead>
<tr>
<th>Indicator Variable</th>
<th>Unstandardized Coefficient (λ)</th>
<th>Standardized Coefficient (λ)</th>
<th>Z-Statistics</th>
<th>R²</th>
<th>Significant at 5% level?</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAWC 1</td>
<td>0.766</td>
<td>0.642</td>
<td>9.990</td>
<td>0.587</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 2</td>
<td>0.745</td>
<td>0.668</td>
<td>10.183</td>
<td>0.554</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 3</td>
<td>0.718</td>
<td>0.696</td>
<td>10.363</td>
<td>0.516</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 4</td>
<td>0.665</td>
<td>0.747</td>
<td>10.603</td>
<td>0.442</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 5</td>
<td>0.733</td>
<td>0.681</td>
<td>10.240</td>
<td>0.537</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 6</td>
<td>0.797</td>
<td>0.604</td>
<td>9.540</td>
<td>0.537</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 7</td>
<td>0.720</td>
<td>0.694</td>
<td>10.290</td>
<td>0.635</td>
<td>Yes</td>
</tr>
<tr>
<td>SAWC 8</td>
<td>0.722</td>
<td>0.692</td>
<td>10.259</td>
<td>0.519</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(Robust Statistical Significance at 5% level)

Structural equation modelling

The results from SEM with EQS shows that the sample data adequately fit the measurement model for health and safety compliance. The examination of the theoretical model through SEM ascertained that the measurement variables for safe acts and working conditions features are theoretically identified (Boomsma, 2000). Therefore, the final structural model was identified for health and safety compliance. Moreover, it is theoretically possible to derive a unique estimate for each parameter (namely, the degree of freedom ≥ 0) and scale assigned to every unobserved variable (Kline, 2010). The EQS result outputs showed that the lowest value for the degree of freedom was 2.0 and the highest value was 4.0 for the current paper. These results show an over-identified model because the scores showed a positive value of degree of freedom. All the eight (8) indicator variables in Table 1 were used for the CFA analysis (Byrne, 2010) since the distribution of residuals covariance matrix was symmetrical and centred around zero (Byrne, 2010). The indicator model (SAWC) provides good measures of residual matrix and evidence of convergent validity.
The CFA results further revealed that the Safe Acts and Working Conditions features had eight (8) dependent variables, nine (9) independent variables and 16 free parameters. The number of fixed non-zero parameters was nine (9). These are the eight (8) dependent indicator variables for the Safe Acts and Working Conditions:

1. Ensure proper lifting, handling or moving of objects.
2. Ensure proper stacking of objects or materials in safe locations.
3. Avoid annoyance and horseplay at the workplace.
4. Availability of facilities within a reasonable distance from the work area.
5. Concentrate on task at hand.
6. Provision of sufficient lighting system for enclosed areas.
7. Facilities must be available to both day and night workers.
8. Provision of adequate facilities (toilet, drinking water, washing and canteen).

The indicator variable is presented in Table 1 and the Safe Acts and Working Conditions features measurement model shown in Figure 1.

Goodness-of-fit statistics – robust maximum likelihood (RML)

The sample data on safe acts and working conditions measurement model yield the $S - B \chi^2$ of 3249.5 with 1861 degrees of freedom (df) with a probability of $p = 0.0000$. This chi-square value indicated that the departure of the sample data from the postulated measurement model was significant and hence, indicative of good fit. The chi-square test is very sensitive to sample size and is used more as a descriptive index of fit rather than a statistical test (Kline, 2010). The chi-square and degrees of freedom was found to be 1.75. This ratio was lower than the limit of 3.00 or 5.0 advocated for, by some authors (Kline, 2010). The CFI value was found to be 0.794 which was lower than the cut-off limit of 0.95 so the model is described to have an acceptable fit. The NFI value was 0.629 which is within the given range, but the given cut-off value of $NFI \geq .95$ is shown in Table 3. Therefore, the model is acceptable. The NNFI value obtained is 0.777 which is also below the cut-off value of 0.80. These fit indexes for the Safe Acts and Working Conditions model suggested that the postulated model adequately describe the sample data and could therefore, be included in the full latent variable model analysis (Table 4).
Table 4: Robust fit indexes for Safe Acts and Working Conditions features construct

<table>
<thead>
<tr>
<th>Fit Index</th>
<th>Cut-off value</th>
<th>Estimate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>S – Bχ²</td>
<td>3249.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>0≥</td>
<td>1861</td>
<td>Good fit</td>
</tr>
<tr>
<td>CFI</td>
<td>0.794</td>
<td></td>
<td>Acceptable</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.051</td>
<td></td>
<td>Good fit</td>
</tr>
<tr>
<td>NFI</td>
<td>0.629</td>
<td></td>
<td>Acceptable</td>
</tr>
<tr>
<td>NNFI</td>
<td>0.777</td>
<td></td>
<td>Acceptable</td>
</tr>
<tr>
<td>RMSEA 95% CI</td>
<td>0.048: 0.054</td>
<td></td>
<td>Acceptable range</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The study provides basic concepts in SEM with EQS in relation to health and safety compliance elements. The results of the CFA analysis revealed that the residual covariance estimates fell within the acceptable range. Likewise, the robust fit indices met the cut-off index criteria and all the parameter estimates were statistically significant and feasible. Considering these criteria, the measurement model for the SAWC feature was found to adequately fit the sample data. In practice, the use of SEM gives flexibility and comprehensiveness than any other univariate or multivariate modelling approaches because it provides a means of controlling extraneous or confounding variables as well as measurement error. SEM can be shown with many statistical procedures because it comes from theory (research design) and sample logic. SEM produces a good-fit and the result greatly supports the individual causal relationships within a model made.

REFERENCES


CONSTRUCTION SAFETY INNOVATION AWARENESS AND ADOPTION IN NIGERIA: A MIXED METHOD APPROACH

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Construction worker safety is a continuous source of concern in most developing countries. Available literature indicates that Nigeria’s built industry has struggled to promote innovation in construction practices. Past studies indicate that the level of innovation correlates to construction performance. Currently, no prior study has looked into the state of adoption and effectiveness of safety innovation in the Nigerian construction industry. To this effect, a study focused on identifying the level of safety innovations in the construction industry alongside pinpointing barriers and enablers of safety innovations is required. First, a synthesis of available literature on construction safety in Nigeria was conducted to determine the current state of safety practice and performance. Subsequently, a survey of construction and design companies in Nigeria was conducted to determine the level of awareness and effectiveness of safety innovations. In addition, barriers and drivers of safety innovations were identified. Lastly, in-depth interviews with construction safety practitioners were conducted to elicit more detailed information on safety innovation awareness. Results from the current study indicate that worker training, client involvement, and government enforcement of regulation are the major enablers of safety innovation adoption. Furthermore, data on the current state of safety innovations in the Nigerian construction industry was provided. Contextual information that could improve worker safety through heightened adoption of safety innovations is also provided. This study may provide valuable guidance for improving worker safety in similar developing countries.

Keywords: developing countries, innovation, Nigeria, safety management.

INTRODUCTION

The construction industries in developed and developing countries are stigmatized with poor performance (Enshassi and Abushaban 2009). Unlike the manufacturing industry, the cyclical, fragmented, and volatile nature of the construction industry creates an environment that strangles potential improvements associated with predictability and continuous improvement (Faridi and El-Sayegh 2006; Odeh and Battaineh 2002). Innovative ideas have been encouraged as a means of overcoming these innate constraints. Innovation can be defined as the implementation of pertinent change and improvement of products, process, or system that is new to the adopting

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Broadly speaking, innovations can be divided into two categories: technology and administrative. The increase in innovative processes (administration) and products (technology) such as mechanization, automation, and use of information technology reduce worker exposure to construction hazards thereby improving worker safety. On the contrary, the construction industry in developing countries is highly dependent on manual labor; leading to increased safety risk (Roland 2016). The use of manual labor could be attributed to limited finance for capital expenditure, availability of cheap labor, lack of skilled labor conversant with automation, and insistence on using traditional methods (Roland 2016). Despite the inherent safety risk workers are frequently exposed to on projects, the construction industries in developing countries continuously struggle to provide adequate safety controls (Alkilani et al. 2013; Vitharana et al. 2015; Kolo 2015). In Nigeria, several studies have been conducted to elicit the core problems behind the construction industry’s poor safety culture (Idoro 2011; Agwu and Olele 2013; Agbede et al. 2016). The lack of significant impact resulting from these studies could be due to absence of consensus in past literature, non-identification of key barriers and drivers of safety innovation adoption, and likely safety innovation saturation. The current study proposes insights on how safety innovation adoption can be improved. The objectives of the current study are to: (1) systematically review the available literature on construction worker safety in Nigeria, (2) evaluate the level and effectiveness of safety innovations, barriers and drivers; and (3) appraise the extent of safety innovation adoption within the construction industry.

SYNTHESIS OF CONSTRUCTION SAFETY LITERATURE IN NIGERIA

According to Gopalakrishnan and Ganeshkumar (2013), the objective of systematic reviews is to identify, evaluate, and summarize the findings of all relevant individual studies, thereby making findings more accessible to stakeholders. To this effect, the current study provides a synopsis of previous construction safety research in Nigeria in order to highlight the current state of the industry and direct future research. Through keyword searches of Google Scholar and Scopus followed by a references check, the researchers identified 47 construction safety related studies conducted in Nigeria. The identified literature was then checked for redundancy and relevance to the research scope. A total of 12 studies were dropped due to duplicity and lack of significant relevance to worker safety. Results show that interest in safety research is growing given that approximately 70% of selected articles were published within the last seven years. Below is a summary of the literature divided into three categories.

Safety Performance

The Nigerian construction industry is plagued with high accident and injury rates (Idoro 2011). The lack of priority placed on workers’ safety in Nigeria is appalling (Ajayi et al. 2015). For instance, construction workers are unable to access adequate compensation for work-related injuries. The lack of effective claims regulation and compensation could negatively impact worker productivity (Kolawole 2014). Although safety management is mentioned in most construction contract documents, safety is rarely a priority during execution (Okeola 2009). One possible reason for poor adherence to health and safety management is the degree of disconnect between the level of safety management efforts and health and safety performance (Idoro 2008). Another reason for the poor implementation of safety innovations is the perceived impact on project cost. Though incorporating safety policies and frameworks on construction projects drives up project cost, implementing safety
policies is strongly correlated with project quality and reduced project time (Okoye and Okolie 2014; Muhammad et al. 2015). In addition, safety consciousness not only improves worker productivity and overall performance, it also enhances a company’s reputation (Udo et al. 2016). Regardless, safety is consistently ignored by contractors in the Nigerian construction industry. Surprisingly, a study conducted by Famakin et al. (2012) revealed that construction health and safety is perceived by contractors and consultants to be more important than other key project performance parameters – cost, time, and quality. Although safety is perceived to be an important project indicator, collective actions of stakeholders in the Nigerian construction industry invalidate this premise. For one, studies show that Nigerian construction workers are unaware of important health and safety issues, including practices (Diugwu et al. 2012; Olatunji et al. 2007). Also, organizations do not pay adequate attention to health and safety management (Diugwu et al. 2012). The insensitivity towards safety management could also be observed in organization hiring of untrained workers. Socio-economic realities, religious and cultural beliefs also play a part in the level of insensitivity (Kukoyi and Smallwood 2016). Alongside employment of unqualified and untrained workers, the influx of immigrants and young workforce into the construction industry increases the potential for accidents. These mishaps are largely due to a knowledge gap, language barrier, and inability to understand implications of worker actions (Kolo 2015; Zuofa et al. 2016). This safety knowledge gap is not peculiar solely for casual field workers but includes formally-trained construction workers. One reason for the lack of safety awareness among educated workers in the built industry is the lack of safety emphasis in the formal educational system (Idubor and Oisamoje 2013; Afolabi et al. 2016). Although available literature posits that construction worker actions (unsafe acts) and the industry safety culture are significant contributors to accidents on construction projects (Aniekwu 2007; Nkem et al. 2015), the lack of awareness of health and safety management practices amongst workers is troubling (Agwu and Olele 2013).

Safety Practices in Nigerian Construction Industry

Similar to most developing countries, the level of safety awareness and implementation of safety practices in Nigeria leaves more to be desired. Given the ineffectiveness of the government safety regulating agencies and nonchalance of clients towards worker safety, Umeokafor (2014; 2014; 2016) recommended promoting worker safety through self-regulation. Self-regulation, in the context of contractors’ safety management, has inherent limitations. For instance, findings from a study conducted by Diugwu et al. (2012) show that though sampled construction workers indicated a decent level of safety regulation awareness, the workers observed actions were in conflict with the regulations. Furthermore, a detailed safety management study conducted by Agbede et al. (2016) indicate that although more than 50% of the sampled construction companies had health and safety policies, only 17.6% of the companies implemented safety practices. This observation shows that while contractors’ self-regulation could improve safety management and performance, the influence of internal and external forces such as company size, cost impact, government involvement, and client’s insistence on implementation of safe practice will have a greater and broader impact (Windapo 2013; Muhammad et al. 2015). Similarly, Famuyiwa et al. (2012) advocated for a national policy and legal framework for enacting and regulating site safety. Going a step further, Okoye et al. (2016) and Orji et al. (2016) emphasized the need to establish safety commissions at the state level if regulation enforcement is to be effective. This suggestion implies that the
government is considered a major player in the struggle to improve worker safety. Some reasons for governments’ ineffective enforcement of safety regulation are a lack of monitoring personnel and the inherently corrupt implementation system (Idubor and Oisamoje 2013). In summary, the current state and future of safety innovation implementation in Nigeria is “gloomy” (Agbede et al. 2016).

**Recommendations**

Following an observation-based study, Olatunji et al. (2007) recommended heightened training (formal and informal) of all level of construction stakeholders as well as integrating safety into the contractor selection process as a solution to the abysmal level of safety awareness and accidents in Nigeria (Afolabi et al. 2016). In addition, increased involvement of clients in safety discussions and regulation enforcement from government agencies are key drivers to improved implementation of safety practices (Idoro 2011a; Idoro 2011b; Kolo 2015). Development and implementation of culturally viable ideas such as Okoye’s (2016) social ecological framework could help improve safety performance. Other factors such as globalization, introduction of principles such as lean construction, use of safety technologies, integration of social responsibility to safety planning, and improved worker compensation claim process could help drive safety awareness which in turn reduces accidents (Idoro 2004; Agwu 2012; Tahir et al. 2012; Zuofa et al. 2016). A close observation of the existing studies indicates that although there is no glaring trend in terms of level of safety awareness, there is some consensus in terms of safety innovation implementation enablers (see Figure 1). These enablers seem to be consistent with what is obtainable in other developing countries (Vitharana et al. 2015).

![Figure 1: Key Enablers of Safety Innovations Adoption](image)

**POINT OF DEPARTURE**

The present study differs from existing literature in that it implements a mixed method approach to assess the level of awareness, effectiveness, barriers, and drivers of safety innovations in Nigeria.

**RESEARCH METHOD**

To achieve the current research objectives, the study was delineated into three phases. In phase one, the researchers conducted a structured literature review to identify and evaluate available studies on construction safety management in Nigeria. This review was carried out to determine the presence or absence of any accentuating
patterns/findings. Phase two focused on evaluating the effectiveness of safety innovation and level of awareness in Nigeria. In total, 23 proven (in developed countries) safety innovations were extracted from the peer-reviewed journals and safety reports (Dorji and Hadikusumo 2006; Choudhry et al 2008; Esmaeili and Hallowell 2011; McGraw Hill Construction 2016). Since the information solicited from respondents is perception based, a survey questionnaire was considered an appropriate tool for the current study (Windapo and Jegede 2013). The survey questionnaire was divided into four distinct sections: (1) demographic questions, (2) effectiveness assessment of safety innovation used on projects, (3) identification of key barriers to adoption of safety innovations, and (4) evaluation of important drivers of safety innovation adoption. Effectiveness and importance were measured using a five-point Likert scale where 1 indicates least effective and least important, and 5 represents most effective and most important.

Phase three involved a combination of structured and standardized open-ended interviews. The interviews provided both quantitative and qualitative information for triangulating findings from the survey. The researchers elected to use a mixed method approach consisting of a survey questionnaire and structured interviews to improve the objectiveness of the study findings (Abowitz and Toole 2010). To ensure research tool internal validity, questions were designed similar to those used by researchers who had previously worked on construction safety innovation (Esmaeili and Hallowell; Ozorhon and Oral 2016). In addition, the survey and interview questions were pilot tested by four experienced Nigerian researchers and three individuals with extensive practical knowledge of the Nigerian construction industry.

The present study participants were drawn using the convenience sampling method due to accessibility and willingness of individuals to participate in the study (Toole, et al. 2010; Jimoh 2016). Prospects were generated through an online search for construction firms as well as personal contacts. The survey was administered using Qualtrics (an online survey tool) and in-person distribution. Ninety-seven (97) out of the 181 individuals contacted responded to the survey. According to Ofori and Gang (2001) and Akintoye (2000), the number of responses received and response rate (53.0%) are adequate. For the structured interview, only individuals with extensive construction and safety knowledge were targeted given the information specificity required from potential interview participants. A total of 15 interviews were conducted. Out of the 97 responses received, 15 were not sufficiently complete and could not be used in the current study, hence a total of 82 responses were used for data analysis. About 45% of the respondents worked for national contractors, 19% employed by multinationals, and 21% are state contractors (see Idoro 2011 for categorization of companies). Approximately 67% of the participants had at least six years of experience in the construction industry. Health and safety professionals made up 15% of respondents while 29% were project managers.

**RESULTS AND DISCUSSION**

A total of 23 safety innovations were evaluated by the survey participants. In terms of use of the innovations, all respondents indicated that upper management was involved in worker safety. Following closely were the use of personal protective equipment (PPE) and frequent safety inspection with 97% and 96% of respondents, respectively. This finding is consistent with Idoro (2008) which ranked provision of PPE as the foremost safety effort by contractors. Conversely, approximately 40% and 39% of
respondents indicated that they have not used location technologies and BIM for safety purposes on a construction site respectively (see Table 1). About 20% of those with past experience using location technology and virtual reality technology indicated that these technologies were not effective. Figure 4 depicts respondents’ perception of safety innovation effectiveness. The use of PPE and the presence of safety personnel were highlighted as the most effective safety innovations (59% and 49%, respectively).

The results indicate that although the use of technology is credited with immense advantages, the adoption and diffusion of technology remains a concern in developing countries. In order to evaluate how safety innovation adoption can be improved in Nigeria, respondents were asked to indicate what factors actually influence the adoption of safety innovations.

Table 5: Level of Awareness and Effectiveness of Safety Innovations (Percentage of responses received)

<table>
<thead>
<tr>
<th>Safety Innovations</th>
<th>Not Used</th>
<th>Not Effective</th>
<th>Slightly Effective</th>
<th>Effective</th>
<th>Moderately Effective</th>
<th>Very Effective</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper management support for worker safety</td>
<td></td>
<td>2</td>
<td>13</td>
<td>25</td>
<td>29</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Implementation of Job hazard analyses (JHA)</td>
<td></td>
<td>5</td>
<td>14</td>
<td>16</td>
<td>30</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>Safety and health orientation and training</td>
<td></td>
<td>1</td>
<td>9</td>
<td>18</td>
<td>31</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>Frequent worksite safety inspection</td>
<td></td>
<td>0</td>
<td>13</td>
<td>13</td>
<td>30</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Conduct thorough near miss investigation</td>
<td></td>
<td>5</td>
<td>15</td>
<td>16</td>
<td>27</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Develop site specific health and safety plan (HASP)</td>
<td></td>
<td>7</td>
<td>11</td>
<td>23</td>
<td>18</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>Emergency response planning</td>
<td></td>
<td>6</td>
<td>18</td>
<td>22</td>
<td>15</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>Safety record keeping and accident analysis</td>
<td></td>
<td>8</td>
<td>18</td>
<td>14</td>
<td>21</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>Include jobsite workers in safety planning process</td>
<td></td>
<td>8</td>
<td>11</td>
<td>18</td>
<td>22</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>Analyze potential site safety hazards in pre-construction</td>
<td></td>
<td>6</td>
<td>8</td>
<td>26</td>
<td>19</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Implement open door policy for reporting hazard</td>
<td></td>
<td>7</td>
<td>11</td>
<td>33</td>
<td>8</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Apply project-specific training and safety meetings</td>
<td></td>
<td>3</td>
<td>16</td>
<td>25</td>
<td>14</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Safety and health committees</td>
<td></td>
<td>7</td>
<td>18</td>
<td>14</td>
<td>14</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td>Implementation substance abuse programs</td>
<td></td>
<td>12</td>
<td>23</td>
<td>8</td>
<td>14</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Provision of safety incentives</td>
<td></td>
<td>10</td>
<td>18</td>
<td>12</td>
<td>23</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Subcontractor selection using safety performance</td>
<td></td>
<td>3</td>
<td>19</td>
<td>24</td>
<td>13</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Implementation of design for safety concept</td>
<td></td>
<td>4</td>
<td>11</td>
<td>24</td>
<td>15</td>
<td>17</td>
<td>29</td>
</tr>
<tr>
<td>Presence of safety manager/engineer on site</td>
<td></td>
<td>3</td>
<td>10</td>
<td>16</td>
<td>14</td>
<td>48</td>
<td>10</td>
</tr>
<tr>
<td>Use of building information model (BIM) to improve safety planning</td>
<td></td>
<td>10</td>
<td>7</td>
<td>21</td>
<td>10</td>
<td>14</td>
<td>40</td>
</tr>
<tr>
<td>Use of personal protective equipment (PPE)</td>
<td></td>
<td>4</td>
<td>3</td>
<td>18</td>
<td>14</td>
<td>59</td>
<td>3</td>
</tr>
<tr>
<td>Implementation of location technologies (e.g., GPS) to reduce accidents onsite</td>
<td></td>
<td>20</td>
<td>8</td>
<td>13</td>
<td>14</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>Use of virtual reality technology in planning operation</td>
<td></td>
<td>20</td>
<td>16</td>
<td>12</td>
<td>11</td>
<td>3</td>
<td>39</td>
</tr>
<tr>
<td>Implementation of information management system</td>
<td></td>
<td>10</td>
<td>16</td>
<td>21</td>
<td>20</td>
<td>11</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 2 summarizes the responses received from survey participants with regards to enablers of safety innovations in construction. Consistent with past literature, client demand and regulatory demand were assessed by respondents to have “very high”
impact in influencing the adoption of safety innovations (35%) while competitive advantage and influence from peers had “very low” impact (10% and 5%, respectively). A more detailed analysis of demographic impact on safety innovation adoption, effectiveness, enablers, and barriers will be discussed in subsequent publication.

Table 2: Enablers of Safety Innovation Adoption (Percentage of responses received, n=82)

<table>
<thead>
<tr>
<th>Enablers</th>
<th>Very low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concern about worker’s safety</td>
<td>3</td>
<td>0</td>
<td>29</td>
<td>37</td>
<td>31</td>
</tr>
<tr>
<td>Insurance costs</td>
<td>8</td>
<td>3</td>
<td>42</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Liability concerns</td>
<td>3</td>
<td>8</td>
<td>26</td>
<td>37</td>
<td>26</td>
</tr>
<tr>
<td>Owner/client demand</td>
<td>0</td>
<td>16</td>
<td>18</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>Regulatory requirement</td>
<td>7</td>
<td>5</td>
<td>22</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>Desire to improve quality</td>
<td>0</td>
<td>6</td>
<td>33</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Desire to improve productivity</td>
<td>0</td>
<td>6</td>
<td>23</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>Past incidence involving worker’s safety</td>
<td>3</td>
<td>11</td>
<td>38</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Industry leadership in overall safety culture</td>
<td>1</td>
<td>11</td>
<td>41</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>Competitive advantage</td>
<td>0</td>
<td>10</td>
<td>46</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>Other contractors are doing it</td>
<td>3</td>
<td>28</td>
<td>42</td>
<td>22</td>
<td>5</td>
</tr>
</tbody>
</table>

The researchers also assessed factors that impede adoption of safety innovation in Nigeria. Congruous with the literature review summary, response from survey participants indicate that training and education of workers is a major barrier to safety innovation implementation. Alongside “lack of expertise and resources”, “wrong perception or underestimation of safety risk” was also considered to be a “high” and “very high” barrier to safety innovation adoption (see Figure 2).

Figure 2: Barriers to Safety Innovation Adoption

Qualitative and quantitative information were gathered in phase three. Methodological triangulation was performed by contrasting survey results with findings from the interview. Triangulation assists in limiting measurement and sample bias thereby improving quality and reliability of research outcome (Love et al. 2002). As part of the interview discussion, interviewees were first asked to fill out a survey questionnaire followed by more detailed explanations to elicit vital information for triangulation. For instance, consistent with the survey, interview participants indicated
that owner demanding for safety and enforcement of regulation requirement have a 
high impact on the decision to adopt safety innovations (50% high, 50% very high). 
This result is supported by the following comment from an interview participant:
“Clients and the government play an important role in construction practices. Clients 
should make it a requirement to hire only contractors with good safety records.”
Furthermore, Table 3 indicates some consistency between results from the survey 
and the interviews. For instance, results from the survey and interview indicate that 
improved worker safety is the primary benefit of safety innovation adoption. To 
improve the quality of comparison, only survey responses received from contractors 
were computed in Table 3.

Table 3: Factors affected by Implementing Safety Innovation (Mean score and ranking 
of responses received)

<table>
<thead>
<tr>
<th>Safety Innovation Contribution</th>
<th>Survey (n =32)</th>
<th>Interview (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Rank</td>
<td>Mean Rank</td>
</tr>
<tr>
<td>Decrease in project duration</td>
<td>2.98 6</td>
<td>3.19 4</td>
</tr>
<tr>
<td>Decrease in project cost</td>
<td>3.05 5</td>
<td>2.29 6</td>
</tr>
<tr>
<td>Increase in worker safety</td>
<td>4.39 1</td>
<td>4.73 1</td>
</tr>
<tr>
<td>Increase in work quality</td>
<td>3.95 4</td>
<td>3.37 3</td>
</tr>
<tr>
<td>Increase in worker satisfaction</td>
<td>3.99 3</td>
<td>4.08 2</td>
</tr>
<tr>
<td>Increase in client satisfaction</td>
<td>4.00 2</td>
<td>3.00 5</td>
</tr>
</tbody>
</table>

Response to open-ended questions indicate that some employers believe safety is the 
responsibility of the workers and making provision for safety is expensive. 
Furthermore, increasing the level of hazard awareness among field workers and 
supervisors was identified as an important way to improve safety innovation adoption. 
Nevertheless, cost associate with increasing awareness such as training and hiring a 
safety supervisor was highlighted as potential barriers. According to some 
participants, investing in safety innovations has little or no impact on contract 
procurement. Using advanced technology such as building information modeling 
(BIM) in pre-construction phases to identify potential hazard was considered cost 
prohibitive. In addition, results from the interviews show that ideas such as designing 
for worker safety are not popular among the sampled population (0% have used or 
plan to use). This result can be seen in the following comment from a respondent: 
“Designing for worker safety (DfWS) sounds like an interesting concept. It will take a 
while to get a hold in Nigeria. One way to actually achieve this [DfWS] is to make a 
safety expert part of the design process whereby the drawing is handed over to the 
safety expert to vet before handing over to the contractor. Training an architect to 
know what is unsafe will take a long time. Regulations should be enforced as well.”

CONCLUSIONS
Findings from the literature synthesis, survey, and interviews indicated that adoption 
of safety innovation could be spurred by increasing worker safety awareness and 
hazard recognition through training, increased involvement of clients in worker safety, 
and government enforcement of regulations. The evaluation of level of awareness and 
effectiveness of safety innovations showed that only one safety administrative control 
– involvement of upper management in worker safety - has been implemented by all 
of the respondents. Although some inconsistencies were observed between the survey
and structured interview results, participants in the standardized open-ended interviews clearly showed displeasure at the current state of safety and level of awareness.

Through identifying key barriers and enablers, the current study provides insights on how worker safety can be improved through increased adoption of safety innovations. To stimulate the adoption of safety innovations, government involvement through enforcing safety regulations is imperative. Enforcing regulations will increase investment in worker safety. In addition to fines for breach of worker safety, regulations requiring contactors to record and report all accidents on a construction site should be enforced and monitored. Based on the aggregated accident data, a system similar to the use of an experience modification rating (EMR) should be introduced to the construction industry. In addition, construction companies do not consider being safe an advantage in the bidding process, thereby reducing investment in worker safety. Training the construction workforce on the importance of safety has immeasurable tangible and intangible benefits. Educating project owners on the significance of making safety a core component when choosing contractors will improve the level of safety awareness among contractors. Finally, conducting a benefit-cost analysis of safety innovation adoption (in developing countries) could increase the awareness of the cost benefits associated with enhanced safety practices. Caution should be applied when generalizing the findings of the current study since a convenience sample was used. Also, a larger sample would provide a more robust picture of the safety innovation adoption trend in Nigeria. Considering the similarities in the construction atmosphere in most developing countries, the results of the current study could have some significance in other developing countries.

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Research studies have shown that the design of a project is related to a significant percentage of construction injuries and fatalities. Prevention through design (PtD), also referred to as “design for construction safety” and “safety in design”, is a concept in which the safety and health of those who construct or manufacture a product is taken into consideration when designing the product. Practical implementation of the PtD concept in the construction industry often involves a collaborative process that combines the field experience of builders with the design skills of architects/engineers (A/Es). However, in some countries, PtD is commonly not considered in the A/E and constructor selection process, and is absent from the contractual requirements of most, if not all, design and construction contracts for commercial and institutional building projects. A case study was conducted in the US to examine the impacts and outcomes of including PtD in the A/E and constructor selection process. While the proposing A/Es reacted differently to the PtD requirement, the majority of those interviewed showed interest in learning about the concept and practicing the concept in varying degrees. Implementation for the case study project primarily involved collaboration to solve specific design and constructability safety issues which the constructor discovered. Impacts on design included increased constructability, awareness of safety hazards, abatement of safety hazards, and collaboration among the design team. The benefits of PtD extended beyond the construction phase into the later phases of the project lifecycle. One factor that drove implementation of PtD past the initial barriers was the continued involvement of the owner.

Keywords: Construction, prevention through design (PtD), request for proposal, architect/engineer.

INTRODUCTION

Despite improvements in construction methodologies and regulations in recent years, the construction industry continues to experience a high number of worker injuries and fatalities. According to the US Bureau of Labor Statistics, among all work industries, the construction industry in the US had the greatest number of work place fatalities (937) in 2015, which represents an increase of 38 from 2014 (BLS 2015a; BLS 2015b).

Traditionally, safety mitigation procedures are emphasized in the construction phase of a project based on the premise that most accidents are worker induced (human error models) or poor construction management practices (management-based theories) (Abdelhamid and Everett 2012; Hosseinian and Torghabeh 2012; Nnaji and Gambatese 2016). Conversely, findings from studies conducted in the past two decades indicate that accidents are not solely outcomes of construction phase activities, but can be traced upstream to design decisions. According to Behm (2005),

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approximately 42% of fatal accidents on construction projects can be linked to decisions made during the design process. This assertion was validated by an expert panel (Gambatese et al., 2005) and supported by findings from a UK Health and Safety Executive study (HSE 2003). Intuitively, construction worker safety can be improved if decisions made upstream take into consideration the hazards created by design choices (Gambatese and AlOmari 2016). By eliminating hazards through altering design choices in the design phase, the highest level of hazard control, elimination (design the hazard out), is being implemented. One way of achieving elimination of hazards in the design phase is through the application of the prevention through design (PtD) concept. PtD, also referred to as design for construction safety (DfCS) and safety in design (SID) is defined as the consideration of site safety in the design and planning phase of a project (Behm 2005). The earliest reported study on PtD in the US was initiated by Construction Industry Institute (CII) in the 1990’s (Gambatese et al. 1997). Subsequently, several studies on the viability of PtD and the perception of stakeholders in the US construction industry have been conducted. As well, studies conducted by Gibbs (2004), Creaser (2008), Mzyece (2012), and Goh and Chua (2016) indicate that the PtD concept is gaining recognition in international design and engineering industries. For one, civil and structural engineers are receptive of the PtD concept in Singapore (Goh and Chua 2016).

Although conclusions from the growing body of literature on PtD indicate the presence of benefits when worker safety is incorporated in the design phase, there remains some degree of unwillingness to implement PtD in the US construction industry (Behm 2005; Gangoletts et al. 2010; Larsen and Whyte 2013; Goh and Chua 2016; Tymvios and Gambatese 2016). Toole et al. (2013), Gambatese (2005), and Brace et al. (2009) highlighted that regardless of the growing awareness of PtD, some industry stakeholders are reluctant to the implement the concept due to liability concerns, lack of safety knowledge, and lack of prioritization. The nonexistence of government backing through legislation exacerbates the situation. In contrast, countries such as United Kingdom, Italy, Sweden, and Spain, guided by European Union directives, introduced legislation requiring designers to be “safety aware” during various phases of design as a means to reducing the construction worker fatality rate in the construction industry (Capone 2016).

In the absence of government legislation, individual owners could promote the adoption and implementation of PtD through incorporating requirements for PtD in contract documents. Since contracting methods could be used as a tool to foster innovation, creating contractual obligations for designers and engineers could be an effective way to energize the adoption of PtD (Blayse et al. 2004; Gambatese and Hallowell 2011; Toole et al. 2016).

According to Tymvios and Gambatese (2014), owners have the requisites to drive implementation of PtD on projects since they financially support designers and contractors. Although some studies have been conducted on the perception of construction stakeholders as it concerns PtD, no prior study has looked into how PtD can be included in the contracting process and its impact on outcome. To this effect, the current study proposes to fill this research gap by assessing the impact of PtD on the A/E and constructor selection process. Bridging this knowledge gap will provide data that could spur the adoption of PtD at a contractual level.
METHODOLOGY

The objective of this study is to assess how incorporating PtD in the contracting phase of a project is received by and could impact project stakeholders. Specifically, the study seeks to gain a greater understanding of how designers that respond to an owner’s Request for Proposals (RFP) perceive PtD, how they take action to implement PtD on a project, and the impacts of the concept on design. To meet this objective, a case study project was selected. The case study project selected was the renovation of an education building in the US Pacific Northwest. Case studies are ideal for situations that require in-depth exploration of a program, activity, or process where the researchers have little or no control over events (Yin 2013; Creswell 2013).

The following steps were taken to meet the research objective:

- Interview shortlisted architects to assess their knowledge and opinions of PtD.
- Interview the hired architect during the project design process to observe what PtD items were and were not implemented and the reasons for these decisions.
- Elicit response from architects regarding the standard practice for addressing safety in design.
- Investigate and document the role of the Construction Manager/General Contractor’s (CM/GC) in enhancing safety through the design of the project.

To achieve the research objective, three questionnaires were developed by the research team to conduct and guide the interviews.

The purpose of the first questionnaire was to judge the “openness to” and “knowledge of” design for construction safety among the four architects shortlisted for the project. This questionnaire consisted of 60 questions distributed into six sections: general information, request for proposal information, general knowledge about the PtD concept, current design practices, PtD impacts, barriers, and limitations, and example design suggestions. The interviews were completed approximately four months after the RFPs were submitted. The questions were originally developed and used as part of a previous study on designing for construction safety (Gambatese et al. 2005). However, some of questions were changed to fit the context of the new study. To encourage participation in design for construction worker safety, the Owner required the architect to make a statement during the proposal process indicating how the designer would address PtD. The RFP included the following PtD question: “Describe your design approach for the building renovation contemplated in this project. Specifically describe your approaches to incorporate constructability/sequencing, construction safety, and sustainability/sustainable materials into the design for this project.” This question is not commonly included in design RFP’s. The written responses by the architects are quoted in Table 1.

After selecting and hiring the Architect, the Owner proceeded to issue a Request for Qualifications (RFQ) to CM/GC firms. The firms that passed the initial qualifications screening process (known as the shortlist) then submitted written responses to the Owner’s Request for Proposals. In the CM/GC RFP, the owner asked the construction team how they would collaborate with the architect to design for construction safety. One question was dedicated to designing for construction worker safety: “Describe your plan to incorporate sustainability, constructability and safety into both the design and construction phases”. The responses submitted by the five construction firms are quoted in Table 2.
Table 6: Architect’s Proposed (Request for Proposal) Approaches to Safety in Design

<table>
<thead>
<tr>
<th>Architect</th>
<th>Approaches to incorporate design for construction safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architect 1 (hired)</td>
<td>&quot;Construction safety is an important aspect of any project but especially on a [Owner’s Name] owned building... there are opportunities where the design team can aid the project with safety measures...[The Architect] Architects will work with the CM/GC to identify areas of work that would benefit from review and modification for issues of construction safety. For example, with any wood structure controlling field welding to reduce fire hazards is a critical component of construction safety... This issue, among others, will be reviewed with the selected CM/GC to assist in reducing costs, easing complexity of details, and reducing hazards associated with construction.&quot;</td>
</tr>
<tr>
<td>Architect 2</td>
<td>&quot;Safety will be a top priority in the design criteria...Structural improvements will likely have the greatest impact on construction safety for [The Project]. It is so important for the CM/GC to be involved in the early stages of structural design so they can review proposed systems and begin crafting a strategy that addresses the structural system within their overall safety plan.&quot;</td>
</tr>
<tr>
<td>Architect 3</td>
<td>&quot;For incorporating considerations relating to constructability/sequencing and construction safety, we would rely heavily on the CM/GC to bring that specific and critical expertise to the team.&quot;</td>
</tr>
<tr>
<td>Architect 4</td>
<td>Not addressed.</td>
</tr>
</tbody>
</table>

The second and third questionnaires were addressed to the Architect and CM/GC that were hired during follow up interviews. The questionnaires essentially asked what measures were proposed for design for construction safety and which measures were actually implemented. The interviews were conducted at approximately 90% completion of design work, which was approximately six months after the RFP interviews. The interviews were conducted over the phone.

For the follow up interviews, the main question was whether the emphasis by the owner (through the RFP) had influenced design. Three main questions were asked: “What did you plan to implement?”, “What have you implemented?”, and “Why?”

The individuals interviewed were chosen because of their direct involvement in the PtD process on the project. For the first questionnaire, all of the architects interviewed were the primary writers of their RFP responses. For the second questionnaire, the Architect’s project manager was interviewed, and the CM/GC’s project manager (PM) was interviewed. The intent was to pick individuals who were intimately familiar with their firm’s written responses and the reasoning behind those written responses.
Table 7: CM/GC’s Proposed (Request for Proposal) Coordination with Architect

<table>
<thead>
<tr>
<th>CM/GC Firm 1 (hired)</th>
<th>Coordinate with Architect for design for construction safety</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;During preconstruction we will examine construction type, design elements, hazmat abatement, materials, access, and procurement from a safety point of view&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Life Cycle Safety: [The CM/GC]’s CM/GC Responsibility: Building Safety Into [The Project]: Designing [The Project] for safety is not [The Architect]’s responsibility alone... we can bring a lot to the table. Kevin, Jim, and Mina have hands-on, field experience that lets them see projects through a craftsman’s eyes. They will collaborate with [The Architect] to ensure a safe design that will serve the campus well for another 100 years, such as installing permanent tie-off anchors and making mechanical systems easily accessible for facilities staff...&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;We will work with [The Architect] to design safety into the project. For example, we will incorporate fall restraints into the design... [The Project] will be a great example of what engineering can bring to the safety design process.&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Safety: Design Phase: Safety begins in preconstruction. [The CM/GC] will work with [The Architect] to build safety into the design, &quot;upstream&quot; from the construction process...&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Preconstruction safety planning will also focus on: ... Type of construction: a lot of steel means a lot of welding. Bolted connections can reduce the risk of fire... Design elements: roof design (fall restraints incorporated) stair system (concrete tread vs. marble etc.) Access (ADA, elevators, service equipment) Floor Loading-review third floor loading for new library... Materials: Back injuries can be avoided if materials are selected that are either light enough for a worker to lift without strain or can be preassembled in a factory environment and hoisted into place. Safe Access: critical to preventing &quot;slip and fall” accidents for workers...&quot;</td>
</tr>
<tr>
<td>CM/GC Firm 2</td>
<td>&quot;We will work with [The Architect] to insure the design documents reflect and promote a safe approach to constructing the work&quot;</td>
</tr>
<tr>
<td>CM/GC Firm 3</td>
<td>Not addressed.</td>
</tr>
<tr>
<td>CM/GC Firm 4</td>
<td>&quot;[The Architect’s] Partnership Role as Project Architect: Designs in safety&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Addressing safety in an RFQ or RFP is very rare and much appreciated. Addressing safety in an architect's RFP, as was done at [The Project], is unheard of. Too often Owner's turn a blind eye to safety and regard it strictly as a contractor issue which they do not want to be part of. We applaud your involvement, and support, in keeping our workers, the project team and the public safe during construction.&quot;</td>
</tr>
<tr>
<td>CM/GC Firm 5</td>
<td>Not addressed.</td>
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**Review of RFP Trends**

The results from the RFP interviews are important because they show that the architects interviewed are very hesitant to change their processes to promote...
construction safety. The reasons behind this mindset are complex but seem to be based on four reasons which are consistent with previous studies: “limit my liability,” “I don’t have the education/tools,” “this will cost extra,” and “this isn’t my responsibility.”

A review of the architects’ answers to questions in Table 1 reflects these rationales. The contracted Architect states “Construction safety is an important aspect of any project... Architects will work with the CM/GC,” which implies that the Architect is willing to collaborate and try to solve design for construction safety issues. Architect #2 (not hired) also parallels these opinions by stating that, “It is so important for the CM/GC to be involved in the early stages of structural design...begin crafting a strategy that addresses the structural system within their overall safety plan.” This statement also suggests a willingness to work collaboratively with the CM/GC. It is important to note that this statement does not say that the architect will be proactive and add items without the input of the CM/GC. Architect #3 (not hired) states that for “constructability/sequencing and construction safety, we would rely heavily on the CM/GC to bring that specific and critical expertise to the team.” This statement also suggests a willingness to collaborate, but not proactively move to enhance construction safety. This last statement also suggests that additional education would be helpful for the architect. The fourth architect (not hired) did not mention construction safety.

A review of the CM/GC responses from Table 2 also shows a willingness to collaborate. The construction firms interviewed potentially have a lot to gain from added safety influence to the design process. Furthermore, the contracted firm also receives a payment for preconstruction services performed, which would include modifications in the design to make a safer workplace. The CM/GC that was hired has an extensive list of areas for potential design contributions. The written response also suggests a strong willingness to cooperate and contribute. CM/GC firm #2 (not hired) states that they are willing to “ensure the design documents reflect and promote a safe approach to constructing the work.” This statement is much less specific than that of the hired CM/GC, but it does promote the collaborative process. CM/GC firm #3 (not hired) did not mention design for construction safety. CM/GC firm #4 (not hired) made a very strong supportive statement: “Addressing safety in an RFQ or RFP is very rare and much appreciated. Addressing safety in an architect’s RFP, as was done at [The Project], is unheard of. Too often Owner’s turn a blind eye to safety and regard it strictly as a contractor issue which they do not want to be part of. We applaud your involvement, and support, in keeping our workers, the project team and the public safe during construction.” This is by far the strongest written statement of support among the contractors. Furthermore, it shows that the construction firm might be willing to promote designing for construction safety with other owners. The fifth CM/GC firm (not hired) made no mention of design for construction safety. The positive responses from the contractors suggest that if this idea can gain traction with owners and architects, the contractors will support it.

**Response to Questionnaire**

Out of the 60 questions in the first questionnaire (interviews conducted after the RFP responses were submitted), some responses were more useful than others in determining the designers’ perceptions. One of the more helpful questions the architect candidates answered was how construction worker safety and health fit within their other design priorities. The actual question is as follows: “What priority
do you place on the following criteria when designing a project? Please rank the criteria with (1) being the highest priority, (2) the second highest priority, and so forth." This ranking format provided a metric that could be analysed to determine an average (mean) ranking between the architects. The results are shown in Figure 1. Note that while a lower ranking would indicate higher priority based on the scale used in the interview question, for the Figure 1, the data was inverted in order to graphically show higher priority with a taller bar. Thus, as shown in the figure, aesthetics was viewed as having the highest priority by the interviewed architects.

The significance of this chart is that construction worker safety and health is not a priority of the architects interviewed. Since the sample size of four interviews is not statistically broad enough to generalize but within the range for case studies (Yin 2013), it may not be appropriate to assume that most architects in the general population agree. As well, it is plausible that some architects do not thoroughly consider the wellbeing of construction workers as they design. Further, the mean rankings suggest that some architects have a lukewarm to negative opinion about this topic.

For example, one architect said that they used to be involved in construction safety: "AIA used to have language that involved the Architect, but we got sued, and now we no longer have involvement."

![Figure 9: Mean rankings of the Architects’ Priorities were 6 = highest priority and 0 = Lowest Priority (n =4)](image)

In addition, some architects feel that getting involved with safety issues might stifle innovation/creativity. For instance, “if the architect states that a certain beam is for tie-offs it might force the contractor to use the beam even if they have a better plan.”

Progress Interview Results

The purpose of these interviews was first, to identify what the Architect and the CM/GC each planned to implement before starting the project. Second, the intent was to find out what was actually implemented individually or as a team, and why or why not. The interviews were conducted at 90% design completion.

Interview with the Architect
This interview was conducted via email with the hired Architect’s project manager. The Architects PM had the following response to the question: “What did you plan to implement for "construction worker safety?"

“The Architect and CM/GC discussed the following regarding issues affecting worker safety;

- Limit or eliminate welding to avoid fire issues on existing wood, worker burns, flammable gases, etc.
- Tie-offs for construction & the Owner’s maintenance workers.
- Using the permanent structure for temporary bracing.”

The response to the question, “What have the Architect and the CM/GC actually implemented for "construction worker safety?" is highlighted below:

“ (a) Initial discussions on this topic revolved around use of bolted connections everywhere possibly to avoid the need of flames, welding, high heat sources, etc near 100 plus year old wood…… the design still incorporates the use of bolted connections to the greatest extent possible to reduce welding safety issues. This structure change eliminated a lot of unknown design and construction issues, decreased the required contingency for unforeseen conditions…..

(b) The team discussed using the permanent structure as temporary bracing to reduce cost and reduce contractor/worker risk and safety issues in the use of temporary bracing as well as safety transferring from temporary to permanent bracing……. The design team will work with the demolition contractor to incorporate their temporary shoring into the overall scheme of design to insure safety, construction, schedule, and the efficient use of materials, i.e. use of permanent structure as temporary shoring.”

In addition, the answer below was provided in response to the question, “How has construction worker safety been influential on design?”

“As architects, we typically don't get involved in the contractor’s issues. However, working with the CM/GC and the Owner overall has opened up views and opinions that will help architects understand the GC point of view and day to day issues they face. I don't know if it directly affects design, but working with GCs on these issues creates more team oriented design through understanding the other point of view.”

**Interview with the CM/GC**

Response from the project manager indicated that some tangible progress was made during the pre-construction phase. Although the architect stayed clear of making any recommendations that could be translated as encroaching on “means and methods”, the Architect and CM/GC team were able to change some materials, modify the roof design (from flat to gable), and change the construction type from “selective replacement of timber beams" to gutting the building. To come to a reasonable solution in a difficult situation, the PM said, “It is better to convince the architect with dollars. If the task is difficult, we just need to educate the architect.” The PM also noted that during “preconstruction, when we see something with a tough detail, we need to give it some thought. First we need to look at the safety issues and second, we need to look at the cost issues.” Reviewing both these areas allows the CM/GC’s project manager to help in designing safe projects. In addition, the PM stated, “We
need to look at the challenging pieces of design now while we are in the (inexpensive) design phase.”

CONCLUSIONS

The objective of this study was to gain a greater understanding of how design for safety could be incorporated in the procurement process, how designers perceive design for construction safety, how the designers take action to implement it on a project, and the impacts of the concept on design. By including design for safety language in the RFQ and RFP, designers were forced to place an emphasis on worker safety while designing the structure. The results of the interviews show that for most of the architects PtD is a challenging concept. However, three of the four architects were willing to consider designing for construction safety. The responses of the construction firms were equally as positive. Three of the five construction firms were willing to work with the architect to ensure the safety of the design. When the architects were interviewed after submitting the proposals, they were more candid about the concept. One architect was concerned about liability for potential workplace injuries, current level of worker safety knowledge (education), and interfering with the construction means and methods of construction and not willing to consider the concept. One firm mentioned liability, but said it had “a moral responsibility,” and considered constructability of the plans. The drawbacks of the PtD concept on design include increased monetary and schedule cost during preconstruction; however, these are likely earned back during the construction phase if the changes are implemented. On a particular project, a Choosing by Advantages (CBA) benefit-cost analysis indicated that PtD solutions generate the greatest value to construction stakeholders and are the most cost effective safety measures (Karakhan et al. 2016). The impacts of PtD include an increased awareness of construction safety issues among designers as well as increased collaboration with the contractor which may lead to increased cooperation in other stages of the project.

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EXAMINING SOURCES OF HIGH NOISE LEVELS IN THE CONSTRUCTION AND NON-CONSTRUCTION INDUSTRIES

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High noise exposure in the construction industry has the potential to cause noise induced hearing loss (NIHL) but also poses an increased risk for other on the job hazards due to impaired communication. Examining sound pressure level measurements of common construction equipment and activities is essential in reducing workers’ risk of NIHL along with on the job injuries associated from poor hearing and communication. The purpose of this study is to assess construction workers’ exposure to high noise levels by examining some of the most commonly used equipment and tools in the industry, and to compare noise exposures and noise sources in construction with non-construction industries. The data for this study came from the Noise Navigator™ Sound Level Database from The 3M Company. This database contains sound levels for more than 1,700 occupational, recreational, and military noise sources. This study describes noise levels among construction equipment and tools and compares these sources to other industries (non-construction). Data analysis indicated that among both the construction and non-construction noise sources (N =656), construction industries (89%) have a significantly higher (X^2 =14.36, p =0.000) percentage of high noise exposures (dBA ≥85) compared to non-construction industries (77%). There was no relation between the three sub-groups (outdoor, indoor, and both) (X^2 =1.04, p =0.594). The loudest sources of noise among the construction category include: jackhammer (dBA =130), pneumatic chipping gun (dBA =120), pavement breaker (dBA =120), earth scraper (dBA =117), asphalt grinder (dBA =114), air track drill (dBA =113), and bulldozer (dBA =110). The study findings will enable construction researchers and practitioners to better understand potential occupational noise sources to develop interventions and practical strategies to reduce noise exposures.

Keywords: noise, hearing loss, construction, equipment

INTRODUCTION

Noise exposure in the occupational environment has long been documented as a significant occupational health concern. The Occupational Safety and Health Administration (OSHA) has reported that annually in the United States (U.S.), approximately 30 million people are occupationally exposed to hazardous noise (OSHA, 2016). Construction workers are particularly vulnerable to loud noise exposures and the associated health consequences. Neitzel et al. (2011) followed 333 construction workers over a ten-year period and found these construction workers had a substantial potential risk of noise induced hearing loss. There have also been studies

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that suggest that high noise exposures not only pose a risk but is associated with loss of hearing function. Seixas et al. (2005) evaluated noise exposures and hearing levels among construction apprentices, and found that those exposed to the average noise level above 90 dBA in the first three years of their working periods experienced measurable losses of hearing function. In general, high levels of noise are associated with most construction tasks. Fernandez et al. (2009) measured common construction activities in Spain for noise exposures and found that between 60% and 70% of construction workers are exposed to a noise dose higher than the 100% along their working day.

Even when construction workers are aware of noise, they may still not wear hearing protection devices. In Kuwait, Koushki et al. (2004) found that more than a third of the workers were aware of construction sites were noisy during the entire 8-hr working day, and yet nearly 80% stated they never used a hearing protection device. Koushki et al. (2004) noted that during their entire 70 hours of noise measurement periods on the construction site, no one was ever seen to be equipped with a hearing protection device at the study construction sites. Neitzel et al. (1999) evaluated carpenters, laborers, ironworkers, and operating engineers for exposure to construction noise. An interesting finding was that all trades were exposed to impulse/impact noise, resulting in exposures above the OSHA-allowable maximum and peak levels. This was also found in the Koushki et al. (2004) study. Trade was a poor predictor of noise exposure; construction method, stage of construction, and work tasks and tools used were found to be better exposure predictors. Heavy equipment and pneumatically driven tools contributed greatly to exposure levels (Neitzel et al., 1999).

Future research should focus on specific pieces of equipment and tasks rather than generically looking at trades. This is where the database highlighted in this study contributes to the body of knowledge. For example, Saleh et al. (2016) evaluated the effectiveness of sound dampening mats in reducing noise level of heavy-construction equipment, an asphalt roller, a grader, and a crane. The sound dampening mats reduced noise in the operator’s cabin noise from 5.6 to 7.6 dBA on full throttle; for these types of heavy equipment this is a substantial decrease, bringing two of the three below the OSHA permissible exposure limit of 90 dBA. This is an excellent example of applying engineering controls to a specific piece of equipment.

In addition to contributing to hearing loss, occupational noise can have an adverse effect on work safety due to less efficient communication between individuals and the problem of excessive fatigue induced by prolonged noise exposure, leading to an increase in errors resulting from the loss of concentration and the predictable cognitive failures (Picard et al., 2008a). Deshaies et al. (2015) analyzed 161 fatal accident reports in Quebec that occurred in noisy environments, and found 31 (19%) occurred in the construction sector, the highest of any occupational sector. They recommend that noise be considered as a potential factor in all work-related accident investigation particularly where vehicular movement or communication between workers is involved (Deshaies et al., 2015). In evaluating all industries, Picard et al. (2008a) estimate that 12.2% of work-related accidents are attributable to noise exposure or noise-induced hearing loss. In another study they find that noise-induced hearing loss and occupational noise exposure in excess of 99 dBA daily exposure can interfere with more than work-related tasks in the workplace as shown by the evidence of adverse consequences on driving safety (Picard et al., 2008b). This is particularly important with regards to the construction industry.
Health and Safety Effects of Noise Exposure

When exposed to loud sounds, particularly for long periods of time, damage begins to occur to sensitive structures within the inner ear potentially resulting in NIHL. Continuous exposure to loud sounds (e.g. noise emitted in a woodworking shop) can also cause NIHL. An individual with NIHL may notice it immediately or over a period of time after the damage has occurred. NIHL is a permanent condition affecting either one ear or both ears. In most severe cases of NIHL, an individual may have extensive inner ear damage requiring the need of hearing devices or implants (National Institute on Deafness and Other Communication Disorders, NIDCD, 2015).

Understanding the effects of NIHL involves understanding how humans hear. Sound enters the ear in the form of waves traveling through the ear canal leading to the eardrum. The eardrum sends vibrations to three tiny bones (malleus, incus and stapes) located in the middle ear. These three bones help send vibrations further into the ear along the basilar membrane where hair cells are located. The hair cells (known as stereocilia) create electrical signals of which the auditory nerve then carries to the brain ultimately translating the nerve into a sound. Since loud sounds damage and can eventually kill hair cells, NIHL is considered irreversible (NIDCD, 2015). This condition can be prevented by identifying sources of noise that can cause hearing damage, the use of protective hearing devices, limiting the distance between an individual and the source of noise, and getting regular hearing performance tests (NIDCD, 2015).

Excessive noise exposure can have serious health and safety effects to the exposed individual. Noise-induced temporary threshold shift (NITTS) occurs when there is a temporary loss in hearing sensitivity generally due to a short-term exposure to noise or when neural fatigue in the inner ear occurs. As NITTS is temporary, hearing sensitivity typically returns to the pre-exposed level within hours or days. While noise-induced permanent threshold shift (NIPTS) is a permanent loss in hearing sensitivity, damage of sensory cells in the inner ear can be caused by long-term exposure to noise or trauma. Another health effect of noise exposure is a condition called tinnitus, which is the occurrence of a sound produced by the inner ear or neural system such as a hum, buzz, or ring while in the absence of actual sound surrounding the individual. Acoustic trauma occurs when there is temporary or permanent hearing loss as a result of a sudden intense acoustic event (e.g. an explosion). Acoustic trauma can cause conductive or sensorineural hearing loss (Anna, 2011).

Research has shown that other health effects associated with noise exposure can occur in workers in noisy occupations. Kalantary et al. (2015) sought to examine the association of noise exposures among workers in the automotive parts industry on blood pressure and heart rate. Data were collected at different units of an automotive parts manufacturing industry in Tehran. The case-control study consisted of 26 workers (cases) between the ages of 20-56 years old with high levels of occupational noise (over 85 dBA). The control group consisted of 16 unexposed administrative (office) employees with ages ranging from 21-52 years. Participants had their heart rate and blood pressure measured twice in a day (at start time before exposure to noise, and at middle shift hours during exposure to noise). Both the control and case groups shared no significant difference in the respective mean BMI for each group. There were no significant differences in diastolic blood pressure, systolic blood pressure, and heart rate of workers in the case group (before exposure) and workers in
the control group. However, paired t-test indicated that there was a significant difference between the heart rate and diastolic blood pressure of the case and control groups before and after noise exposure. The results indicate that there may be an association between exposure to industrial noise and increased heart rate of workers.

Tonne et al. (2016) sought to determine whether long-term exposure to traffic air and noise pollution was associated with all-cause mortality or hospital readmission for myocardial infarction (MI) among survivors of hospital admission for MI. The sample population was derived from a secondary database, Myocardial Ischaemia National Audit Project (MINAP), for individuals who died from or were admitted to a hospital with MI in Greater London. The methods of this investigation involved usage of high spatially-resolved annual average air pollution which was derived from a dispersion model and road traffic noise for the years 2003-2010. Most air pollutants were shown to be positively associated with all-cause mortality alone and in combination with hospital readmission for non-exhaust particulate matter (PM10), oxidant gases, and the coarse fraction of PM. Their investigation provided evidence that long-term exposure to air pollution is associated with all-cause mortality and hospital readmission for MI among survivors of MI.

Work-related accidents associated with noise exposure was investigated by Picard et al. (2008a) of which the researchers compared the total number of reported work-related accidents that occurred over a 5-year period with the latest audiogram completed for each of the 52,982 male study participants. The participants were followed an additional 5 years following their more recent hearing test. The researchers hypothesized that noise-induced hearing loss may be caused by noise exposure thus compromising safety in the workplace (e.g. potentially causing accidents). Sound level meters (type II) were used when noise levels were steady; various exposures were captured and integrated into a representative and personalized $\text{Leq}$ when workers were mobile. The study found that the more severe a worker’s hearing loss was, the greater the increase in the accident risk. The study also found that working in an environment where the noise levels are equal or greater than 90 dBA, there was an increase in the accident risk to a prevalence ratio (PR) of 1.08. This study suggests that workers exposed to high levels of noise can be susceptible to increased accidents in their work place.

**Control of Noise Sources and Noise Exposures**

It is essential for employers to identify sources of noise in the workplace facility. Based on the Occupational Noise Exposure standards (29 CFR 1910.95 and 29 CFR 1926.52), OSHA requires employers to implement an effective hearing conservation program if workers are exposed to noise levels equal or greater than 85 dBA for an 8 hour exposure or if in the construction industry as noise exposures exceed 90 dBA for an 8 hour exposure (OSHA, 2016). The hearing conservation program requires the employer to measure noise levels, provide free hearing exams annually, provide free hearing protection, training, and conduct evaluations of the adequacy of the hearing protectors in use.

Noise sources in occupational settings are generally categorized as either the surface motion of a vibrating solid or turbulence in a fluid. Developing a written noise control plan is the first step to reducing noise. There are three common methods of noise control: engineering and administrative controls, and use of personal protective hearing devices or hearing protection devices.
Engineering controls are typically implemented when administrative controls cannot be used to reduce noise exposures. The most effective engineering control measure is to completely eliminate the source of noise by removing loud equipment and processes and replacing them with quieter options. However, this is also the most costly method. Applying noise control treatments to noisy equipment is an option for controlling noise in the workplace. It is essential to analyze the source of the noise prior to determining which noise control treatment is appropriate. Installing the most simple treatment options for the loudest sound sources first is most effective. Noise sources that have a vibrating surface can be controlled by reducing the drive force, the response of the surface to the driving force, and the radiation efficiency of the vibrating surfaces. Fluid turbulence can be controlled by limiting turbulence by reducing pressure drops and velocities, and by smoothing flow. If sound is transmitted to the air, it may be reduced by treating the sound path through sound absorption, equipment enclosures, personnel enclosures, shields or barriers, lagging, and mufflers (Anna, 2011).

Administrative noise control measures involve moving workers away from areas that are noisy or redistributing noise exposures. Rather than allowing few workers to operate on noisy equipment for extended periods of time, giving many workers shifts that involve low exposures prevents workers from excessive exposures to loud noise (Anna, 2011). Hearing protection devices (HPDs) are essential for the prevention of hearing loss and other ear damage. However, engineering or administrative controls should take utmost priority when establishing an effective hearing conservation program. HPDs (e.g. earmuffs and earplugs) should primarily be used when engineering or administrative controls are not feasible or when worker’s hearing evaluations indicate hearing loss or other severe damage (OSHA, 2016).

**Noise Level Databases**

Noise level databases are an efficient means of distributing information related to noise levels; essentially providing direct measurement data often unfound in published articles or studies. These databases contain information collected from both unpublished data (e.g. occupational surveys) and published studies offering a vast array of data that allow professionals to access information that otherwise would be difficult to attain. The target audience for noise level databases are individuals or entities seeking information on specific noise level sources such as industrial hygienists, management personnel, noise control engineers, researchers, governmental agency staff, and health and safety committees. Noise level databases encourage sharing of occupational noise data and promote standardized reporting of noise measurements.

This study will utilize data obtained from the Noise Navigator™ Sound Level Database, Version 1.8 (revised June 26, 2015), received from Mr. Elliott Berger of 3M, Personal Safety Division. The Noise Navigator™ Sound Level Database includes sound levels for 1,707 occupational, recreational, and military noise sources. While the database includes both occupational and non-occupational noise source data, only occupational source data will be included in this study. The database consists of sound level measurements from references in the literature and researchers from 3M Personal Safety Division (Berger et al. 2015). The Noise Navigator™ Sound Level Database spreadsheet provides measurements primarily as A-weighted sound levels.
The purpose of this study was to examine the sources of high noise levels in construction work settings along with various other occupational settings included in the Noise Navigator™ Sound Level (NNSL) Database. The specific aims of this study were to: identify the occupations with the highest noise exposure levels in the NNSL Database; determine the specific types of noise sources in the NNSL Database that are associated with high noise exposure levels; determine the association between occupations that are primarily outdoor and high noise exposure; and compare the noise exposures between workers in outdoor and indoor occupations listed in the NNSL Database.

The findings of this study offer valid evidence in identifying which occupations are exposed to high levels of noise. This study also provides a cross-examination of multiple sources of noise, such as equipment used in the workplace that can give further insight in understanding where excessive noise levels within various occupations occur. Identifying noise sources is one of the best control strategies in reducing noise exposure as it addresses the exposure problem directly at its source. This study does indeed identify sources of noise exposure, ultimately aiding in the overall reduction of occupational risk to NIHL. This is important because NIHL is irreversible.

This study gives recommended control strategies for reducing excessive noise level exposures by targeting the noise sources. This study further provides future researchers with baseline data on noise exposure levels from sources of noise among multiple occupations.

**METHODOLOGY**

**Data Collection**

For the purposes of this study, The Noise Navigator™ Sound Level Database was categorized based on occupational setting (indoor or outdoor) and whether a source is used in construction or a non-construction occupation. The occupations within the indoor category include: automotive, welding, industrial, music/recording, and office. The outdoor category includes: construction, farm, transportation, marine, logging, mining, recreation, public, and warning (ambulance and police sirens). The determination of a source as either construction, non-construction, or both was made based off of its respective reference.

For this study, the noise exposure data was also categorized according to exposure intensity (low and high). Noise exposure data is defined as low if a noise source is less than 85 dBA, while high-level exposure is defined as 85 dBA or greater since prolonged exposure to 85 dBA has been known to increase the risk to NIHL. In addition, 85 dBA is the OSHA action limit for noise, as well as the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits (RELs) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLV) for noise.

**Data Analysis**

The Noise Navigator™ Sound Level Database includes 679 sources of noise several of which are listed multiple times and contains a range of noise frequency (dBA) reported for several sources (e.g. air grinder = 100-105 dBA). The revised database used only the median (rounded up) noise frequency (dBA) of the reported range (e.g. air grinder = 103).
To determine if construction sites (based on the source of noise) are exposed to higher levels of noise than other occupational sites, a side-by-side box plot analysis was performed. In addition, a side-by-side box plot analysis was also performed to determine if outdoor occupations (based on the source of noise) are more susceptible to high noise exposure than workers of indoor occupations. Frequency statistics were performed for a numerical summary of the data and since some noise sources are listed multiple times. Two sampled t-test with confidence intervals were also performed to determine if there are any significant differences. To determine which tool or equipment (i.e. noise source) is associated or contributes most to the noise exposure level for specific occupations, the revised database was further examined by distinguishing the noisiest sources (highest dBA) among the construction category as well as other occupations (non-construction) such as agriculture, transportation, police, emergency responders, etc.

RESULTS

After data cleaning and sorting, there was a total of 656 sources of noise included in this study. Table 1 shows the loudest noise sources among construction and non-construction and indoor, outdoor or both categories. The loudest noise source was the high pressure exhaust which is used in non-construction outdoor industrial settings (noise measurement of 158 dBA). The motor test chamber had a noise measurement of 140 dBA. The third loudest source was the needle gun (found inside gear housing) with a noise measurement of 132 dBA. There were three sources of noise measured at 130 dBA (the fourth loudest level within the database) including the: jackhammer, riveter, and steam let down (used in petroleum refining).

<table>
<thead>
<tr>
<th>Source of Noise</th>
<th>dBA</th>
<th>Cons/Non-const</th>
<th>Indoor/Outdoor/Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pressure exhaust</td>
<td>158</td>
<td>Non-construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Motor test chamber</td>
<td>140</td>
<td>Non-construction</td>
<td>Indoor</td>
</tr>
<tr>
<td>Needle gun (inside gear housing)</td>
<td>132</td>
<td>Non-construction</td>
<td>Indoor</td>
</tr>
<tr>
<td>Jackhammer</td>
<td>130</td>
<td>Construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Riveter</td>
<td>130</td>
<td>Non-construction</td>
<td>Indoor</td>
</tr>
<tr>
<td>Steam let down (petroleum refining)</td>
<td>130</td>
<td>Non-construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Police boat (w/siren)</td>
<td>124</td>
<td>Non-construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Oxygen torch</td>
<td>121</td>
<td>Non-construction</td>
<td>Indoor</td>
</tr>
<tr>
<td>Pneumatic chipping gun</td>
<td>120</td>
<td>Construction</td>
<td>Both</td>
</tr>
<tr>
<td>Turbine generator</td>
<td>120</td>
<td>Non-construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Pavement breaker</td>
<td>120</td>
<td>Construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Pneumatic machine-mounted drill</td>
<td>117</td>
<td>Non-construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Pneumatic percussion tools</td>
<td>117</td>
<td>Non-construction</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Earth Scraper</td>
<td>117</td>
<td>Construction</td>
<td>Outdoor</td>
</tr>
</tbody>
</table>

Table 1: Loudest Noise Sources with the Highest Sound Levels (dBA)
When examining the loudest sources of noise among the construction category, the jackhammer (outdoor) was found to have the highest noise measurement (130 dBA). Table 2 shows the loudest sources of noise among the construction category. The pneumatic chipping gun and pavement breaker have the second highest noise measurement (120 dBA) and the earth scraper has the third highest among this category (117 dBA).

An independent-samples t-test was conducted to compare sources of noise from the construction category and non-construction noise sources. Among both the construction and non-construction noise sources (N =656), construction industries (89%) have a significantly higher (X^2 =14.36, p =0.000) percentage of high noise exposures (dBA ≥85) compared to non-construction industries (77%).

### Table 2: Sound Levels (dBA) of the Loudest Construction Noise Sources

<table>
<thead>
<tr>
<th>Source of Noise (construction)</th>
<th>dBA</th>
<th>Indoor/Outdoor/Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackhammer</td>
<td>130</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Pneumatic chipping gun</td>
<td>120</td>
<td>Both</td>
</tr>
<tr>
<td>Pavement breaker</td>
<td>120</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Earth scraper</td>
<td>117</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Asphalt grinder</td>
<td>114</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Air track drill</td>
<td>113</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Bulldozer</td>
<td>110</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Air hammer</td>
<td>110</td>
<td>Both</td>
</tr>
<tr>
<td>Paving machine</td>
<td>110</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Pneumatic chipper (diesel)</td>
<td>109</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Pneumatic hammer (chipping concrete)</td>
<td>109</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Saw, chop/cutoff</td>
<td>109</td>
<td>Indoor</td>
</tr>
<tr>
<td>Earth scraper</td>
<td>109</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Air gun</td>
<td>108</td>
<td>Both</td>
</tr>
<tr>
<td>Circular saw (cutting laminated countertop)</td>
<td>108</td>
<td>Indoor</td>
</tr>
<tr>
<td>Compactor</td>
<td>108</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Wood planer</td>
<td>107</td>
<td>Indoor</td>
</tr>
<tr>
<td>Loom</td>
<td>106</td>
<td>Indoor</td>
</tr>
</tbody>
</table>
These results suggest that tools and equipment (sources of noise) used in the construction industry are louder than non-construction occupational sources of noise. When comparing indoor, outdoor and both sub-categories within the construction category (N =247), there was no relation between the three groups ($X^2 =1.04, p =0.594$); as expected outdoor construction sources of noise (89%) have a higher percentage of high noise exposures compared to indoor (85%) construction sources of noise.

**CONCLUSIONS**

The results of this study demonstrated the excessive noise level measurements emitted from tools and equipment construction workers are regularly exposed. Our findings indicate that there was a statistically significant difference between sources of noise level measurements of non-construction and construction occupations and the data suggests that workers from both categories are exposed to levels above the current exposure limit of 85 dBA. These findings reinforce the need for effective hearing conservation programs. Relying solely on HPDs is not an effective strategy in reducing an employee's risk for NIHL. As discussed earlier, engineering control measures should be implemented first. In addition, the employer should: regularly monitor noise exposures; implement engineering, work practice, and administrative controls for excessive noise; provide HPDs to all employees who are overexposed; offer employee training and education; and provide and record baseline and annual audiometry tests.

Future studies on this issue is crucial in reducing NIHL among construction workers. A suggestion for addressing the excessively loud sources of noise construction workers are regularly exposed is for researchers to develop close partnerships with manufacturers or engineers of such tools and equipment so that new design strategies focused on less noise can be developed. Another research effort in reducing the rate of NIHL among construction workers involves further understanding of workers' perception of noise exposure. Conducting focus groups or oral interviews to identify barriers prohibiting workers and employers from practicing hearing conservation measures is essential. The work presented here provides further evidence of the excessive noise level measurements that workers may typically be exposed to on a given work day.

**REFERENCES**


Indian construction industry faces severe health and safety challenges. Specifically, the challenge in the smaller community development projects is significant. Thus, using the case study of construction projects in community development blocks in India, this study examined the factors that bring health and safety perils to the construction workers and how the situation can be improved in such projects. The study was conducted by using a survey research method to collect both qualitative and quantitative data from various stakeholders. It is revealed that no structured and appropriate health and safety measures are available to protect the construction workers. Factors such as lack of compulsory health and safety provision, lack of awareness regarding health and safety, lack of budget for funding safety measures, lack of safety checks and audits, lack of protective gears and equipment, lack of safety related skills and training, provision for emergency treatment facilities close to project locations, and callousness of project administration and execution authorities are the major reasons that bring safety challenges in projects. However, policy measures to enforce compulsory safety measures, incorporation of safety related expenses as a part of the estimated cost of projects, creation of safety awareness, provision of safety training and availability of protective gears and equipment can assist to improve health and safety of construction workers.

Keywords: budget, community development projects, construction, protective gears, equipment, safety measures.

INTRODUCTION

Health and safety is an invasive challenge in construction industry in India. The challenge is more prevalent in community development projects that are undertaken by Government agencies. Community development projects are essentially the projects carried out in Community Development Blocks (an administrative unit at local level for development purposes). The projects include but not limited to construction of primary schools, community centres, Government aided residential houses, local roads, water harvesting structures, dispensaries, etc. The projects usually have smaller budgets and construed by use of local labour forces and materials. However, it has been observed that adequate health and safety interventions to protect the workers are not being taken in construction. Consequently, construction workers are exposed to perils of accidents, poor health and threat to life. This scenario demands appropriate health and safety policy measures and practical interventions to
alleviate the challenge, which warrants an investigation. This study therefore examines the factors that bring health and safety perils to the construction workers and explores possible measures that can act as antidotes to improve the situation in community development projects in India. The investigation was conducted by using the case study of three Community Development Blocks in Odisha State of India. Both qualitative and quantitative explorative approaches were followed. A survey research method was used to collect both qualitative and quantitative data from various stakeholders such as community development project executives, contractors, engineers, project administrators, and supervisors, local leaders at the Community Development Block and district level, policy makers at the State level and construction workers at the project level. Findings suggest that there are no structured and appropriate health and safety measures available to protect the construction workers. Lack of compulsory health and safety provision, lack of awareness regarding health and safety, lack of budget for funding safety measures, lack of safety checks and audits, lack of protective gears and equipment, lack of safety related skills and training, provision for emergency treatment facilities close to project locations, and callousness of project administration and execution authorities are the major reasons that bring safety challenges in projects. However, according to stakeholders, policy measures to enforce compulsory safety measures, incorporation of safety related expenses as a part of the estimated cost of projects, creation of safety awareness, provision of safety training and availability of protective gears and equipment can act as antidotes for improved health and safety of construction workers.

HEALTH AND SAFETY CHALLENGES: A DISCOURSE WITH SPECIFIC EMPHASIS IN INDIA

Both literature and opinions from industry agree that construction industry plays an important role in global economy (Li, Poon, 2013). The construction industry is being widely recognized as both economically and socially important (Ofori 2011). Particularly in developing countries, such as India, it contributes significantly to the employment generation. For example, it the second largest employer in India only next to Agriculture (Meena, Nemade, Pawar, and Baghele, 2013). However, across the globe, it is also considered as the most hazardous industry (Alkilani, Julie, Sawhney Anil, 2013; Awwad, Souki, Jabbour, 2016; Charles, 2007; Farooqui et al., 2008; Jannadi and Bu-Khamsin, 2002; Konkolewsky 2004; Larcher and Sohail 1999, Hamalainen et al., 2007). The accident rates, remain very high and problematic in many countries (Li, Poon, 2013). The number of fatal accidents that are found to be taking place at the construction sites is quite alarming (Shirur and Torgal 2014). The poor health and safety scenario and consequent accidents cause loss in precious human resource that lead to poor performance and poor efficiency, loss of money and also create reputation and image challenges (Charles Pillay and Ryan, 2007; Kumar and Bansal, 2013; Shamsuddin, Ani, Ismail, and Ibrahim, 2015).

According to scholars, the various factors that cause health and safety challenges in construction projects can be categorised into 7 indirect factors, such as human, economics, hectic schedule, legislation and enforcement, insufficient data and organizational factors; and 2 direct factors, such as site conditions and weather (Li, Poon, 2013). However, studies across the globe has revealed that specifically
unsafe site conditions, continuously changing worksites, multiple operations and crews working in close proximity are recognised as other common causes of construction-related accidents (Charles, Pillay, Ryan, 2007). Further, it is also argued that poor health and safety and accidents are associated with management system pressures that includes financial restrictions, lack of commitment to safety, policy, standards, knowledge and information, restricted training and task selection, and poor quality-control systems (Abdelhamid, and Everett. 2000; Awwad, Souki, Jabbour, 2016; Charles, Pillay, Ryan, 2007). Moreover, accidents in construction projects are also linked indirectly to social pressures, such as group attitudes, trade customs, industry traditions, attitudes to risk-taking, workplace behaviour norms and commercial or financial pressures experienced by contractors and highly fragmented nature of operations, and time and budgetary pressures (Awwad, Souki, Jabbour, 2016; Charles, Pillay, Ryan, 2007; Abdelhamid, and Everett. 2000). As well, according to Jasani, Joshi, Kartha, Mehta Shah, (2016), lack of awareness and proper knowledge regarding work related hazards and its prevention increased the chances of accidents and workers who do not use personal protective equipment (PPE) have more chances of injuries. However, scholars also argue that the causes of accidents and poor health and safety scenario vary based on context and conditions, for example while the state of health and safety have been seriously taken up in developed world, it has been undermined in developing countries (Charles, Pillay, Ryan, 2007; Meena, Nemade, Pawar, and Baghele, 2013; Wilson Jr. and Koehn, 2000).

Particularly in the case of India, construction industry is the second largest employer. It contributes about 7.5% of the total world labour force. Concurrently, it is considered as the most hazardous industry and the safety issues have been undermined. It contributes about to 16.4% of fatal global occupational accidents (Kulkarni, 2007; Meena, Nemade, Pawar, and Baghele, 2013). According to a study by International Labour Organization (ILO), India has the world’s highest accident rates among construction workers. It is evidenced that 165 out of every 1,000 workers are injured on the job (Praveen Kumar and Vishnuvarthan, 2014). However, it is not only the construction workers who suffer accidents but also the public including children get affected from the accidents that occur in construction sites (Meena, Nemade, Pawar, and Baghele, 2013).

However, in the past few decades, there is stress on safety awareness among construction industries (Wilson Jr. and Koehn, 2000), as it is being realised that the cost of such poor health and safety and accidents in construction projects have huge socio-economic and performance implications such as workers’ compensation, insurance premium, indirect costs of injuries, and litigation and loss of time (Shamsuddin, Ani, Ismail, and Ibrahim, 2015).

Furthermore, like many developed countries, in India certain steps have been taken to improve health and safety and reduce accidents in construction projects. For example, the departments under the Ministry of Labour and Employment are responsible for health and safety issues in construction sector under the head of Chief Labour Commissioner. Moreover, the Directorate General Factory Advise Service Labour Institute (DGFIASLI) provides technical support in drafting model rules, carrying out surveys, and conducting training programmes in construction sector (Meena, Nemade, Pawar, and Baghele, 2013). Besides, a number of Labour Laws such as Contract Labour (Regulation & Operative) Act, 1970, Minimum Wages Act, 1948, Payment of
Wages Act, 1936, Equal Remuneration Act, 1976, Inter-State Migrant Workmen (Regulation of Employment and Condition of Services) Act, 1979, and The Building and Other Construction Workers Act, 1996 have been in place to protect the workers engaged at construction sites. Furthermore, the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996, was enacted to protect construction workers. This act is applicable to all construction projects/establishments employing 10 or more workers in any building and other construction works (Meena, Nemade, Pawar, and Baghele, 2013; MLE, 2011).

Nonetheless, it is found that there is no specific act that is addressing health and safety in construction projects. Moreover, larger construction projects are observed to be better organized than small to medium firms from the point of view of adequate safety program and community development projects are mostly remained out of purview of such programmes (Meena, Nemade, Pawar, and Baghele, 2013; Wilson Jr. and Koehn, 2000).

It is also argued that safety issues should be taken up and from the inception of project, through design stage till the completion and handing over of the project irrespective of the type and size of projects. A proper coordination among all the stakeholders such as administrators, engineers, contractors, clients, and workforce is essential to create better health and safety conditions in construction projects, which is lacking in Indian construction projects (Abudayyeh, Fredericks, Butt and Shaar. 2006; Charles, Pillay, Ryan, 2007; Kanchana Sivaprakash and Joseph, 2015; Meena, Nemade, Pawar, and Baghele, 2013). It is also observed that not much studies on health and safety have been conducted on the community development construction projects. Therefore, this study is aimed at to explore to bridge the knowledge gap that is existing with regards to scenario of health and safety challenges in relatively smaller community development construction projects in India.

**METHODOLOGY: CASE STUDY AREA AND DATA COLLECTION AND ANALYSIS**

An inductive and exploratory survey research method was used to conduct this study. Both qualitative and quantitative data from various stakeholders engaged in community development construction projects such as engineers, contractors, project administrators, supervisors, local leaders at the Community Development Block and district level, policy makers at the State level and construction workers at the project level were collected. For this purpose, from three community development blocks in Odisha state of India were selected as the case study area.

The blocks selected were Balipatna (Block 1) and Balianta (Block 2) of Khurda district and Odapada block (Block 3) of Dhenkanal district of Odisha state. The blocks were chosen because they were highly populated and are engaged in a number of community development projects. The various projects that were investigated include primary schools, community centres, government aided residential houses and road works. Table 1 presents the profile of the respondents in the study areas. A sample size of totalling to 96 (35 from Block 1, 30 from Block 2 and 31 from Block 3) was used. The respondents include 8.33% engineers, 6.25% administrators, 10.42% local leaders, 7.29% supervisors, 19.79% contractors and 47.92% construction workers.
Additionally, 5 persons (3 at district level and 2 at State level) engaged in decision and policy making were also discussed with. These stakeholders were selected because of their direct and indirect association with project execution and health safety in projects. The respondents such as administrators (Government officers engaged at block and district level to manage and administer different projects), engineers and supervisors were directly selected from the incumbent personnel at the community development blocks and districts. However, the local leaders (leaders belonging to different political parties and communities), contractors (individuals or organisations engaged in construction work on contract basis) and construction workers were selected by using random sampling method from different projects. The quantitative data were collected by conducting a survey among the stakeholders using a pretested questionnaire through semi-structured interviews. For quantitative data respondents were asked to provide their responses regarding availability of health and safety measures and occurrence of accidents in affirmative, negative, to certain extent indicators. A Likert scale ranging from 1 to 5 (where 1 - strongly disagree, 2-disagree, 3-neutral, 4-agree and 5- strongly agree) were used to acquire the responses and also to evaluate the importance of the parameters relating to challenges of health and safety in projects and various plausible measures that are needed to improve the situation. On the other hand, qualitative discussions with decision makers and policy makers were conducted through semiformal personal and telephonic discussions to obtain their viewpoint and opinions.

Table 1: Profile of respondents

<table>
<thead>
<tr>
<th>Stakeholder respondents</th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Total</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>8.33</td>
</tr>
<tr>
<td>Administrators</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>6.25</td>
</tr>
<tr>
<td>Local leaders supervisors</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>10.42</td>
</tr>
<tr>
<td>Contractors</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>19</td>
<td>19.79</td>
</tr>
<tr>
<td>Construction workers</td>
<td>18</td>
<td>13</td>
<td>15</td>
<td>46</td>
<td>47.92</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>30</td>
<td>31</td>
<td>96</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Quantitative descriptive statistics analysis and Cronbach’s alpha test of the data collected were conducted to observe the reliability of the data. Percentage analysis and Perception index (PI) based on average index method were used to evaluate the significance of the various variable relating to health and safety in the projects in the study area. Perception index was calculated by obtaining the mean value of Likert scale values assigned by the respondents and the consistency was checked by use of Standard Deviation (SD).

Besides, qualitative analysis of the information gathered from the semi structured interviews and telephonic discussions was done to extract the excerpt of policy and decision makers’ opinions. The qualitative analysis was conducted manually by using narrative analysis.
RESULTS AND DISCUSSIONS

Tables 2(a) and 2(b) present the health and safety scenario and measures available to meet the health and safety challenges in the study area. As seen from Table 2(a), according to the perception of majority of the respondent’s (68.8%), accidents occur regularly, and 17.4% say that accidents occur occasionally during construction in the projects. However, according a minority of respondents (12.5%) accidents do not occur. Although, majority of accidents seem to be of minor in nature (47.9%), according to a significant portion of respondents (39.6%) major accidents do occur in the construction of projects in the study area. Thus it is found that both major and minor accidents are regular phenomena in construction projects in the study area and non-occurrence of accidents is significantly low.

Table 2: Occurrence of accidents

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence any of accidents (regularly)</td>
<td>68.8</td>
</tr>
<tr>
<td>Occurrence of accidents to (occasionally)</td>
<td>17.4</td>
</tr>
<tr>
<td>Nonoccurrence of accidents</td>
<td>12.5</td>
</tr>
<tr>
<td>Major accidents</td>
<td>39.6</td>
</tr>
<tr>
<td>Minor accidents</td>
<td>47.9</td>
</tr>
</tbody>
</table>

Table 2(b) presents the evaluation of availability of health and safety measures. The evaluation revealed that no significant measures are available (according to 66.7% respondents) in the construction projects. Some of the respondents (21.7%) said that whatever facilities available are limited to first-aids only. Thus, there exist a significant challenge of health and safety such as regular occurrence of accidents in construction projects and the meagre availability of any health and safety measures to meet the challenges.

Table 2 (b): Availability health and safety measures

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate Availability of health and safety measures</td>
<td>11.5</td>
</tr>
<tr>
<td>Only first aid is available</td>
<td>21.9</td>
</tr>
<tr>
<td>No health and safety measures available</td>
<td>66.7</td>
</tr>
</tbody>
</table>

It is also necessary to know the various health and safety challenges that persists in the study area. Thus an evaluation was made based on the perception of respondents to understand the major challenges in construction projects in the community development blocks in the study area. The various health and safety challenges that persist in construction projects are given in Table 3. The PI values show the significance of the challenges. However, SD values for each parameter were checked to ascertain the consistency of the perception index values provided by the respondents. The lower SD values (0.48 to 0.68) indicate constancy and relatively high Cronbach α values ranging between 0.77 to 0.86 indicate reliability of the responses. According to the perceptions of the respondents lack of compulsory health and safety provision (PI=4.64), lack of awareness regarding health and safety (PI=4.42), lack of protective gears and equipment (PI=4.36), lack of safety related
skills and training (PI=4.12), and lack of budget for funding safety measures (PI=4.06) are the most significant health and safety challenges in the study area. Followed by lack of safety checks and audits (PI=3.86), provision for emergency treatment facilities close to project locations (PI=3.62), and callousness of project administration and execution authorities (PI=3.52) are the other major challenges. However, complexity and difficulty of activities, careless among workers and environmental condition at work sites are lesser challenges.

Table 3: Challenges of health and safety measures in projects

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Perception index (PI)</th>
<th>Standard deviation (SD)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of compulsory health and safety provision</td>
<td>4.64</td>
<td>0.68</td>
<td>1</td>
</tr>
<tr>
<td>Lack of awareness regarding health and safety</td>
<td>4.42</td>
<td>0.64</td>
<td>2</td>
</tr>
<tr>
<td>Lack of protective gears and equipment</td>
<td>4.36</td>
<td>0.67</td>
<td>3</td>
</tr>
<tr>
<td>Lack of safety related skills and training</td>
<td>4.12</td>
<td>0.52</td>
<td>4</td>
</tr>
<tr>
<td>Lack of budget for funding safety measures</td>
<td>4.06</td>
<td>0.55</td>
<td>5</td>
</tr>
<tr>
<td>Lack of safety checks and audits</td>
<td>3.86</td>
<td>0.61</td>
<td>6</td>
</tr>
<tr>
<td>Provision for emergency treatment facilities close to</td>
<td>3.62</td>
<td>0.52</td>
<td>7</td>
</tr>
<tr>
<td>project locations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Callousness of project administration and execution</td>
<td>3.52</td>
<td>0.48</td>
<td>8</td>
</tr>
<tr>
<td>authorities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity and difficulty of activities</td>
<td>2.82</td>
<td>0.49</td>
<td>9</td>
</tr>
<tr>
<td>Carelessness among the workers</td>
<td>2.47</td>
<td>0.53</td>
<td>10</td>
</tr>
<tr>
<td>Environmental conditions at the work site</td>
<td>2.23</td>
<td>0.48</td>
<td>11</td>
</tr>
</tbody>
</table>

(Note: Cronbach α = 0.77-0.86)

Based on the challenges, an examination was made based on the perceptions of the stakeholders to explore the various plausible health and safety measures that are essential to improve the situation. The lower SD values of the responses (ranging between 0.37 and 0.61) for each parameter and significant Cronbach α values (ranging between 0.79 and 0.84) indicated the consistency and reliability of the responses respectively. The PI values of the responses about the various measures to improve health and safety situation in the study area are presented in Table 4. It is found that policy measures to enforce compulsory safety measures (PI=4.24) and incorporation of safety related expenses as a part of the estimated cost of projects (PI=4.01) are the two most important measures that could enhance health and safety measures in the construction projects in the study area. Furthermore, the other significant measures should include creation of safety awareness (PI=3.83), provision of safety training (PI=3.52), and availability of protective gears and equipment (PI=3.47), which would assist in improving the health and safety in community development projects in the
study area. However, improvement of site conditions and availability of emergency facilities may not improve the scenario significantly.

Table 4: Measures to improve health and safety measures in projects

<table>
<thead>
<tr>
<th>Plausible health and safety measures required</th>
<th>Perception index (PI)</th>
<th>Standard deviation (SD)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy measures to enforce compulsory safety measure</td>
<td>4.24</td>
<td>0.61</td>
<td>1</td>
</tr>
<tr>
<td>Incorporation of safety related expenses as a part of the estimated cost of projects</td>
<td>4.01</td>
<td>0.54</td>
<td>2</td>
</tr>
<tr>
<td>Creation of safety awareness, provision of safety training</td>
<td>3.83</td>
<td>0.52</td>
<td>3</td>
</tr>
<tr>
<td>Provision of safety training</td>
<td>3.52</td>
<td>0.47</td>
<td>4</td>
</tr>
<tr>
<td>Availability of protective gears and equipment</td>
<td>3.47</td>
<td>0.43</td>
<td>5</td>
</tr>
<tr>
<td>Improving site conditions</td>
<td>2.62</td>
<td>0.37</td>
<td>6</td>
</tr>
<tr>
<td>Availability of emergency facilities</td>
<td>2.56</td>
<td>0.39</td>
<td>7</td>
</tr>
</tbody>
</table>

(Note: Cronbach α = 0.79 - 0.84)

Thus, it is revealed that occurrence of accidents is a regular phenomenon in community development construction projects and significant health and safety challenges persist, which need significant redressal. According to policy makers and decision makers, the Government has instructed the implementing and executive agencies to take adequate health and safety measures. However, the challenge remains with implementation of various measures and cost of making the measures available. The absence of appropriate and clear health and safety regulations to administer health and safety measures makes it difficult to enforce health and safety measures in projects and thus remain a challenge. For that purpose, two important suggestions were made, that are: (1) to develop appropriate policies specific to health and safety in construction and may be creation of an act through legislative process and (2) to make health and safety measures as an integral part of projects and accordingly provisions may be made in the budget and projects estimates.

CONCLUSION

Health and safety aspect in construction projects in India particularly in community development projects has been observed to be a challenge. It has been undermined and never been considered as an integral part of construction projects. Apparently, it is alleged that no appropriate health and safety measures are available to deal with the challenges. Therefore, this study explored that various challenges and factors that bring perils to construction workers and how the health and safety in construction projects can be improved in the study area. To realise the aim of the study, a survey research method was used to obtain the perceptions of the stakeholders who are engaged directly and indirectly in construction projects and in some way responsible

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1 Policy makers’ opinions
2 Administrative officers and
3 Policy makers’ opinion
4 Policy and decision makers’ opinions
for health and safety measures in the projects. For this purpose, a case study was performed by using three community development blocks in India.

The study revealed that occurrence of both major and minor accidents in construction projects in the study area is a regular phenomenon bringing perils to the people engaged in construction. Also, it is found that no structured and appropriate health and safety measures are available as well as no appropriate policies are available to enforce such measures. Findings also suggest that lack of compulsory health and safety provision, lack of awareness regarding health and safety, lack of budget for funding safety measures, lack of safety checks and audits, lack of protective gears and equipment, lack of safety related skills and training, provision for emergency treatment facilities close to project locations, and callousness of project administration and execution authorities are the major reasons that bring safety challenges in projects, which need redressal. However, stakeholders, policy makers and decision makers perceive that policy measures to enforce compulsory safety measures, incorporation of safety related expenses as a part of the estimated cost of projects, creation of safety awareness, provision of safety training and availability of protective gears and equipment can able to improve the health and safety situation construction projects. The study has certain limitations such as it is purely based on perceptions of stakeholders and the study was conducted in a limited study area and therefore generalisation of the findings may not be prudent; thus needs further detailed investigation. Moreover, as community development projects are different from large commercial construction projects and the construction workers have a different level of skill and awareness, the requirements of health and safety are likely to different. Therefore, there is a need to explore what kind of health and safety measures are precisely essential and how they can be achieved in such projects, which is the the further scope of the research. However, despite the limitations as suggested by stakeholders, development of appropriate policies, creation of an act through legislative process, making health and safety measures as an integral part of the project and making compulsory provisions in the budget and projects estimates may act as antidotes for improved health and safety of construction workers in the study area.

REFERENCES


FEUDALISTIC ATTITUDE: A BARRIER AGAINST RESPECT FOR PERSONNEL ENGAGED IN CONSTRUCTION IN INDIA

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People in construction, particularly the work force at the middle and lower echelons are being undermined in India. A hypothesis has emerged that people having the attitude and behaviour of historically oriented feudalistic class system based on social and economic status is a barrier against respect for such personnel. Therefore, this study examines the attitude and behaviour of various stakeholders including administrators, political leaders, clients, contractors, financers, and professionals involved in the construction industry; and how it engenders lack of respect towards the construction workforce. The study was conducted by using an explorative qualitative survey research method, and analyses of perceptions of the stakeholders considering Odisha State in India as a case study. Findings suggest that the historical feudalistic social system that has developed a relationship of master and subjects still persists in the current society- and it has penetrated to the construction industry. It dictates the status and respect of the personnel engaged in it. The attitude and behaviour of people based on this system-dominance and superiority complex of socially and economically well off people; hegemony, and omnipotence of politically powerful people; and control, imperviousness and apathy of project executives and administrators act as barriers against respect for personnel engaged in construction.

Keywords: attitude, behaviour, class system; construction, feudalistic, respect; stakeholders.

INTRODUCTION

Respect for people- individually and in groups although remained a critical factor in every society, it has been found to be undermined and understated in India. Apparently, it is being taken as an obvious that respect should emanate from our cultures and attitudes naturally. However, since long in every society paradox prevails. Every single individual expects respect from the others but forgets to respect the counterparts. As evident, respect has become a commodity that is available based on different societal attributes such as class, race, wealth, colour, gender power, position, tradition, and so on (Goel, 2013; Mehta, 2013). This scenario is also prevalent in construction industry in India. People in construction, particularly the workforce at the middle and lower echelons that includes professionals, supervising staff, skilled and unskilled labourers are observed to be undermined both personally and professionally². It is alleged that many of the working class people are being

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² According to majority of work force that includes Professionals, engineers, support staff and construction workers
looked down upon and professionally and personally belittled by the people in the authority in charge of projects. Although, this could be attributed to individual behaviours of certain people with power, position, wealth, and so on and may not necessarily be generalised, it demands an exploration as to why such situations occur in a democratic society, where every individual is equal irrespective of race, class, gender, education, wealth, profession, etc. In this regard, one of the major hypotheses, which has emerged is that people having the attitude and behaviour of historically oriented feudalistic class system based on social and economic status is a barrier against respect for such personnel. Therefore, this study examines the attitude and behaviour of various stakeholders including decision markers, political leaders, clients, contractors, financiers, administrators and professionals involved in the construction industry; and how it engenders impertinence towards the construction workforce. The study was conducted by using an explorative qualitative survey research method, and analyses of historical social systems and their relationship with the working class by considering Odisha State in India as a case study. Findings suggest that the historical feudalistic social system that has developed a relationship of master and subjects still persists in the current society—particularly among people belonging to socially and economically higher strata of the society in India. Such a system is observed to have percolated to the construction industry, which dictates the status and respect of the personnel engaged in it. The attitude and behaviour of people in a hierarchical social system that includes dominance, superiority complex and imperiousness of socially and economically well-off people, hegemony, and omnipotence of politically powerful people; and control, imperviousness and apathy of project executives and administrators act as barriers against respect for people engaged in construction.

**FEUDALISTIC SOCIETY IN INDIA AND ITS IMPLICATION ON THE SOCIAL BEHAVIOUR**

Lack of respect for individuals is invasive in a democratic society, where every individual has equal rights as of fellow citizens in country and fellow members of a society. However, it is alleged that attitude and behaviour of certain sections of the society has been the barrier against the respect. Arguments have emerged that this attitude and behaviour has been emanated from the historical class system developed based on feudalistic society of medieval period. So, while examining how the social behaviour and attitude based on feudalistic social system influence respect for people in construction industry, it is essential to unlock what is feudalism and its characteristics and implications on the social behaviour.

There are no unequivocal and universal definitions of feudalism. It usually refers to the type of society that existed in Europe during 5th to 15th century A.D. It was characterised by a self-sufficient economy, a dominant class of landlords, who had extracted surplus, products and labour services from the peasants during that period. It is being argued although without unanimity that it has emerged because of decline of trade and commerce, decline of urban centres and decline of circulation of coins and money. The landlords had the hegemony instead of the kings as the central power and development of regional tendencies (http://www.preservearticles.com). In India, it rose into prominence during the early medieval period which was seen as a ‘Dark
Age’, that was characterised by stagnation, decay and un-stratified, communally land owning village societies. Several causes could be attributed to the rise of feudalism that include the practice of land-grant in the Gupta and post-Gupta period, and development of many administrative and economic units outside the control of the king. The various features of feudalism during that period as outlined by Historian Sharma (1985, 2001) are the practice of making land grants that granted the beneficiaries judicial and fiscal rights. Additionally, it also granted the rights over the people of donated village as well as the increasing incidence of forced labour, decline in trade and coinage and payment of officials through land revenue (Mehta, 2013; Sharma, 1985, 2001). In India, this new class was named differently such as zamindars, jagirdar, sardar, mankari, deshmukh, chaudhary and samanta in different regions (Habib, 2007; Mehta, 2013). Consequently, the newly crowned nobles called landed nobility held lands from the Kings in exchange for providing military service, and the peasants were obliged to live on the landlord's land and give them homage, labour, and a share of the produce, notionally in exchange for military protection. The peasants or the common people are often subjected to oppression and exploitation (Goel, 2013; Mehta, 2013; http://www.importantindia.com). Further on, these feudatories build their own sub-feudatories and categories of officials on hierarchical manner (Mehta, 2013; http://www.historytuition.com) to collect the produces, revenues and fees and fines based on their authority as landlords. In the process the densely populated villages and the land tenant cultivators, peasants and agricultural labourers were exploited and treated as subservient to the feudal lords and officials. Thus, the society was divided into that of masters and class of subjects, where the feudal lords and their officials becomes nobles, has the fiscal and judicial authority and masters of the land.

Feudalism also became an important feature of the political system. A hierarchical system with ministers under the kings were appointed on the hereditary basis, Numerous feudal chiefs who had ties with ruling class have emerged. With the limited power with the kings, the ministers and the feudal chiefs became all powerful. The enjoyed special privileges and powers which no ruler could ignore (http://www.historytuition.com).

Furthermore, a caste system was formed the basis of the society as in earlier periods. Two powerful castes- the kshatriyas (warriors) and the Brahmmins (priestly class) were given more privileges and the other castes (Vaishya (traders) and Sudras (serving class), were degraded and were treated as lower class. A number of sub castes that include the working class skilled people such as potters, weavers, goldsmiths, musicians etc., proliferated. Alongside this system, the rights of the lower castes were lessened and some of the castes were even treated as untouchables. Moreover, the aristocratic and higher class became more powerful and their attitude became more rigid and they have got a more superiority feeling. So, in a nutshell they became all powerful and nobles, and the common people became their subjects without rights and respect (http://www.historytuition.com).

However, most of these systems were abolished after the independence of India in 1947. There were negotiations for a social contract when it gave up its feudal structure soon after independence, however unfortunately the feudal mind set has not yet disappeared (Waslekar, 2004). The intermediary class that developed later on after
independence that include people belonging to higher civil service, other Government services, political leaders, business and so on have adopted the feudal mental framework. They flourished in a system where trading and control have primacy over creation. As a result, the same attitude of belonging to the class nobility, aristocracy and superiority based on the authority vested to them to render service, the power they exercise, the wealth they possess prevail, which hamper the development of an equitable society with respect for one another. This attitude is seen to be prevalent in construction industry and also hampering its development to certain extent.

**METHODS**

The study followed an explorative qualitative survey research method. The qualitative study included analyses of historical social systems and their relationship with the working class, analytical induction and narrative analysis of the perceptions and opinions of the respondents. For this purpose, a stakeholders’ perception and opinion analysis was conducted by considering construction activities by Government agencies in Odisha State in India as a case study. The qualitative survey was conducted among the stakeholders engaged in the construction industry, such as professionals and engineers (21.4%), administrative officials (12.6%), support staff (5.8%), construction workers (32.0%), socio-political experts and commentators (10.7%), philanthropic social and community organisations (2.9%), and common people (11.7%) by using non-structured discussions and interview process. Besides, an analysis of the various events such as meetings and project inspections were also conducted. The responses were collected from 103 stakeholders (Table 1) and compiled through a snowballing approach over a period of 5 years from 2009 to 2014. The information was collected by the researcher with the assistance of some assistants engaged from time to time.

*Table 1: Profile of respondents*

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Numbers</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professionals and engineers</td>
<td>23</td>
<td>22.3</td>
</tr>
<tr>
<td>Administrative officers (local level)</td>
<td>7</td>
<td>6.8</td>
</tr>
<tr>
<td>Administrative officers (District level)</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>Administrative officers (State level)</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Support staff</td>
<td>6</td>
<td>5.8</td>
</tr>
<tr>
<td>Construction workers</td>
<td>32</td>
<td>31.1</td>
</tr>
<tr>
<td>Political leaders and councillors</td>
<td>11</td>
<td>10.7</td>
</tr>
<tr>
<td>Personnel engaged in social and philanthropic organisations NGOs</td>
<td>3</td>
<td>2.9</td>
</tr>
<tr>
<td>Socio-political experts and commentators</td>
<td>3</td>
<td>2.9</td>
</tr>
<tr>
<td>Common people associated with construction projects</td>
<td>12</td>
<td>11.7</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>100.0</td>
</tr>
</tbody>
</table>

1 Opinion of stakeholders such as professional engaged in construction industry
The analysis of the responses was done manually through narrative analysis from the storylines of the individuals and group of stakeholders and analytical induction of different events such as analysis of stakeholders’ meetings, review meetings and project inspections. However, a total anonymity was kept in the analysis at the behest of the projects and individual respondents.

RESULTS AND DISCUSSION

The findings of the study were categorised into perceptions of (1) stakeholders in terms of professionals and construction workers engaged in construction, (2) opinions of administrative officers and authority of the projects, (3) perceptions of common people and people engaged in philanthropic and community organisations (4) social and political experts and commentators. Besides, a discussion on the various events that occur with regards to the conduction projects were made.

Stakeholders in terms of professionals and construction workers’ perception

According to majority of stakeholders particularly the professionals such as engineers and construction workers together, the historical feudalistic social system— a kind of relationship of master and subjects still persists in the current society— particularly among people belonging to socially and economically higher strata of the society in India¹. For example, it is alleged that higher administrative level officials and elected political leaders particularly those have some kind of authority behave like the owners of the projects and try to dictate the execution of projects². They rarely consult with the people directly engaged in the in construction process. Moreover, there is a sense of scepticism and lack of respect towards them³. As some of the engineers have observed:

“...the authorities and leaders don’t care about the personnel engaged rather they want their wishes to be fulfilled and orders to be followed although how irrational those may be... “.

Another set of engineers quipped “… the executive authorities want final outputs and political leaders want their promises to be kept…they least care about who are the people engaged in and how are the things to be done”.

In no case, the authorities care about the technical and professional management acts of the projects. According to some professional staff members:

“…sometimes they ask to do unethical activities and if we do not comply then we have to face the consequences that may range from public humiliation, suspension, loss of salary, transfer to loss of job....”

Moreover, they lack professional respect towards the people engaged in construction. They also want control and red tape and do not like others to look beyond their orders

¹ Social and political experts, people engaged in philanthropic and community organisations, common people and professionals
² Professionals and support staff
³ Professionals, engineers and support staff
and decisions. There is no respect and sympathy for personal life, family, financial and health challenges\(^1\). According to construction workers, nobody including the professionals, engineering staff and supervisors even look after the safety, security and work conditions of the construction workers. There is always an apathy towards them\(^2\). As some labourers said:

“…. We are being considered as labour class and we have no rights until we remonstrate. People sometimes even do not talk to us with minimum degree of respect….”

There seems a class difference between ‘political leaders and higher level administrative officers’ and ‘professionals and support staff’. The higher authorities lack respect and behave apathetically towards the professionals and support staff, whereas, professionals and support staff have a sense of fear, lack of trust and insecurity towards the authorities. Moreover, contractors and investors have an attitude of superiority and because of their financial supremacy they look down others\(^3\). Similarly, the construction workers are not at all respected by the authorities, contractors and professional and support staff. The minimum requirements such as health and safety, security, personal life, and work conditions are undermined\(^4\).

**Perception of administrative officers and political leaders**

On the other hand, the administrative officers at the higher level perceive that the Government priorities and common benefits are most important. They have to implement the construction projects for the common good of the majority of the people\(^5\). The project execution has to be carried out according to the policies, rules and regulations\(^6\). There is no place for individuals and personal benefits\(^7\). While refuting that there exists lack of respect towards personnel engaged in construction projects, they say that, they have to conduct their jobs according the professional ethics and government guidelines and regulations\(^8\). Moreover, local level administrative officers say that they have to work according to the advices of the senior administrative officers and political leaders, otherwise they may face unwarranted consequences\(^9\). Similarly, according to political leaders, some administrative officials, professionals and support staff look for individual gains from the projects instead of common benefits. They have to look for common benefits. Every individual needs to be respected but the prime concern is common benefit and keeping of the promises made to the people. As the protector of the projects they have to be concerned with projects than any individuals\(^10\).

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\(^1\) Professionals, engineers and support staff  
\(^2\) Construction workers  
\(^3\) Professionals, engineers and support staff and construction workers  
\(^4\) Construction workers  
\(^5\) Administrative officers at higher level  
\(^6\) Administrative officers at local level  
\(^7\) Administrative officers both at higher and local level  
\(^8\) Administrative officers both at higher and local level  
\(^9\) Administrative officers at local level  
\(^10\) Political leaders and administrative officials
Perception of philanthropic, social, and community organisations and common people

The storyline extracted from the people engaged in philanthropic and social, and community organisations and common people revealed that project authorities, professionals and support staff— all are apathetic to the common people and construction workers. According to them they least care about the human aspects and workplace conditions of the projects. Moreover, some people alleged that:

“… The authorities and professionals and support staff engaged in construction talk about common benefits, but in reality they look to either appease their superiors or gain personally. They show a sense of apathy, disrespect and scepticism towards construction workers and other stakeholders”.

According to common people, nobody respects the other and only looks for their own interest. The people engaged in philanthropic and community organisations echoes the same sentiment of the common people. Their opinion is that people seems to demand respect according to their positions and status. For example, it is very difficult to meet a high level official or civil servant and most times they are inaccessible. They don’t value others time and trouble. Engineers and middle level administrative officers want to be treated differently than other personnel engaged in construction. A hierarchical class system based on position and status is always observed. Furthermore, everybody is concerned about the project but not about the plight of the people working in the projects. They corroborated the fact that higher officials and incumbent political leaders are apathetic towards the personal life such as health and safety, financial, family and personal challenges, etc., of the people engaged in construction industry.

Opinion of politician and social experts and commentators

According to the political and social experts and commenters, the society has not changed much despite the fact that India has become a democratic society. The challenge remained with the long tradition of governance system—first monarchy followed by feudal political system and colonial rules. Beyond that the long years of class system, segregation based on wealth, power and status have overwhelmed the individuals and the society. The people belonging to the elite class based on family status, wealth and traditions are placed at higher levels of the society. The wealthy and powerful people have the major say in everything of the society and others follow them. The system has been interwoven into the fabric of the society and found to be pervasive in the current society. The same culture has transcended to the construction industry. For example, the promoters, clients, investors and contractors who have money, power and clout think they are superior to others and have an attitude of highhandedness and supremacy. The political leaders have strong hegemony over the

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1 Opinions of common people
2 Opinions of philanthropic and social and community organisations
3 Opinions of philanthropic and social and community organisations
4 Social and political exerts
5 Social and political exerts
community and since they are accessible to decision making, and everybody including stakeholders in the construction industry wants to appease them. Therefore, lack of respect in the construction industry is an outcome of social, administrative and political systems that influence individuals and communities alike.

**Review of stakeholder’s meetings and project inspections**

The analysis of stakeholders’ meetings and project inspections was conducted to understand the project management environment. It was conducted based on the perceptions of the stakeholders. It is ascertained that most of the meetings were top down and the emphasis is on achievement of targets. The authorities mostly demand explanations if the target is not achieved. The meetings rarely focus on work environment, labour aspects, respect, health and safety, etc. According to some of the professionals and local administrative support staff, they scare to go to such meetings. The meetings hardly achieve anything tangible other than seeking explanations and informing about targets. Besides, the ‘time’ and ‘troubles’ of the people are not respected. The meetings are conducted on the whims and fancies of the authorities. Similarly, a few professionals while keeping their anonymity alleged that more often they are disrespected and humiliated in the meetings as a whole and also individually. To support the view, they said one senior administrative officer once quipped in a meeting that:

“… I don’t want to add another crook to a bunch of thieves…”.

This was targeted towards a group of engineers in a project review meeting. The scenario of project inspections follows the similar trend. The engineers, contractors, and support staff including construction workers are always on their toes and have to tolerate the whims and imperiousness of the superior authorities and project inspection teams. For example, a group of engineers were made to wait for long without giving any explanation before the inspection. Again a project engineer alleged that a group of engineers including him were chased from their offices to worksites during an inspection by a higher authority, when they were ready for the inspection. Thus it is evident that imperiousness, and lack of respect to subordinate staff and construction workers are prevalent.

**CONCLUSION**

This study was aimed to explore the attitude and behaviour of various stakeholders in the construction industry; and how it engenders impertinence and lack of respect towards the construction workforce. Findings suggest that the historical feudalistic social system that has developed a relationship of master and subjects still persists in

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1 Social and political exerts
2 Administrative officers and engineers
3 Professionals and engineers
4 Professionals and engineers
5 Professionals, engineers and support staff
6 Professionals, engineers and support staff
7 Professionals, engineers and support staff
8 Professionals, engineers and support staff
the current society—particularly among people belonging to socially and economically higher strata of the society in India. Such a system is observed to have percolated to the construction industry, which dictates the status and respect of the personnel engaged in it. The strands of attitude and behaviour of such a system—(1) dominance and superiority complex of socially and economically well off people based on tradition and family status; (2) financial supremacy and imperiousness of financially strong people such as investors, financers and contractors; (3) hegemony, and omnipotence of politically powerful people; and (4) control, imperviousness and apathy of project executives and administrators act as barriers against respect for personnel engaged in construction. Consequently, lack of respect and an attitude looking down on subordinates, support staff and work force by people in superior positions is pervasive. Therefore, it is necessary to create an appropriate work environment and culture to engender respect among the people engaged in the construction industry. Perhaps legislation to curb the lack respect as well as awareness among the stakeholders regarding the respect of individuals engaged in the industry may assist to restrain feudalistic attitude and enhance respect.

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CONTRIBUTION OF STRESS TO CONSTRUCTION SITE ACCIDENTS, DANGEROUS OCCURRENCES AND NEAR MISSES

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One of the noted denouements of stress is the causation of accidents, dangerous occurrences and near misses. In construction, stress has been noted to be on the rise due to several antecedents such as; ambitious deadlines, workload, role conflict, poor communication, and dangerous working environments. This study therefore sought to empirically establish the contribution of organizational stressors, job-related stressors and work environment stressors to the occurrence of construction site accidents, dangerous occurrences and near misses. Data for the study was obtained from a questionnaire survey of 204 construction site workers in Ghana. Structural Equation Modelling was the foremost technique employed in analysing data from the survey. Data on construction related stressors showed ambitious deadlines, low salary and working in dangerous environment to be the stressors causing the most stress on construction workers in Ghana. The overall contribution of stressors to accident occurrence, dangerous occurrences and near misses achieved was 0.968 (96.8%) which denotes a very high contribution. Results from the Structural Equation Model (SEM) also showed workload to be the stressor contributing the most (79%) to accidents, dangerous occurrences and near misses occurring on construction sites. The study provides a powerful insight into the failings of construction site safety measures. It empirically points to the soft side of the problem. Data for the study was collected largely from sites with less labour-intensive work and also highly skewed towards the male gender. This therefore may limit the number and type of stressors identified and used in the study. For better results, construction site health and safety officers will need to collaborate more closely with project managers to ensure stress is better managed on site since these are high contributors to incidents on site that have the potential to cause harm and/or damage.

Keywords: Stress, accidents, near misses, dangerous occurrences, construction site.

INTRODUCTION

Stress, as stated by Fimian et al. (2009), is the second most reported work-related health problem. According to Health and Safety Authority (2011) stress is a negative state which embroils varying degrees of anxiety, fear and agitation. It comes about when a person is asked to perform an activity or task which exceeds his/her ability. Stress at the individual level, as explained by Yao et al. (2015) can be related to several factors; physical, behavioural, psychological and other factors. Studies have revealed that employees that are incessantly subjected to a challenging work environment have a high tendency to experience higher stages of stress (Kokt & Ramarumo, 2015). The construction industry easily fits into this situation. The construction industry has witnessed remarkable transformation across the world over the last decade. Economic advancements, client preferences and technological improvements, improved and modified building procedures, increased pace of delivery and a tremendous upsurge in productivity have accounted for a greater demand for construction products (Ibem et al., 2011). Continuous modification of construction processes, pace and complexity of work and the rise in the request for higher productivity has become a
characteristic of the construction industry (Ibem et al., 2011). This, according to Wahab (2010) has charged the working environment on several construction sites. The tight working schedules and complex nature of construction activities, amongst others has collectively made construction work psychologically and emotionally demanding and extremely stressful.

When it comes to the construction industry, stress and its impact can be considered to be slightly different from that of other industries. This difference can be attributed to the physical environment of the workplace, the construction methods available, nature of the construction work operations, construction materials, heavy equipment and tools used on construction sites, and other physical properties of a construction project. A survey carried out by the Chartered Institute of Builders (CIOB) showed 84 percent of their respondents, who mostly have over six years’ experience in the industry, felt that stress was a factor for poor retention levels in the construction industry (Campbell, 2006). Leung et al. (2011) also noted construction projects to be very intricate, involving different complex steps and techniques at both design and construction stages. In their view, this has accounted for the rampant occurrence of accidents on construction sites. It must be noted however that, the CIOB survey involved mostly construction professional working in developed countries. Just like that CIOB survey, the works of Enshassi et al. (2015); Leung et al. (2011); Campbell 2006; Bowen et al. (2013); Kokt & Ramarumo (2015); and Idris et al. (2010) on stress in the construction industry have tended to focus on the developed world. Most of these studies were done in the USA and Europe where the techniques and methods used in construction are mostly different from what is seen in most developing countries. Kheni et al. (2008) opined that developed countries have shown commitment to dealing with stress and its effects on performance but same cannot be said for developing countries.

In spite of poor recording keeping in the construction industry of developing countries, one is left in no doubt at all of the very high rate of accidents on construction sites. It is for this reason that, more empirical studies into causes of accidents on construction sites in developing countries is required so as to provide the needed direction for policy makers and also inform managerial strategies. What is the contribution of work place stress on the occurrence of accidents, dangerous occurrences and near misses on a typical construction site in a developing country? This study in answering this overarching question will provide relevant insight into the interrelationship between stressors, stresses and safety performance on construction projects in developing countries. From an organizational perspective, the study will highlight on the relevance of understanding the antecedents that form the basis for workplace stress, especially with the diversity that exist within the working population.

Occupational stressors are the several activities related to a person’s work or work environment that cause the body to be stressed (HSE, 2001). These stressors could be related to the management style (organizational stressors), the work packages or activities been carried out (job- related stressors) or the work environment (environment stressors).

CONCEPTUALIZING CONTRIBUTION OF STRESS TO ACCIDENTS

Substantial research has been conducted on conceptualizing stress and stress models. Several researchers from different fields (medicine, clinical psychology, engineering psychology etc.) have delved into modelling stress and its effects on workers. There exist several different models of occupational stress with varying popularity and empirical support. Raven et al. (1998) for example have outlined the key stress models in their study to include: The person-environment fit model; The demand-control-support model and Macro/micro Stress Models. Regardless of the numerous research works on stress, the definition of stress varies slightly in context. In addressing the different context of stress, Health and Safety Executive UK in their report defined stress to be a situation which occurs when an individual is pressured, or
the responsibilities placed on him/her are bigger than he/she can handle. The continual existence of these pressures may cause mental, physical or behaviour problems to the individual (Health & Safety Executive, 2007). Yao et al. (2014) quoted Lazarus’ transactional model of stress and averred that stress did not reside only in the person or the environment, but rather in the interaction between the two entities. Work Related Stress is therefore stress caused by work and thus basically refers to a person’s perception of his work environment in a manner that goes beyond his coping limits.

**Stress in Construction**

According to Fimian et al. (2009) stress is the second most reported occupational health problem and that the magnitude of reports is only likely to increase over the coming years. Construction work is generally noted to be a very stressful profession (Statt, 1994; Ibem et al., 2011). Construction projects are characterized by longer working hours and dynamic activities which has caused an elevation in its stressful nature (Lingard et al., 2010). Ibem et al. (2011) concluded in his research that work stress is considered as a major threat to the growth of the construction industry. Table 1 summaries some of the reasons put forward by various researchers as the cause(s) of stress in the construction industry.

### Table 1: Causes of Construction Work Related Stress from Literature

<table>
<thead>
<tr>
<th>Literature Source</th>
<th>Causes of Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leung et al. (2012)</td>
<td>Construction personnel are most at times expected to consider production ahead of their own personal safety.</td>
</tr>
<tr>
<td>LaDou (2003)</td>
<td>Lack of legal framework in occupational health and safety in developing countries.</td>
</tr>
<tr>
<td>Hughes and Ferret (2007)</td>
<td>Poor communication between management and the workforce in an organization.</td>
</tr>
<tr>
<td>HSE (2001)</td>
<td>Frequent pressures with minimum or no time to recover.</td>
</tr>
<tr>
<td>Poon et al. (2013)</td>
<td>High level of work demand.</td>
</tr>
<tr>
<td>Ibem et al. (2011)</td>
<td>Tight budgets and ambitious deadlines.</td>
</tr>
</tbody>
</table>

As indicated earlier in this paper, occupational stressors could be related to the management style, the work packages or activities been carried out or the work environment. The effect of stress in the construction industry can be seen in the poor safety performance at the workplace (Wahab, 2010; Ibem et al., 2011; Leung et al., 2012). Even though individuals are affected by work stress by way of accidents, job performance is also significantly affected when employees get stressed out and this leads to near misses and dangerous occurrences. According to Poon et al. (2013), protracted aftereffects of job stress might cause job burnout, which could induce accidents on job sites and affect the organization in the form of lost working days and an increment in the total project cost. Job burnout as a result of prolonged stress, will either have a direct effect, no effect at all or an indirect effect through some intermediaries, based on the level of involvement of the worker. Personnel who normally experience job burnout, become susceptible to safety provisions. Job burnout is stated by Nahrgang et al. (2011) to cause lack of focus and concentration endangering employees on job sites.

Ademola (2005) and Melinda et al. (2010) agreed that the aftereffects of stress can be placed under four major categories which are; mental (how the mind operates), physical (how the body works), behavioural (the things we do), cognitive (the way we think and concentrate). Strains that occur to individuals as a result of unbearable stress may exhibit certain symptoms such as; negative emotions, physiological fatigue, insomnia, interpersonal hostility or aggressiveness in communication. In addition, stress also
breeds behavioural responses which includes lateness, absenteeism and keeping to one’s self (Leung et al., 2008). All these have been seen to directly impact on the occurrence of incidents. According to OHSAS 18001 standard, an accident is defined to be a work-related incident that cause the individual to suffer injury, ill health or even death. A near-miss is considered to be an incident where no injury or illness occurs whiles accident relate to the opposite situation of a near-miss. Therefore, an incident can either be an accident or a near-miss or a dangerous occurrence (near-miss with a major would-have-been consequence).

Anne & Ma (2006) stated in their study that accidents occurring on construction sites were mainly instigated by two factors. These include physical (physical and psychological capability) and job factors (supervision, design, tools and equipment etc.). Literature abounds on accident causation models. These models designed to provide hypothetical basis for explaining the core source of accidents that transpire at various work places. They are mostly developed from statistical data (the workplace, occurrence, victims, causes, etc.) collected on accidents that occur on construction sites and usually provide a basis for preventing any of such accidents in the future. One of such models is the Human Error Theory. This approach identifies the individual as the main causative factor of an accident. It studies the predisposition of humans to make error whiles executing their activities under various conditions and states. Even though this theory puts the worker in the centre of the cause of accident and support the hypothesis that stress will contribute to occurrence of accidents, it does not blame the workers as the only problem for accident occurrence, but considers other factors such as design of the work site amongst other things (Abdelhamid and Everett, 2000). In general, the overall objective of human error theory is to construct a better design workplace, tasks, and tools that suit the human limitation.

According to Abdelhamid and Everett (2000) other theories that relate to the human error theory (behaviour model, human factor model and Ferrel theory) have also been appraised by other authors. Reason (2000) noted that the human error factor can be explained in several approaches (person approach and system approach). Most of these theories address the individual as the main problem that instigates an accident such as the permanent characteristic of a human, the combination of extreme environment and overload of human capability and conditions that make humans tend to commit errors (Abdelhamid and Everett, 2000). The human error theory and its related theories therefore support the hypothesis that organizational stressors, job-related stressors and work environment stressors significantly contribute to the occurrence of unplanned incidents on construction sites.

Some studies have shown ample relationship between construction injuries and stress on the workers. According to Sorensen et al. (2014) stress can contribute to accidents by causing construction workers to: sleep badly, drink excessively, feel depressed, feel anxious, feel nervous, feel angry and reckless, become distracted, make errors in judgment, miscarry normal activities that require hand-eye or foot-eye coordination etc. According to Gyekye (2006) workers’ perceptions of high job demands and work pressure tend to be associated with an increased tendency to employ unsafe acts when carrying out construction operations, which in turn will increase accident occurrence (Hoffman and Stetzer, 1996; Gyekye, 2006). A proposition made by Goldenhar et al. (2003) showed the correlation between job stressors and accident occurrence on construction sites. It was concluded in their study that, workers with high levels of
psychological symptoms or effects are more vulnerable to near-miss occurrence while higher levels of physical symptoms indicated a higher risk of suffering an accident.

The conceptual framework from Goldenhar et al. (2003) (Figure 1) is adopted in this study to explore the main underlying construct which is: stress (organizational stressors, job-related stressors and work environment stressors) significantly contributes to the occurrence of construction site accidents, dangerous occurrences and near misses self-reported on construction sites.

METHODOLOGY

Since the study primarily involved investigating the relationship between multiple independent variables (stressors) and multiple dependent variables (accidents, near misses and dangerous occurrences) a positivistic approach was chosen for this study where data was collected using a structured question in a survey of construction site workers.

Included in the questionnaire were construction related stressors obtained from extensive review of literature, and seven most occurring accidents, near misses and dangerous occurrences recorded from a desk study of incident records on construction site selected for the study. These factors were incorporated in the structure of the questionnaire. The questionnaire was made up of five (5) sections;

**Section A** which formed the first part of the questionnaire was designed to inquire about the respondents’ personal information. This section was used to determine if any of the variables inquired about has any effect on the research findings. Construction related studies, as noted by Hallowell & Gambatese (2009) requires respondents who have attained some specific years of experience in their field of work and a particular level of education. **Section B** formed the second part of the questionnaire. This section required respondents to rate certain job related stressors identified from literature as to how they (respondents) are affected by these stressors in carrying out their duties on construction sites. These formed the independent variables used in the study. The impact of the stressors was measured using a Likert scale of 1 – 5 where 1 = Not Severe, 2 = Less Severe, 3 = Moderately Severe, 4 = Severe and 5 = Very Severe as adopted from Campbell (2006) research in determining occupational stress in the construction
industry. **Section C** required respondents to indicate the effects of job stress they experience. These effects were derivative from literature and noted to be the prevailing effects expected to be experienced by a person affected by stress. The effects were adopted from Melinda et al. (2010). The effects were measured on a 5 point likert scale (1 = Not Probable, 2 = Somewhat Improbable, 3 = Neutral, 4 = Somewhat Probable and 5 = Very Probable). **Section D** of the questionnaire demanded respondents to indicate how often they experienced the indicated accidents and injury. Eight (8) accidents were identified from literature and respondents were asked to rank these accidents by stating how frequently they have suffered any of these accidents in the past 12 months. The frequency of these accidents were assessed on a 5 point Likert scale (1 = Not Frequent, 2 = Less Frequent, 3 = Moderately Frequent, 4 = Frequent and 5 = Very Frequent). **Section E**, which is the last section of the questionnaire required respondents to indicate the extent to which each of the stressors affect each of the seven accidents. A 5 point likert scale was adopted, where 1 = Very Low, 2 = Low, 3 = Medium, 4 = High and 5 = Very High.

With regards to construction companies, construction sites of companies currently working for Kwame Nkrumah University of Science and Technology (KNUST) formed the target population. The subject of the study comprised workers who are involved in the direct construction work. The sample size chosen for this study was influenced by the analytical tool employed for the study. A minimum sample size of 200 is needed in order to effectively model using the Structural Equation Model (Bentler, 2005). According to Bentler (2005), a variable ratio of 5:1 is considered an appropriate sample size for a SEM model. With that in mind, the 48 observed variables required a sample size of 240. As such a total of 250 questionnaires were administered. A total of 204 responses were retrieved from all the 12 construction sites employed in the study.

**DATA ANALYSIS AND DISCUSSION OF RESULTS**

**Demographic Information**
The American Psychological Association (2011), indicates that both men and women experience different levels of impacts of stress on their health. Women are however considered by many scholars to be more likely to be under stress. Bowen et al. (2013), in their study on the nature of stresses experienced by construction workers in South Africa concluded that female professionals in the industry were more susceptible to experience work place stress than their male colleagues. Of the 204 respondents sampled in this study, 90% (184) were male and the remaining 10% (20 respondents) were females. This implies the findings will be mainly skewed towards the masculine perception of stress. A greater number of the respondents fell between the ages of 18 to 30 years which typically describes the youth in Ghana (National Youth Authority, 2014). The American Psychological Association (2011), refers to persons of ages 18 to 33 as millennials and purport that these persons are more likely to report higher stress levels. This assertion makes the study interesting since most of the construction workers sampled fall into this category. Knowledge of the profession or job title of the respondents is critical to establishing a relationship between that and the job stressors they are mostly exposed to on site. Labourers formed the highest category of respondents (27%) followed by Masons (20%). The remaining 53% were distributed as carpenters, electricians, foremen, instrument technicians and ironworkers (steel erectors). Other categories of workers included heavy equipment operators, painters, plumbers, safety officers, truck drivers and welders.
RESULTS AND DISCUSSION

Measurement Model
Data obtained from this survey was analysed in two phases. The Confirmatory Factor Analysis (CFA) was initially conducted to ensure internal consistency of the model, scale reliability and construct validity of the measurement items before the main model assessment was executed. The study employed the use of Comparative Fit Index in measuring incremental fitness of the model and Root Mean Square Error of Approximation (RMSEA) to measure absolute fitness out of the many available options (Kline, 2010). A result of 0.988 was recorded for incremental fit showing good fitness of the model. Scholars such as Benlter (2005) recommend an acceptable level of fit to be $CFI > 0.90$ and a good fit of $CFI > 0.95$. The fit value recorded which is above 0.95 showed the model was very good in terms of fitness. The value of 0.079 obtained for RMSEA was within the good and acceptable level of fitness. Lei and Wu (2008) recommend RMSEA, which projects a value less than 0.05 to be considered good fit and value less than 0.08 as acceptable fit. The model fitness was found to be statistically good conforming to the conventional cut-off points.

Table 2: Goodness of-fit measures of the model

<table>
<thead>
<tr>
<th>Goodness-of-fit Measure</th>
<th>Levels of fit</th>
<th>Estimated Measure</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental fit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFI</td>
<td>$x \geq 0.90$ (Acceptable)</td>
<td>0.988</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>$x \geq 0.95$ (Good fit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute fit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSEA</td>
<td>$x \leq 0.08$ (Acceptable)</td>
<td>0.079</td>
<td>Acceptable</td>
</tr>
<tr>
<td></td>
<td>$x \leq 0.05$ (Good fit)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CFI, Comparative Fit Index
RMSEA, Root Mean Square Error of Approximation

The study resorted to the use of the Coefficient of determination ($R^2$), to determine the predictability of the variables under experiment (Job stressors and accident occurrence). Values of the $R^2$ are computed between 0 (0 percent) to 1(100 percent). The greater the value, the better the fit. Henseler (2010) developed a scale for describing the $R^2$ values; where $X \geq 0.75$ is ‘substantial’, $X = 0.5$ is ‘moderate’, and $X \leq 0.25$ is ‘weak’.

The Cronbach’s Alpha was used in measuring the reliability of the measurement items. The Cronbach’s Alpha value observed was 0.894. This high value indicated that the measurement satisfied both construct validity and internal reliability criteria. Theory suggests that three factors contribute to stress on construction sites i.e., organization stressors, job demand stressors and work environment stressors (Leung et al., 2010; Campbell 2006). The structural equation model was employed to analytically measure the impact on theoretically assumed and confirmed relationships. Determining the significance of the parameters estimated and the test statistics to assess the probability of the impact was conducted by examining the values of the Standardized estimates and the $Z$-test (Kline, 2010). The standardized estimates and the $Z$-values obtained in the results revealed that the parameters estimated were more than the cut-off value of 1.96 which are adequate and reasonable in terms of the degree. The standardized coefficients were high greater than 0.5 (close to 1) which showed that the measurement items were observed to be associated with type of stressors on construction site.
Table 3: Standardized Coefficient, Variance Accounted for and Model Testing of the Construct (Job Related Stressors)

<table>
<thead>
<tr>
<th>Indicator Variable</th>
<th>Standardized Coefficient</th>
<th>Z-Values</th>
<th>R Squared (R²)</th>
<th>Path Coefficient (SE)</th>
<th>Cronbach's Alpha</th>
<th>Significant level at 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS1</td>
<td>0.811</td>
<td>32.02</td>
<td>0.657</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>OS2</td>
<td>0.787</td>
<td>28.09</td>
<td>0.619</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>OS3</td>
<td>0.770</td>
<td>25.87</td>
<td>0.593</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>OS4</td>
<td>0.817</td>
<td>33.19</td>
<td>0.667</td>
<td></td>
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<td>0.000</td>
</tr>
<tr>
<td>OS5</td>
<td>0.849</td>
<td>40.74</td>
<td>0.721</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>OS6</td>
<td>0.779</td>
<td>26.99</td>
<td>0.607</td>
<td></td>
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<td>0.000</td>
</tr>
<tr>
<td>JDS1</td>
<td>0.891</td>
<td>56.32</td>
<td>0.794</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>JDS2</td>
<td>0.823</td>
<td>34.32</td>
<td>0.677</td>
<td></td>
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<td>0.000</td>
</tr>
<tr>
<td>JDS3</td>
<td>0.881</td>
<td>51.73</td>
<td>0.777</td>
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<td>0.000</td>
</tr>
<tr>
<td>JDS4</td>
<td>0.854</td>
<td>42.03</td>
<td>0.730</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>JDS5</td>
<td>0.806</td>
<td>31.19</td>
<td>0.650</td>
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<td>0.000</td>
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<tr>
<td>JDS6</td>
<td>0.799</td>
<td>30.07</td>
<td>0.639</td>
<td></td>
<td></td>
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<tr>
<td>WES1</td>
<td>0.184</td>
<td>2.67</td>
<td>0.034</td>
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<td></td>
<td>0.008</td>
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<tr>
<td>WES2</td>
<td>0.450</td>
<td>7.88</td>
<td>0.202</td>
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</tr>
<tr>
<td>WES3</td>
<td>0.440</td>
<td>7.62</td>
<td>0.193</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>WES4</td>
<td>0.837</td>
<td>37.66</td>
<td>0.701</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>Overall Effect</td>
<td></td>
<td></td>
<td>0.968</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Standardized Coefficient, Variance Accounted for and Model Testing of the Construct (Accident Occurrence)

<table>
<thead>
<tr>
<th>Indicator Variable</th>
<th>Standardized Coefficient</th>
<th>Z-Values</th>
<th>R Squared (R²)</th>
<th>Path Coefficient (SE)</th>
<th>Cronbach's Alpha</th>
<th>Significant level at 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCA</td>
<td>0.641</td>
<td>12.62</td>
<td>0.410</td>
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<td>0.000</td>
</tr>
<tr>
<td>ACCB</td>
<td>0.207</td>
<td>2.78</td>
<td>0.043</td>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>ACCC</td>
<td>0.105</td>
<td>1.35</td>
<td>0.011</td>
<td></td>
<td></td>
<td>0.177</td>
</tr>
<tr>
<td>ACCD</td>
<td>0.769</td>
<td>18.60</td>
<td>0.591</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>ACCE</td>
<td>0.719</td>
<td>16.22</td>
<td>0.516</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>ACCF</td>
<td>0.771</td>
<td>19.05</td>
<td>0.595</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>ACCG</td>
<td>0.199</td>
<td>2.590</td>
<td>0.040</td>
<td></td>
<td></td>
<td>0.010</td>
</tr>
</tbody>
</table>

The R-square which measured the amount of variance in the measurement items explained by the construct (factors) were adequate. The measurement items in the work environment stressors which had low variances were reasonable; inadequate ventilation accounted for 20 percent variance, poor lighting accounted for 3 percent variance and noise levels accounted for 19 percent variance. The results showed that the measurement items significantly identified the construct which are all associated with the stressors experienced on the construction site.
A standardized coefficient close to 1.00 indicates significant impact on the dependent variable. The level of impact of the exogenous variables on the dependent variables increases the standard coefficient resulting in the reduction in the significance level. Categorically, all the parameters of organizational stressors and job demand stressors had high standardized coefficient ranging from 0.770 to 0.891 with their respective statistically significant effect. The study observed one of the measurement items of work environment stressors, thus working in dangerous environment having high standardized coefficient of 0.837. The other three measurement items had their standardized coefficient below 0.5 however, they were statistically significant.

The standardized estimates and the Z-values obtained in Table 3 revealed that the parameters estimated were all more than the cut-off value of 1.96. The standardized coefficients were highly greater than 0.5 (close to 1) which showed that the measurement items were observed to be associated with the type of stressors on construction site. The path coefficient measured the predictive accuracy of the model which loading was 0.284. This was the composite effect of the exogenous variable’s R-square on the endogenous variable. The value of the overall effect of job related stressors on the endogenous variable (accident occurrence) was 0.968 (Table 3) which was observed to be highly significant. The model was observed to be fitting and construct was significantly reliable. The overall estimation of the model indicated that job related stressors significantly impact on accident occurrence in construction site.

CONCLUSIONS
This study focused on the impact of stress on the occurrence of accidents on construction sites. Organizational stressors, Job demand stressors and Work environment stressors were identified from literature as workplace stressors. Investigations into the relationship between these stressors and the accidents, dangerous occurrences and near misses that occur on construction sites showed that the overall impact of the job stressors on occurrence of these events was 0.968 which denotes a very high influence. A careful study of the results revealed job demand stressors lead the most to causes of accidents and near misses or dangerous occurrences on construction sites in Ghana followed by organisational stressors. Work environment stressors were not seen as major causes of safety problems except for dangerous working environment which showed a very strong correlation with accidents and near misses or dangerous occurrences. This study provides a powerful insight into the failings of construction site safety measures. It empirically points to the soft side of the problem. However, since data for the study was collected largely from sites with less labour-intensive work and also highly skewed towards the male gender, the findings are only generalizable to similar context. This notwithstanding, for better results, construction site health and safety officers will need to collaborate more closely with project managers to ensure stress is better managed on site since these are high contributors to incidents on site that have the potential to cause harm and/or damage.

REFERENCES


The concept of sustainable development has gained worldwide acceptance by governments and economic sectors, including the construction industry. The construction industry is a strategic driver of sustainable development due to its notable contribution to national economic and social development. Although global trends indicate increasing attention to sustainability in construction projects, such attention focuses narrowly on environmental issues, and limited attention is given to workplace health and safety (H&S). Several impediments undermine the realisation of the comprehensive integration of sustainability principles in construction H&S, thus contributing to a disproportionate occurrence of accidents, disease, and fatalities. This study utilises questionnaires administered to construction industry practitioners in Harare and Bulawayo to investigate the barriers to integration of sustainability principles in construction H&S. The results of the study suggest that sustainability principles are inadequately integrated in H&S. Inadequate financial and other resource provision for H&S, inadequate commitment from clients and contractors, inadequate knowledge with respect to sustainability, perceived cost implications of sustainability and lack of comprehensive frameworks for defining sustainability aspects for H&S are the top five barriers to the integration of sustainability principles in H&S. In addition to contributing to the related body of knowledge, identification of barriers to integration will help in the development of comprehensive intervention strategies in pursuit of attainment of decent work in construction. The integration of sustainability principles in H&S will extend the discourse beyond environmental conservation to human resources conservation. This research was, however, limited to construction industry stakeholders, with unfortunate exclusion of sustainability experts outside this industry.

Keywords: construction, health and safety, sustainability, Zimbabwe

INTRODUCTION
The contribution of the construction industry to national socio-economic development, highlights its importance to attainment of sustainable development. Despite this, the construction industry’s health, safety and environmental (HSE) record is poor. Several studies suggest that the construction industry contributes disproportionately to workplace diseases, injuries, fatalities (Lopez-Valcarcel, 2001; Smallwood, 2013), excessive resource consumption, land degradation, and waste generation (Ofori, 2012). In Zimbabwe, the construction industry’s non-compliance to H&S is estimated to be around 80% (NSSA, 2012) culminating in a fatal injury rate of 7.15 per 100 000 over a 5-year period from 2010 to 2014. In the United Kingdom, Stubbs (2008)
estimates that the construction industry generates 109 tonnes of waste every year. Waste generated from the construction process pollutes the air, water and pose serious H&S problems (Baloi, 2003). These health, safety and environmental effects emanating from construction activities are retrogressive in terms of achieving sustainable development objectives. It is against this background, that sustainable construction has emerged as a guiding paradigm to create a new kind of built environment (Ametepey et al., 2015). Sustainable construction is a relatively new trend in developing countries (Emuze and Smallwood, 2013; Ametepey et al., 2015) and in Zimbabwe, sustainable construction is still at the infancy stage. However, some initiatives by the construction industry stakeholders are underway towards sustainable construction objectives. Although sustainable construction has a great opportunity to improve H&S, its implementation is not holistic and need to review. Several studies (Gambatese et al., 2007; Behm and Schneller, 2011; Emuze and Smallwood, 2013; OSHA, 2016) suggest that its implementation has a narrow focus on environmental and H&S issues of occupants of completed buildings and gives little attention to key social and workplace issues such as H&S of construction workers. Therefore, more attention need to be directed towards ensuring effective and sustainable workers’ H&S. To achieve this, integration of sustainability principles in construction H&S is an alternative innovative strategy to which construction H&S can leverage on to improve workplace H&S outcomes. The Occupational Safety and Health Administration (OSHA) (2016) demonstrates how the environmental movement has managed to leverage on the sustainability principles to advance improvements in its outcomes. Through integration, the H&S profile will be raised to resonate to the expected standards of sustainability. Consequently, value is enhanced on projects as H&S issues are mitigated (Emuze and Smallwood, 2013).

Notwithstanding the above, sustainability studies in construction focus more on environmental issues and leave out key social and workplace issues such as H&S (Emuze and Smallwood, 2013; OSHA, 2016). A study conducted by Bezalel and Issa (2016) conclude that limited research has been conducted relative to sustainable construction H&S, and that which has been conducted, is limited to developed countries, and then mainly the United States of America (USA). Nevertheless, these studies demonstrate that integration of sustainability principles in construction H&S has been slow (Chan et al., 2014) and inadequate (Rajendran and Gambatese 2009; Schulte, et al., 2013; Hinze et al., 2013; Emuze and Smallwood, 2013; Boileau, 2016). It is against this view that; this study seeks to explore the barriers to effective integration of sustainability principles in construction H&S practice in Zimbabwe.

**REVIEW OF RELATED LITERATURE**

**Sustainable Development**

The United Nations (UN) Conference on the Environment held in Stockholm in 1972 is credited for setting the theoretical framework for sustainable development (Harding 2005; Drexhage and Murphy, 2010). Although, several UN conferences further refined the concept, it is the World Commission on Environment and Development (WCED) which gave it the stimulus that popularised it until today. The WCED mainstreamed sustainable development into the political arena of development thinking (Elliot, 2013). According to the WCED (1987), sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own. Sustainable development requires the simultaneous equitable adoption of social, environmental and economic principles.
(Labuschagne and Brent, 2005; Bansal, 2005). The adoption of Agenda 2030 in September 2015 by the UN represented a firm commitment to sustainable Development by world leaders (Mpofu, 2017).

Zimbabwe prioritized 10 Sustainable Development Goals (SDGs) adopted by the UN. These goals relate to economic growth; energy; agriculture, food security and nutrition; infrastructure; water and sanitation; global partnership and financing; health; combating climate change; and, gender and women empowerment (Mpofu, 2017).

Among these SDGs, there are some which are polarised to H&S. These goals relate to decent work and economic growth, responsible consumption and production (OSHA, 2016), poverty reduction, and health. Notwithstanding the above, Okoye and Okolie (2013) assert that sustainable development is inimical without sustainable construction. According to Kibert (2013), sustainable construction is concerned with the role of built environment in contributing to sustainable development. Currently, H&S exists outside the ambit of sustainable construction and there is need to integrate it.

**Sustainable Construction Health and Safety (SCHS)**

According to Rajendran and Gambatese (2005), the objective of sustainable construction health and safety (SCHS) is to sustain a worker's H&S for the duration of the current and future projects a worker is involved in, and during the worker's remaining lifetime after retirement. To be succinct, it is the application of sustainability principles to construction H&S to sustain the safety of workers during and after their working life. According to Flouris and Yilmaz (2011), for firms to express sustainable development, sustainability principles must be incorporated in their policies, products, and practices. In this regard, the principles which shape sustainable development: social equity, environmental integrity and economic prosperity may be used to frame sustainable H&S practice as illustrated in Figure 1.

![Figure 10: Conceptual model for integrating sustainability principles in construction H&S](image)

Each of these principles represents a necessary, but not sufficient condition (Flouris, and Yilmaz, 2011) for achieving sustainable construction H&S. The integrative process involves trade-offs among the three sustainability principles and SCHS is then achieved at the intersection of these principles. This demonstrates how important each
principle is for the attainment of sustainable H&S. The process of integration will also benefit from the integrative qualities of sustainable development (Robinson, 2004; Emas, 2015). However, attainment of SCHS is also subject to multi-stakeholders’ commitment and, proper management of existing and emerging barriers to integration. The following sections discuss the interface between the sustainability domains and H&S, and the opportunities for integration.

Social sustainability is informed by the need to achieve social equity (WHO, 1994; Beheiry et al., 2006) as defined in the Rio Declaration on Environment and Development. The concern for human wellbeing is central to both sustainable development and H&S (Rajendran and Gambatese, 2009; Molamohamadi and Ismail, 2014). Globally, workers represent half of the world’s population (WHO, 2014) providing the means with which the objectives of sustainable development may be achieved. Therefore, respect of workers’ rights to freedom, wellbeing, equality and social inclusion are prerequisites to achieving socially sustainable production. Social sustainability principles such as intergenerational equity, access to information, participation and justice, can therefore frame a socially sustainable H&S practice. According to Valdes-Vasquez (2013) integrating social sustainability principles in H&S will improve both long term project performance and the quality of life for those affected by the project. In light of this, several studies (Gambatese et al., 2007; Rajendran and Gambatese, 2009; Hinze et al., 2013) recommend incorporation of construction worker H&S in sustainable construction rating systems.

Environmental Sustainability seeks to protect and conserve biodiversity. Accordingly, the concern for resource conservation, both natural and human, provides the connection between the environmental and H&S movements. This synergy is confirmed through several research studies (Cole, 2000; Howard, 2011; Emuze and Smallwood 2013; Amponsah-Tawiah, 2013; Molamohamadi and Ismail, 2014; WHO, 2016) which clearly justify the integration of environmental and H&S initiatives. Amponsah-Tawiah (2013) study argues that promoting workers' H&S while polluting the environment within which they reside with their families is retrogressive. Integrating environmental sustainability principles such as the precautionary principle, environmental protection, and the polluter pays principle, in construction H&S fosters a preventive strategy in sustainable H&S. Designers can contribute to the preventive strategy through designing for safety (Boileau, 2016).

Economic sustainability focus on attainment of stable economic growth with minimal environmental (OGC, 2007) and H&S footprints (Boileau, 2016). A healthy workforce and safe workplace are prerequisites for continuous uninterrupted production, quality products, competitiveness, and sustainability of enterprises (WHO, 1994). These observations are corroborated in latter empirical studies (Fellows et al., 2002; Smallwood, 2004; Ikpe et al., 2011) whose findings suggest that the total cost of accidents exceed the cost of accident prevention. Therefore, applying the principles that frame economic sustainability such as responsible production and consumption, economic efficiency, and a long-term perspective provoke construction stakeholders to look beyond short-term interests relative to investing in H&S. The success of integration, anchors on appropriate financial and technical provisions for H&S.
Barriers to integration

According to Chan et al. (2014) adoption of sustainable H&S practice in the construction industry has generally been slow. The slow shift may be attributed to the existence of some barriers in the integrative process. However, limited studies have been conducted to investigate barriers to integrating sustainability in H&S. Against that background, studies seeking strategies to integrate H&S in sustainable or green building rating systems, sustainability in construction practice, project management, value management, and procurement, provided the basis of assessment of potential barriers to integrating sustainability principles in H&S. These barriers are discussed in the following sections.

According to Roelofs (2007), technical and financial barriers are the main factors inhibiting implementation of sustainable practices relative to construction H&S. This observation is confirmed in studies which assert that implementing sustainable practice need a significant amount of time and is a costly investment (Abidin, 2009; Chan et al., 2014). Although the problem of financial resources affects a cross section of construction stakeholders, Chan et al. (2014) argue that it is most pronounced in small to medium enterprises. This problem is compounded by the perceived cost implications of sustainable practices (Abidin, 2009b) and H&S (ILO, 2014) which may culminate in low resource provisions for sustainable H&S initiatives.

The other barrier to integration is lack proper knowledge in sustainability initiatives (Knott et al., 2014; Chan et al., 2014; OSHA, 2014). This barrier may be attributed to inadequate awareness of sustainability and its interface with H&S, and inadequate incorporation of sustainability in built environment programmes. A study conducted by Hecker and Gambatese (2004) established that design professionals limit their focus to the safety of the facility end-users such as building occupants while overlooking the H&S of construction workers. In another study investigating the incorporation of sustainability issues in civil engineering education, Valdes-Vasquez and Klotz (2011) conclude that social sustainability is often overlooked in preference of environmental and economic considerations. Lack of knowledge affects construction practitioners’ commitment (Karunasena et al., 2016) and decision-making relative to sustainability and H&S issues. This is consistent with several studies (Abidin, 2010; Valdes-Vasquez, 2011; Karunasena et al., 2016) which attribute the slow pace of action towards sustainable practice on team members’ knowledge of sustainable practice.

Inadequate legal requirements to apply sustainability principles in H&S also affect the integrative process. A study conducted by Toole and Carpenter (2012) suggests that construction lacks comprehensive framework to define social sustainability aspects with regards to its projects. The results of Roelofs’ (2007) study indicate that weak standards and weak enforcements affects integration of environmental and worker protection worlds. Inadequate integration of legal instruments which impinge on sustainable construction health and safety amplifies the problem. According to (Mosly, 2016), in most countries, construction H&S regulations and green building rating systems are not integrated. In Zimbabwe, H&S and environmental management have separate procedures and regulating institutions. However, lack of coordination between environmental and H&S operations expose workers to the problem of risk shifting.
According to Edmun-Fotwe and Price (2009), focus on single order sustainability is an obstacle to integrating H&S and sustainable construction through the lens of green building rating systems. Green building rating frameworks such as the Leadership in Energy and Environmental Design (LEED) are biased towards achieving environmental sustainability (Hinze et al., 2012; OSHA, 2016; Karakhan, 2016) while marginalising key social issues such as workers’ H&S.

**METHODOLOGY**

This research paper presents initial findings of an ongoing broader research seeking to integrate sustainability principles in construction H&S in Zimbabwe. The study employed an exploratory research design due to limited literature with respect to this subject in Zimbabwe. An exploratory design explores the possibility of obtaining as many relationships as possible between different variables (Panneerslvam, 2004), and is particularly suitable for subject areas where there is little literature and experience to serve as a guide (Kothari, 2004). The primary data was collected through structured self-administered and emailed questionnaires to construction industry practitioners, namely consultants, management personnel from contractors, and the government in Harare and Bulawayo. The two cities were chosen because they house most construction consultants, contractors, and government offices. Data gathered were entered in the Statistical Package for the Social Sciences (SPSS) software and analysed using percentage frequencies and mean scores (MS).

**RESULTS AND DISCUSSION**

*Demographics of Respondents*

A total of 34 questionnaires out of 47 distributed were received and analysed representing 72% response rate. The responses were distributed as follows: central government (27%); contractors (32%), and consultants (41%). The respondents’ experience in construction ranged from 3 to 25 years, with a mean of 8.2 years and a standard deviation of 5.75. The respondents were holders of the following qualifications: Master’s degree (29%); Honours degree (65%), post graduate diploma (3%) and higher national diploma (3%). The respondents’ work experience in the industry and academic qualifications were useful to provide a valid and reliable assessment of the issues addressed in the questionnaire.

*Importance of integrating sustainability principles in H&S*

The research results suggest that integrating sustainability principles will improve construction H&S practice (MS = 4.00). Integration ensures that sustainability principles are incorporated in all H&S decision making thus fostering an all-inclusive approach to H&S management. Respondents perceive that integration leads to economic, social and environmental benefits because of the reduced risk of accidents, increased productivity, minimal downtime, and safe work environment. Despite the perceived importance of sustainability, a weighted mean score (MS = 2.54) for all pre-selected principles suggests that the level of integration is low. However, at the low level of integration, regulated social sustainability principles (MS = 2.72) are rated higher that environmental (MS = 2.62) and economic sustainability (MS = 2.54).

*Barriers to integration of sustainability principles in construction H&S*

Table 1 shows the respondents’ assessment of pre-selected barriers to integration in terms of responses to a scale of 1 = not important to 5 = extremely important, and a mean score (MS) ranging between 1.00 and 5.00, the midpoint score being 3.00. The
results show that most of the barriers have a MS > 3.00 which suggests that they are perceived to be important.

The study results suggest that several barriers affect the integration of sustainability principles in construction H&S. The top five barriers will be discussed in the following sections.

Table 1: Barriers to integrating sustainability principles in construction H&S

<table>
<thead>
<tr>
<th>Barrier</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate financial and other resource provision for H&amp;S</td>
<td>4.09</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate client commitment to promote sustainable H&amp;S</td>
<td>3.91</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate knowledge of sustainability among team members</td>
<td>3.88</td>
<td>3</td>
</tr>
<tr>
<td>Inadequate contractor management commitment to sustainability</td>
<td>3.85</td>
<td>4</td>
</tr>
<tr>
<td>Perceived cost implications of sustainability</td>
<td>3.82</td>
<td>5</td>
</tr>
<tr>
<td>Lack of comprehensive frameworks for defining sustainability aspects for H&amp;S</td>
<td>3.71</td>
<td>6</td>
</tr>
<tr>
<td>Inadequate understanding of the synergy between H&amp;S and sustainability</td>
<td>3.57</td>
<td>7</td>
</tr>
<tr>
<td>Separation of design and construction</td>
<td>3.26</td>
<td>8</td>
</tr>
<tr>
<td>Passive and negative perception about integration</td>
<td>3.15</td>
<td>9</td>
</tr>
<tr>
<td>Lack of collective view around the concept of sustainability</td>
<td>3.14</td>
<td>10</td>
</tr>
<tr>
<td>Fragmentation / lack of relevant H&amp;S laws and regulations</td>
<td>3.09</td>
<td>11</td>
</tr>
<tr>
<td>Inadequate integration of H&amp;S in business and environmental operations</td>
<td>3.06</td>
<td>12</td>
</tr>
<tr>
<td>Separation of H&amp;S and environmental laws and policies</td>
<td>3.06</td>
<td>13</td>
</tr>
<tr>
<td>Skepticism around the business value of sustainability</td>
<td>2.97</td>
<td>14</td>
</tr>
</tbody>
</table>

Inadequate financial resources (MS = 4.09). The study results suggest that inadequate financial and other resource provision is the leading factor inhibiting integration. It is perceived that inadequate financial resources may negatively influence the amount of resources that construction stakeholders can allocate for H&S improvements. Inadequate financial resources may be attributed to current national economic recession characterised by high company closures and high cost of development finance. Under these circumstances investments in H&S are likely to be affected. In a previous study, the ILO (2014) observed that H&S budgets are affected during periods of economic recessions. Yet, availability of financial and technical resources determine how sustainability initiatives will be implemented relative to H&S. The results of this study are, however, consistent with findings from previous studies (Eijkemans et al., 2004; Roelofs, 2007; Sourani and Sohail, 2011) which, attributes inadequate implementation of sustainable work practice to limited resource provisions.

Inadequate client (MS = 3.91) and contractor commitment (MS = 3.85). The study results suggest that inadequate client and contractor commitment to sustainable H&S inhibit integration of sustainability principles in H&S. As financiers and employers, clients and contractors are in a strategic position in decision making relative to integration of sustainability principles. Whilst client leadership is recognised as a crucial driver for improving H&S performance throughout the supply chain (OGC, 2007), previous studies conducted in Zimbabwe suggest H&S is not among the key considerations in sustainable procurement (Chari and Chiriseri, 2014) and for the award of public tenders (Chigara and Smallwood, 2016). In the absence of adequate commitment, sustainability and H&S issues are not dealt with as matters of economics and inadequate resources are allocated.
Lack of knowledge about sustainability (MS = 3.88): The study findings suggest that inadequate knowledge affects decision making relative to sustainable construction H&S practice. The level of knowledge that construction stakeholders have relative to sustainability and its interface with H&S influence their decision making. Although lack of knowledge is rated third, however, its impact cut across the whole decision-making functions with regards to integration. Previous initiatives towards sustainable development through implementation of Millennium Development Goals (MDGs) was affected by lack of awareness among people, particularly in the private sector, and at provincial and district levels (Mpofu, 2017). The problem of lack of knowledge may be attributed to inadequate awareness programmes relative to sustainability and inadequate inclusion of social sustainability issues in built environment programmes in the country. Most built environment programmes in Zimbabwe inadequately incorporate H&S and sustainability issues. In Valdes-Vasquez and Klotz (2011) study, social sustainability issues are given less attention civil engineering education. These results also corroborate findings from previous studies (Sourani and Sohail, 2011; Chari and Chiriseri, 2014; Ametepey et al., 2015) relative to adoption of sustainable practice in construction.

The perceived cost implications of sustainability principles (MS = 3.82): The respondents perceive that introducing sustainability principles in H&S will increase the cost of H&S and subsequently cost of construction works. Non-availability of information relative to the business value of integrating sustainability in H&S, tight profit margins in construction, and the national financial crisis may exert pressure on construction industry stakeholders to perceive sustainable improvements in H&S as an additional economic burden. The existing perception where H&S investment is seen as an economic burden (Agumba and Haupt, 2009; OSHA, 2016) amplifies the problem. These findings are consistent with previous related studies where perceived cost of sustainability was identified as a principal barrier to implementing sustainability in construction (Zhou and Lowe, 2003; Sertyesilisik, 2016) and procurement (Chari and Chiriseri, 2014).

Lack of comprehensive frameworks for defining sustainability aspects for H&S (MS = 3.71): Lack of a framework that integrates sustainability and H&S is another stumbling block for integration. The legal, institutional, and policy frameworks addressing sustainable development issues are disjointed making it difficult to operationalise and implement sustainability issues in construction H&S. In addition, H&S laws are also fragmented and not comprehensive. However, previous studies suggest that availability of legislation (Emuze and Smallwood, 2013) is a motivating factor for implementing H&S programmes within the construction industry. Therefore, in the absence of sustainable development frameworks at national, industry or organisation level, it is difficult to convince, compel, or enforce implementation to sustainable work practices.

CONCLUSIONS
The construction industry has a major role to play in the achievement of sustainable development. The industry employs a significant number of workers and provides infrastructure needed to propel the wheels of sustainable development. However, the construction industry’s health, safety and environmental (HSE) record is poor. It is against this background, that sustainable construction emerged as a new development.
paradigm for the built environment. Despite this, H&S exists outside the ambit of sustainable construction and there is need to integrate it with sustainability principles. This study explored the perceived barriers to integration of sustainability principles in construction H&S practice in Zimbabwe. The results of the study suggest that integration will improve H&S performance as a result of the adoption of precautionary, inclusive and responsibly productive work practices. Nevertheless, the level of integration is perceived to be low. The perceived barriers to integration include *inter alia*; inadequate financial resource provisions, inadequate commitment from clients and contractors to sustainability principles, inadequate knowledge relative to sustainability, perceived cost implications of sustainability, and lack of comprehensive frameworks for defining sustainability aspects relative to H&S. Although these results are generally consistent with related previous studies, they, however, suggest that construction H&S practice in Zimbabwe is not sustainable. Conclusively, integrating sustainability principles in built environment programmes, increasing awareness of sustainability principles to construction industry stakeholders, widening scope of H&S policy and regulatory frameworks to incorporate sustainability principles, among other strategies, will promote sustainable construction H&S in Zimbabwe and elsewhere. These results can inform policy relative to advancing the sustainable construction H&S agenda.

REFERENCES


CAUSES OF INEFFECTIVE COMMUNICATION AMONG PROJECT TEAMS IN LAGOS, NIGERIA

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Communication plays a significant role among project team in the construction industry, this is because if there is no effective communication; there is a tendency that project construction will experience failure regarding completion time, cost overflow, quality of work and clients dissatisfaction. Therefore, the aim of this research paper is assessing the factors that cause ineffective communication in Lagos state, Nigeria. The quantitative method is used in the study; while the literature was a review on construction communication, ineffective communication factors and project team. The quantitative approach was through the distribution of questionnaire survey to the project team in the industry. A total of 201 construction professionals were involved in the research. Findings from the questionnaire survey indicates that Poor communication, making use of inexpert consultants by the client, wrongly interpretation of working drawings and late circulation of project information among project team are the most significant factors that cause ineffective communication among the project team. However, lack of quality documentation and language use among project team are the least factor that makes communication unsuccessful. The findings create awareness for the project team in construction to identify and avoid factors that impede communication effectiveness from the commencement of a project to the completion stage for project success to be achieved. Communication method should clearly be defined from the inception of the project and information should be readily available to time to avoid project delay and dispute.

Keywords: Construction Project, Effective communication, Ineffective communication and Project team.

INTRODUCTION

Ineffective communication among the project team is a key contributing factor to the success of construction projects. It was identified as a challenge that can lead to conflict and subsequent legal process (Gorse, 2003). As noted by Lavers (1992) project failure occurred not frequently because of the disparity between belief and information. Also, the quality of service delivery in a building may be of a low standard as a result of poor communication. Therefore, the various professionals in the building project must endeavours to effectively communicate their idea for a given project to be successful. Goji, Oyiza & Liyasu (2014) stated that when a project is revealed and the design is understood information likes drawings, specifications; schedules and systems of construction must be transferred from one professional to another. Foley (2005) indicated that communication that is not well attained would lead to the de-motivated workforce, design errors, a slowdown in the entire job and failure in production. The need to communicate effectively is at the heart of a business

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be it construction, banking, medical sector and any form of dealing. No matter our individual knowledge and skills, if we cannot effectively communicate our ideas to others, we will be unable to succeed in our endeavours.

Chen and Kamara (2008) stated that building industry is a demanding environment regards to information from design stages to completion stages. The efficiency of information management is fundamental to the construction project and it is recognised as a very important advantage to construction companies because of the strength and multiplicity of construction information. As observed by Gorse & Emmitt (2003), no matter how clear the briefing and drawing process, and how good the site management, there are always some problems that will arise during each and every project, regardless of size or in any location. Some of the difficult can be minor and can quickly be resolved; some can be major and lead to dispute, but with every new project fresh and slightly different problems developed. Hence, the challenges in a construction project can be related back to ineffective communication between project team. As stated by Tipili et al (2014), ineffective communication is when a participant among project team failed to convey his or her intention to another member correctly and timely, and can result in delays, alteration, disagreement, conflict and probably terminating of the project. Therefore, design and construction challenges need to be fixed by using a suitable communication means and channel. Information must be properly managed, transferred and understood, so that the various aspects of the project can be assembled to achieve the design objective and client satisfaction (Tipili et al., 2014).

In the 1940s the Nigeria building industry commenced a structured construction contracting with few overseas companies coming to set up (Gorse, 2002). The Nigeria construction is a huge investment industry with many contractors who bid for projects and have records increasing percentage of success, in the past few years the support had been remarkable with a large number of the companies experiencing a high turnover (Tipili et al., 2014). The research was conducted to identify the factors that cause ineffective communication among construction project team to reduce project dispute.

**LITERATURE REVIEW**

**Construction Communication**

Notes (2009) stated that communication is a method of exchanging information, ideas, thoughts, feelings and excitements through dialogue, signs, script, or conduct. In the communication process, a sender (encoder) encodes a message and then sends it using a medium/channel to the receiver (decoder) who decodes the message and sends back appropriate feedback/reply using a medium/channel after processing information. Construction communication, within an organisational setting, is the act of impacting the actions or attitude of others, when an instruction is sent it can also comprise of an exchange or demand for information throughout a construction project (Abdullah, 2016).

Effective communication can be defined as stated by a two-way information sharing process which involves one party sending a message that is easily understood by the other party receiving it. Fielding (2005) stated communication as a transaction how people work together as a team to create meaning by exchanging symbols. PMBOK (2008) noted that effective communication is the information delivered in the right frame, at the right time, and with the right impact. It also goes further by saying
effective communication means providing only the information that is needed. However, with all this study on effective communication, we can conclude that communication is ineffective if there is no appropriate feedback or is not giving at the right time when the information is needed. Abdullah (2016) stated Communication in building project situations comes with an exceptional task. As identified by Dainty et al. (2006) communication in itself a complex term, which means different things in different situation and context. It further pinpoint that the construction industry relationship is categorised by bringing various groups of individuals together for a limited time before closure to work on other projects.

According to PMBOK (2008), the different project team that are involved in construction projects are from numerous organisational and cultural background with different perspectives, expertise and interest in project implementation and result, which have effects on the way they communicate. Ineffective communication has continued to be a difficult task confronting construction project delivery (Gunhan et al., 2012; Hoezen, 2008; Dainty et al., 2006). However, Wikforss (2007) agreed that one of the causes attributed to constant ineffective communication among projects team is the nature and unique qualities of construction projects. Construction projects are complicated and uncertain; requiring every project participant should be active contributors. Co-operation and co-ordination of activities through interpersonal and group communication are necessary in ensuring the project is completed successfully (Gorse, 2003).

As stated by Wysocki (2007) defines a project as “a sequence of unique, complex and connected activities having one goal or purpose and that must be completed by a particular time, within budget and according to specification”. Turner cited in (Knipe et al., 2002), also buttress the definition by saying that a project is “something with a definite beginning and an end”. Therefore, a project team are some professional brought together over a period to accomplish the task set before them and to achieve project success. Wood (2009), if there is a breakdown of communication among them, the project will be unsuccessful. The project team in Nigeria are divided into three groups namely the clients, consultant and contractor and the communication flows in that order, and this brought us to different ways of communicating either verbally, written and non-verbal.

Appropriate communication skills are crucial at any construction project phases regarding communication from the start to completion of a project as identified by (Bakar, 2011). In construction project written communication are site reports, minutes of meetings, site instruction, etc, while verbal communication is a telephone conversation, face-to-face, site meetings, visitation, etc. Drawings and visual media can be identifying as non-verbal communication.

However, communication in construction projects flows in two forms either formally or informal, and these are both important for communication to go on effectively among the project team, occasionally informal communication can go a long way in solving challenges on site rather than formal. According to Middleton (1996), informal dialogue creates a basic element among professional teams because it is from discussion and arguments that events can understand appropriately and improves the co-ordinations of activities. With all this contextual report on what communication is, we can deduct what are the factors that can cause ineffective communication.
Ineffective Communication factors

The construction industry has been identifying of having a poor status in which the member and organisation communicate with one another (Emmitt & Gorse, 2003). There are reports that have subsequently drawn attention to ineffective communication in the construction sector (Lathan, 1994; Egan, 1998). It goes further by identifying lack of trust, separation of designs, lack of coordination separation of design and construction activities are factors that impede effective communication. As established by Emmitt and Gorse (2003) conflicts, dispute and probably legal cases can be as a result of ineffective communication challenges. Poor communication, communication method, lack of regular site meeting, language barrier among project team, late circulation of project information, unclear understanding of project information between project team, project team dispute, inaccurate bill of quantity provided by the quantity surveyor, Lack of site inspection, unavailability of consultants’ representative regularly during site meetings are the problems that can occur during construction stages, while wrongly interpretation of working drawing, inability to interpret drawings by technicians, making use of inexperienced consultant can lead to design challenges and in turn leads to design mistakes. Affare (2012), also identify that the most common obstacles to communication on construction projects when view from clients, contractors and consultants are in descending order: poor listeners, poor leadership, unclear communication, unclear channels of communication, ineffective reporting system, limited resources, lack of necessary skills; lack of trust, language difficulty.

Further, looking at poor communication how does it affect the construction projects, as identified by Emmitt and Gorse (2003) poor communication can result in service delivery regarding quality that is low in standard and client dissatisfaction. In fact, poor communication is the major factor that springs up others. Secondly, language barrier among project team is also an issue, Potter & Wetherill (1987) as cited by Emmitt and Gorse (2003) construction professional depend on to a lesser or greater extent on language and codes that are used among them the way it is identified and received it. Emuze & James (2013) also emphasised how languages and culture have contributed to ineffective communication and some challenges that follow includes low employee morale, poor product quality and reworks. Gorse (2003) goes further that project team in construction communicate with different attitudes, perceptions and principles because they are trained in diverse ways and so their professional slangs and jargons are not the same.

However, from the design perceptive the use of inexperienced consultant, unable to interpret drawings, information flow and transfer contribute to communication problem. When project team lacks the basic knowledge and skill needed to do a design that is standard and acceptable according to rules or professional practice, the information flow is hampered, the design will be faulty; also will have an effect on the construction and leads to building failure. As reviewed by Thomas, Tucker and Kelly (1998) also agreed that extremely lengthy channels of communication could further obstruct communications flow.

METHODOLOGY

The study embraced the use of quantitative method, through the means of a survey as the measurement tool by distribution and collection of the structured questionnaires from the project team in the construction industry. The questionnaire was derived from the review of the existing literature regards communication in Nigeria.
construction project and based on the initial study conducted at the onset of this study. The purpose of this research method is to ascertain the research aim by identifying factors that cause ineffective communication in construction. As reviewed by Blaxter et al. (2006) quantitative research techniques regularly includes applying of statistical interpretation, enormous random samples and limited cases of illustrative applications. Also, Vanderstoep and Johnston (2009) stated that quantitative approach is a technique used in identifying statistical works to forecasts or control the phenomenal that is been study. The objective of using quantitative research is to know the connection between a dependent and independent variable in a population sample (Glesne and Peshkin, 1992). The questionnaire was divided into two sections. Section A sought after the overall particulars of the respondents, while section B was to determine the eighteen factors that is identified as the causes of ineffective communication. However, because of the population and land mass of the country, the research work was conducted within construction project team in Lagos state, Nigeria, this is because the city is the commercial capital of the nation and construction works is always ongoing throughout the year. The member of the project teams the questionnaire was sent to includes these professionals; Project Managers (PM), Architect, Quantity Surveyor (QS), Land Surveyor (LS), Geotechnical Engineers (GE), Structural Engineers (Strct.E), Mechanical & Electrical Engineers (M&E), Civil Engineer, Builders, Contractors and likewise the client who is the originator of the communication process, it is necessary to includes all the construction professional through their various council. Swan and Khalfan (2007) opined that inclusion of all construction professionals is essential for successful project delivery. The questionnaire is a structured question which asked the respondents to select an answer from a given set of choices. According to Bhattacherjee (2012), the responses to individual items on a structured questionnaire could be grouped into a multiple scales or index for statistical analysis. Thus, 250 structured questionnaires were distributed through self-administration, 220 was returned but 201 was useable representing 78% of the overall return and useable rate (table 1); as reviewed by Moser and Kalton (1971) the results of a survey can be measured as partial and of slight significant if the rate of return is lesser than 30 to 40%. Thus the return rate for this study was considered satisfactory for the analysis.

The respondents were asked to rank the factors that cause ineffective communication using five-point Likert scale. According to Bertram (2007) likert scale is a psychometric response scale that is frequently used in the research questionnaire to get respondents degree of agreement within a set of statement. Therefore, to facilitate the analysis of the responses, the statistical values that were assigned to the respondents' ratings are as follow: (1) = strongly disagree; (2) = Disagree; (3) = Neutral ; (4) = Agree; and (5) = strongly agree. The result from the survey response was coded using statistical package for social science (SPSS) version 23 and the questionnaires were measures to check the reliability and validity of the result (table 2). According to Pallant (2013) the reliability of a scale shows how free it is from illogical mistake, and validity of a scale is referring to the degree it is measures what it needs to measure.

Further, the ranking of each factors identified in making communication to be ineffective among project professional was estimated using the mean interval score (MIS) of the respondents. Each response was given a weight ranging from one to five of ‘strongly disagree’ to ‘strongly agree’ as stated below using the mathematical design, after the computation the criteria were ranked in descending order from highest to lowest.
MIS=1n1+2n2+3n3+4n4+5n5.................................Equation 1.0
\[ \sum N \]
Where:

n1 = number of strongly disagree respondents  
n2 = number of disagree respondents  
n3 = number of neutral respondents  
n4 = number of respondents agree  
n5 = number of strongly agree respondents  
N = total number of respondents

Table 1 Questionnaire distribution and response

<table>
<thead>
<tr>
<th>Description</th>
<th>Number distributed</th>
<th>Number of respondents</th>
<th>% of number distributed</th>
<th>% of number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager</td>
<td>45</td>
<td>30</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Architect</td>
<td>60</td>
<td>51</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Quantity Surveyors</td>
<td>65</td>
<td>54</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>Engineers</td>
<td>60</td>
<td>52</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>Builders</td>
<td>20</td>
<td>14</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>250</td>
<td>201</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FINDINGS, ANALYSIS AND DISCUSSION:

DEMOGRAPHIC DESCRIPTION

The returned questionnaire consisted of professionals who are 51 Architects, 54 Quantity Surveyors, 30 Project Managers, 52 engineers and 14 Builders, while the respondents' works for different organisations, 77 works for consultancy firms, 48 from private clients, 35 from contracting firms, 34 from public sector and the remaining 7 are individual clients. All the respondents have various experiences in the field of construction but at different levels, 40% of the respondents have 1-5 years' experience, 27% had 6-10 years, 19% with 11-15 years' experience, 6% with 16-20 years of experience and 9% had 21 years and above experience.

From the questionnaire the educational background possessed by the respondents are listed; 50% had BSC/HND, 35% had their master’s degree, while 6% held a diploma and doctorate degree, respectively and only 3% had a professional qualification. Also, the number of projects the respondents are currently working on are 1-2 projects (23%), 3-4 projects (25%), 5-6 projects (28%) 7-8 projects (6%) and eight projects upward is (14%). The respondents’ ethnicity group are Igbo (26%), Yoruba (67%), Hausa (8%) and other are (2%). With this finding, it could be concluded that the data can be deemed reliable based on the opinion of the respondents because the professionals have the knowledgeable idea of the construction projects in Lagos, Nigeria.
Reliability

Reliability is used to measure how the scale is free from error and to check their internal stability to see if they are all measuring together. This is done using Cronbach Alpha efficiency as an indicator, which must be > 0.7 according to Pallant (2007). Table 2 presents the reliability results of 18 factors that cause ineffective communication; it indicates a good internal consistency with a Cronbach alpha coefficient of 0.84.

Table 2: Reliability Statistics

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Cronbach's Alpha Based on Standardised Items</th>
<th>No of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.840</td>
<td>0.840</td>
<td>18</td>
</tr>
</tbody>
</table>

The questions regarding factors that cause ineffective communication in construction projects, the opinion of the respondents were collected and analyse using 5-point Likert scale of 1- strongly disagree to 5- strongly agree. The result indicated that late circulation of project information ranked as the first and most important factor affecting communication among project team in construction projects with a standard deviation (SD) of 0.900 and mean score of 4.20; poor communication was ranked second with a mean score of 4.04 and SD=1.038; thirdly ranked factor is making used of inexperienced consultant by the clients with a mean of 4.01 and SD = 0.903; while, inability to interpret drawings by technicians and wrongly interpretation of working drawings both ranked fourth with 3.96 as the mean item score and the standard deviation of 1.074 and 0.948 respectively. However, the least ranked factor are: availability of regular documentation ranked 12th with a mean score of 3.71 and SD=0.984, unavailability of contractor representative regularly during site meeting ranked 13th with MIS= 3.65 and SD=1.081, unavailability of consultants’ representative regularly during site meetings ranked 14th position with MIS =3.64 and SD 1.114; also, inaccurate bill of quantity provided by the quantity surveyor had mean item score of 3.62 and SD of 1.112 with 15th position. Lastly, project team dispute had the 16th position for the ranking with 3.53 as the mean item score 0.954 for SD, the least factors that cause ineffective communication in construction projects as answered by the respondents is the language used among project team with a mean score of 3.39 and Standard deviation of 1.049.

Findings

Based on the ranking, (R) using mean item score (\(\bar{x}\)) and standard deviation (SD) the most significant factors that cause ineffective communication among project team in construction projects are as follows; late circulation of project information (\(\bar{x}=4.20;\) SD= 0.900); Poor communication(\(\bar{x}=4.04;\) SD =1.308); making use of inexperienced consultants by the client (\(\bar{x}=4.01;\) SD=0.903); inability to interpret drawings by technicians (\(\bar{x}=3.96;\) SD=1.074); wrongly interpretation of working drawing (\(\bar{x} =3.96;\) SD = 0.948); communication method (\(\bar{x} =3.94;\) SD=0.947); lack of site inspection (\(\bar{x} =3.92;\) SD=1.012).

Unclear channel of communication (\(\bar{x}=3.90;\) SD=1.007); lack of regular site meeting between the project teams (\(\bar{x}=3.87;\)SD=1.121); unclear understanding of project information between project team; (\(\bar{x}=3.85;\) SD=0.931).
Table 2: Causes of ineffective communication in the Construction project

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean = ( \bar{x} )</th>
<th>Std deviation = ( \Sigma x )</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late circulation of project information among project</td>
<td>4.20</td>
<td>0.900</td>
<td>1</td>
</tr>
<tr>
<td>Poor communication</td>
<td>4.04</td>
<td>1.038</td>
<td>2</td>
</tr>
<tr>
<td>Making use of inexperienced consultants by the client</td>
<td>4.01</td>
<td>0.903</td>
<td>3</td>
</tr>
<tr>
<td>Inability to interpret drawings by technicians.</td>
<td>3.96</td>
<td>1.074</td>
<td>4</td>
</tr>
<tr>
<td>Wrongly interpretation of working drawing communication method</td>
<td>3.96</td>
<td>0.948</td>
<td>4</td>
</tr>
<tr>
<td>Lack of site inspection</td>
<td>3.92</td>
<td>1.012</td>
<td>5</td>
</tr>
<tr>
<td>Unclear channel of communication</td>
<td>3.90</td>
<td>1.007</td>
<td>6</td>
</tr>
<tr>
<td>Lack of regular site meeting between the project teams</td>
<td>3.87</td>
<td>1.121</td>
<td>7</td>
</tr>
<tr>
<td>Unclear understanding of project information between project team</td>
<td>3.85</td>
<td>0.931</td>
<td>8</td>
</tr>
<tr>
<td>Unavailability of the principal officer who can take a decision during site meeting.</td>
<td>3.83</td>
<td>1.020</td>
<td>9</td>
</tr>
<tr>
<td>Quality documentation</td>
<td>3.81</td>
<td>0.909</td>
<td>10</td>
</tr>
<tr>
<td>Availability of regular documentation</td>
<td>3.71</td>
<td>0.984</td>
<td>11</td>
</tr>
<tr>
<td>Unavailability of the contractor representative regularly during site meeting</td>
<td>3.65</td>
<td>1.081</td>
<td>12</td>
</tr>
<tr>
<td>Unavailability of the consultants’ representative regularly during site meetings</td>
<td>3.64</td>
<td>1.114</td>
<td>13</td>
</tr>
<tr>
<td>Inaccurate bill of quantity provided by the quantity surveyor</td>
<td>3.62</td>
<td>1.112</td>
<td>14</td>
</tr>
<tr>
<td>Project team dispute</td>
<td>3.53</td>
<td>0.954</td>
<td>15</td>
</tr>
<tr>
<td>The Language used by project teams.</td>
<td>3.39</td>
<td>1.049</td>
<td>16</td>
</tr>
</tbody>
</table>

Source: Author fieldwork (2016).

The finding from the present survey is in support of the previous researchers. In the study of Tipili et al., (2014) and Affare (2012); poor and distorted information, inexperience interpretation of working drawings, unclear channels of communication, and late dissemination of project information, lack of regular site meetings are all factors that contribute to ineffective communication which often leads to project delays, cost overrun, project abandonment and project failure. As agreed with the work of Gorse and Emmitt (2003) that said poor communication, lack of consultation and inadequate feedback are to be found as the cause of shortcomings in many construction projects. Having ranked the ten most important factors that causes ineffective communication in construction project from the study, it is evident that the factors identify were as well confirmed in the study.

However, the least factors ranked as the cause of ineffective communication from the study are as follows;

Unavailability of principal officer who can take decision during site meeting (\( \bar{x}=3.83; SD=1.020 \)); Quality documentation (\( \bar{x}=81; SD=0.909 \)); Availability of regular documentation (\( \bar{x}=3.71; SD = 0.984 \)); Unavailability of contractor representative...
regularly during site meeting (\(\bar{x}=3.65; SD=1.081\)); Unavailability of consultants’ representative regularly during site meetings (\(\bar{x}=3.64; SD =1.114\)); Inaccurate bill of quantity provided by the quantity surveyor (\(\bar{x}=3.62; SD =1.112\)); Project team dispute (\(\bar{x}=3.53; SD =0.954\)); and the least factor ranked is language used among project teams (\(\bar{x}=3.39; SD=1.049\)). Findings by Affare (2012) were in agreement that language used among the project team is the least ranked factor that can cause ineffective communication among the project team. Meanwhile, contrary from Tipili et al. (2013) language problems were ranked second to the least and training of operative was ranked the last. Although, in the work of Emuze and James (2013) language was stated as the most important factor that can have effect in construction projects communication, also the study of Loosemore (2002) acknowledged language as the fifth important barriers that needs to be addressed to improve communication in order to achieve performance in Singapore construction project. Therefore, both studies by the scholar were in disagreement with the report in this study. The reason for this in Nigeria construction project may be because they all speak the same language which is English and that is the main official language.

**CONCLUSIONS**

In the study of factors that causes ineffective communication among project team in construction, the results show that most of the factors are all causes or problems that make the communication to be ineffective, the factors are wrong interpretation of working drawing, late circulation of project information, unavailability of project, unavailability of both contractor and consultant, poor communication, lack of site inspection, availability of document, communication method and unclear communication channels as the challenges. Lack of regular site meeting, the language used among project team, and inaccurate bill of quantity are the fewer factors. Though based on the literature review or speculation one will consider language will be a major issue but with this survey, it has proved that is different among project team in Lagos Nigeria. The study provides project team in the construction projects the factors that are responsible for ineffective communication, and that can be a hindrance to the communication flow among the project team. Furthermore, it is recommended that emphasised should be on drawings that are clear, and the use of competent contractors and consultants should be ensure; communication method should be clearly defined from the inception of the project and information should be readily available to time to avoid project delay and dispute. Effective communication is necessary for construction project team through every stage of construction projects.

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THE APPLICATION OF EMERGING TECHNOLOGIES IN THE MEASUREMENT OF PRODUCTION AND PRODUCTIVITY DATA ON CONSTRUCTION SITES

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Timely and accurate production and performance measurement is a key foundation for successful project management. Some commentators argue that current industry practices fail to provide dependable insights that project stakeholders require. Emerging technologies represent a significant opportunity to improve extant construction management processes for data collection and production tracking in support of project management goals. This research pursues a design science research approach to develop a technology artefact that combines mobile computing and real-time location sensing hardware to capture real-time production and performance data including the context of location and worker movement. These datasets are combined in a bespoke visual analytics environment to communicate real-time insights to construction management stakeholders to effect construction management outcomes. The technology artefact development is described and lessons learned from deployment and testing on an active case study project are shared.

Keywords: automation, mobile technology, real-time location sensing, visualisation

INTRODUCTION

The construction industry is defined by stagnating productivity relative to other industries (Agarwal et al., 2016), while sectors that have embraced innovation and innovative practices have seen significant improvement in performance (Goodrum and Haas, 2004). Recent reports issued by public and private sector organisations have highlighted the challenges facing the industry in terms of poor productivity, and opportunities for improvement (Agarwal et al., 2016, Green, 2016, World Economic Forum, 2016). These conclude that automation and digitisation of construction management (CM) processes represent a significant improvement opportunity for the industry. Innovation, digitization and the greater deployment of technology to construction has, for many years, been quoted in the academic and non-academic literature as a solution to pervasive challenges impacting the industry (Brynjolfsson and Hitt, 1996, Thomas et al., 2004, Dong et al., 2009, Froese, 2010, Armstrong and Gilge, 2016, Omar and Nehdi, 2016).

Concurrently, there is a significant increase in both the creation and the use of data in society, and the extent to which data is improving the efficiency and productivity of industry and organisations (Manuel et al., 2016). There are concerns, however, around the manner in which data can support, or cloud, decision making in CM (Froese, 2010, Armstrong and Gilge, 2016), and whether technology deployment in the industry creates additional complexity. A frequent observation of the data ecosystem in construction is that it is siloed, disconnected, and complicated (Bowden et al., 2006, Nitithamyong and Skibniewski, 2006, Pusadkar and Kambekar, 2015).

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Challenging the industry’s current utilisation of data is the increasing availability of technology solutions developed specifically for construction (Froese, 2010), including mobile, cloud based software and hardware offerings.

These complex tools have the potential to create additional silos of data, and further complicate the realisation of value from the deployment of technology within the industry. For technology and innovation to empower positive disruptive change in the industry, the way that construction companies leverage both the technology and the data that they deliver must take into consideration the specific context of the CM environment (Armstrong and Gilge, 2016).

There is clearly a paradox here: Technology represents both an opportunity and a risk to the construction industry.

**RESEARCH METHODOLOGY**

**Introduction to the Research Project**

This work involves a collaborative engagement between a small technology company and a large international general contractor (GC) to develop a technology artefact to accurately measure prefabrication production and to permit comparison with traditional stick built construction on a large healthcare facility construction project. Specifically, the GC was challenged by the project owner to determine new and innovative ways of gathering and communicating project cost and production data.

Prefabrication is an alternative approach to construction where modules and construction elements are fabricated offsite in a more controlled and predictable environment (Jaillon and Poon, 2014). Prefabrication has been shown to deliver increases in performance (Tam et al., 2007), however it is important to monitor the works to assure that prefabrication does not introduce additional constraints and challenges (Jaillon and Poon, 2014).

The research involved measuring the prefabrication of 205 modular elements on a longitudinal basis over six months, creating the opportunity to benchmark production and identify learning curves, cycle time, variance and non-value added tasks across a range of prefabrication tasks. Reliable measurement of production was considered by the GC team to be challenging if using traditional, manual timekeeping and production tracking. Paper-based methods and closed circuit cameras were considered as an option, but both were discounted as being too labour intensive.

This work builds upon recent work (Moon and Yang, 2010, Razavi and Haas, 2010, El-Omari and Moselhi, 2011, Razavi and Haas, 2011, Guarnieri et al., 2013, Liu et al., 2013, Maalek and Sadeghpour, 2013) to test whether mobile computing technology (Chen and Kamara, 2011) and ubiquitous, real-time location sensing hardware (Zekavat et al., 2014, Omar and Nehdi, 2016) can combine to create a technology artefact that improves the collection, analysis and communication of construction production and performance data.

**Research Aim**

The research aim is summarised as the iterative development and testing of a technology artefact to fulfil the requirements included in Figure 11 below:
Research Framework

The research employs a design science research framework. Design science is a commonly applied within the fields of information systems (IS) and software development (Holmström et al., 2009) and reflects the iterative nature of technical artefact development to solve ill-defined socio-technical problems. Its popularity as a framework for research with a problem-solving perspective (Piirainen et al., 2010) is growing.

The phases of the research framework deployed in this research, modified from (Peffers et al., 2007), is described below:

Phase 1: Problem Definition and Motivation

This phase involves defining the problem and justifying the value of a solution. Problem definition aids in the identification of the underlying principles and functional requirements of the artefact, and confirms that the artefact can meet the objectives of a solution.

Phase 2: Establish Objectives

Establishing objectives requires understanding the CM constructs underpinning the artefact development and the problem definition, empowered by a comprehensive knowledge of what is possible and feasible (Peffers et al., 2007).

Phase 3: Review of Knowledge Domains

A design science artefact is any object in which a research contribution is embedded in the design (Peffers et al., 2007). Design science therefore requires designs that are tightly coupled with extant theory. Literature reviews determined previous applications of the artefact components and incorporated characteristics of prior research into the planning, development and deployment.

Phase 4: Design, Develop & Iterate on Technical Artefact

This phase involves the design, development and deployment of the artefact. Included in this phase is establishing functionality, system architecture, including software and
hardware instantiations, technical parameters and all necessary installation, commissioning and testing.

Phase 5: Case Study Demonstration

This phase involves a case study demonstration of the artefact to solve the problem definitions. Important general considerations are resolution of planned and actual data arising from the deployment to identify if and how the artefact contributes to the resolution of the problem definition.

Phase 6: Evaluation & Communication

The evaluation phase assesses how the artefact supports the problem definitions (Peffers et al., 2007). This involves a review of the artefact behaviour in terms of the research aims and objectives in the context of the case study results. Peffers et al. (2007) highlighted that evaluation can take many forms, and is highly contextual. It can be objective and quantitative in nature, or subjective and qualitative in approach. Communication involves an assessment of the manner in which the artefact and its deployment contributes to CM theory, and a means of sharing the outcomes of the research to inform the practitioners of CM in industry more generally.

RESULTS

This section represents the evaluation and communication phase of the design science framework and presents the technology artefact development, deployment and testing in the context of the project case study objectives. It is not an empirical validation of the production data.

To facilitate assessment of the results the research case study objectives are indicated in figure 2 below:

<table>
<thead>
<tr>
<th>Objective 1</th>
<th>Objective 2</th>
<th>Objective 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop &amp; Test Technology Artefact</td>
<td>Measure Prefabrication &amp; Traditional Construction Tasks</td>
<td>Identify Contribution to CM Processes &amp; Theory</td>
</tr>
</tbody>
</table>

Figure 2: Summary of Case Study Objectives

Objective One: Artefact Development & Deployment

The artefact comprised hardware and software components that were commercially available but otherwise disconnected and non-integrated. A significant developmental challenge was to design a systems architecture that supported the combination of both mobile computing and real-time location sensing (RTLS) to deliver accurate project data. This was achieved via the development of a bespoke instantiation for the case study technology involving resident servers and cloud hosted database solutions to capture and host the project data.

While this represented a significant challenge in the context of this research, it is not, in and of itself, an insurmountable information systems challenge, leveraging open source and
widely utilised cloud-based systems, database architecture and programming languages. It is appropriate to state that these technical resources are beyond the scope of most construction companies, and certainly most projects, but as an initial development, future iterations can serve to become more scalable and deployable.

**Installation Challenges**

Installation challenges arise from the need to install permanent network and power connections in temporary and changeable work areas. The artefact relied on network switches to provide power to RTLS beacons which were regularly disconnected by craft workers in need of temporary power.

Future deployments will benefit from early incorporation into project design of temporary power connections to facilitate installation of anchors. Network cabling remains a challenge, however, it is anticipated that advances in mesh-networking will overcome some of these, resulting in installations with less initial infrastructure and requiring less maintenance.

**Deployment Challenges**

Deployment challenges were complicated by several factors:

Mobile computing: The smartphone and mobile application component of the artefact was designed to assure ease of use, with a digital representation of the work breakdown structure that would be easily understood by the workers engaged in the study.

Training materials were developed by the author to facilitate deployment. Training sessions were given to workers and supervision on two separate occasions. Training materials were installed in the work area showing in detail the mobile computing steps required to use the technology.

Batteries on the RTLS beacons and the smartphone would operate for one shift before expiring so a daily charge was required. This required infrastructure be installed in the work area for craft to charge both devices daily. This is a significant limitation of the artefact, as there is no system redundancy for collecting data if the batteries in either device expire.

Privacy concerns abound with the deployment of this technology. Ubiquitous personnel location tracking has not been deployed extensively in the United States; in fact, the craft workers had not heard of the concept prior to engaging in the study. To protect participants in the study, the location data was anonymised. At no stage, could the data be used to associate worker identity with location information. This is an important characteristic of the system moving forward, as adoption and uptake is highly contingent upon acceptance by the workforce, and is a key element of the ethical application of technology deployment in the industry, although this aspect of discussion has not been extensively covered in this research.

**Artefact Summary**

In summary, the artefact functioned as intended and objective one was met. Future artefact iterations must address the socio-technical issues identified around installation challenges, system redundancy and craft adoption.

**Objective Two: Project Performance Monitoring Data**

Objective two requires that the artefact measure prefabrication and construction production. This evaluation presents data and production trends obtained from the artefact. This graph represents production data for prefabricated and stick-built bathroom pods.
Figure 3: Mean Duration for Prefabrication Tasks

Figure 3 represents the mean construction duration of prefabrication tasks measured by the artefact. What is important to note is that this is a higher level-of-detail that the GC planned to measure prior to the artefact evolution, which was intended to track at the per-module level. That the artefact was capable of measuring consistently at this level of granularity is testament to the ease-of-use and the design such that workers could record production data. There is some error to be expected in the data, and this has not been empirically validated as there was no control.

Figure 4 below indicates the improvements of the optimised prefabrication, represented by the bathroom pods that exhibit minimal improvements and consistent production durations, compared to a baseline of non-optimised modules, which are represented by the initial 20% of prefabricated bathroom pods. The data indicates that the optimised prefabrication modules required 44% less time to construct than initial bathroom pods. While this is to be expected based on process learning, this curve is further validation that the artefact can generate insightful data in support of CM outcomes.

Figure 4: Learning Curve Improvements for Bathroom Pods (All Trades)
Traditional Stick-Built Construction Data

The case-study involved a comparison of prefabrication with traditional stick built construction. In the case study, one-bathroom pod was constructed in the main hospital floor using traditional processes. This was considered a benchmark, albeit not a statistically significant control, against which prefabrication durations could be compared. This is an important aspect of the artefact evaluation to determine whether the artefact has relevance beyond the well-controlled environment of prefabrication operations, and in wider construction.

Figure 5 shows mean prefabrication durations compared to traditional construction. It indicates that prefabrication exhibits significantly favourable construction durations for carpentry tasks than traditional construction. This not an empirical evaluation of the methods, but further evaluation of the ability of the artefact to deliver CM insights. Figure 6 combines prefabrication and traditional construction data to indicate the time savings of prefabrication over traditional methods, indicating that traditionally built modules require 48hrs/unit, while the mean duration to prefabricate a bathroom pod is 30.9 hrs/unit.

Objective three: Construction Management Process and Theoretical Contributions

The results presented hitherto support a successful evaluation of the artefact for the objectives one and two of the research. Objective three requires demonstration of application that contributes to construction management insights and theory.

Activity/Work Sampling

The introduction to the paper highlighted the opportunity to improve activity sampling through the generation of real-time insights in a manner which delivers additional context, and contributes to the creation of a contextually aware system (Khoury and Kamat, 2009).

The artefact successfully provided two key contextual elements required of work sampling. The first being total distance travelled by a worker while engaged on a task, while the second is reliable measurement of time at the workface.

The theoretical contribution of this work therefore is that real-time RTLS data coupled with real-time production data gathered from the workers combines to deliver significant improvements in work sampling approaches. The artefact creates a spatio-temporal relationship between task and motion that can be used as a proxy for productivity and performance within construction management systems. The following results indicate the evolution of this construct.
Figure 5: Prefabrication vs. Traditional Construction: Mean Activity Durations

Figure 6: Comparison of Prefabrication with Traditional (Stick Built) Construction Unit Rates

Figure 7 indicates the location of craft workers for all tasks associated with a prefabricated module. Figure 8 indicates location for a traditionally built bathroom pod in the main hospital floor. For the prefabricated bathroom pod the total construction duration was 18.3 hours and a total distance travelled of 2.9 miles. For the traditionally constructed bathroom pod the total time was a substantially larger 58.7 hours with nearly 13 miles covered over the course of its construction.
Figure 7: Artefact Work Sampling Output for Bathroom Pod Prefabrication

Figure 8: Artefact Work Sampling Output for Traditional Stick Built Construction

Figure 9 below shows an initial heat map showing aggregation of time proximal to the traditional bathroom pod in the main hospital floor with the added context of distance travelled. This figure indicates how the separate contextual elements gathered by the artefact could be incorporated into CM analytics.
This work has shown that it is possible to generate a contextually aware system that identifies waste. It creates a new paradigm for construction management where location and movement data passively obtained from workers engaged in work tasks, contextualised by real-time task and production data gathered from mobile computing, creates a proxy for production and performance measurement.

CONCLUSIONS

The challenge in this research was to develop a technology solution to resolve some outstanding and critical issues impacting the ability of the industry to benchmark performance. The nature of construction is such that while measurement is understood to be important, reliable systems that support performance measurement have not evolved to account for increasing industry complexity or needs.

Design science represents a viable approach for developing technology artefacts that are bounded in the situational realities that they are trying to improve. As a tool to solve real-world socio-technical challenges in dynamic and complex situations it is well suited for the development of technology artefacts within the industry where the fragmented and changeable nature of the industry makes the iterative process inherent in design science flexible, pragmatic and relevant.

In this work, design science was the foundation for a successful partnership of technology, industry stakeholders and researcher to solve a real-world challenge impacting an ongoing construction project. The technology artefact addressed the research aim conclusively, and has been recognised by the project manager as exceeding his needs for data, supporting positive changes in CM outcomes, and representing a viable tool for further development and deployment. It provides further indication of the potential for technology to positively influence outcomes on construction projects.

Future areas of focus for this work involve further integration of location sensing technology into other areas of construction management. Location is a fundamental part of lean construction where pull planning, location-based management and area-based scheduling rely on the importance of location in their underlying methodologies. That location can be passively recognised and feedback mechanisms developed that can
automate and improve these processes represents significant opportunities to empower extant processes.

Insofar as the privacy concerns arising from RTLS use have yet to be resolved, they represent a significant risk. This is an aspect that requires careful attention for anyone looking to further the research via the deployment of location sensing technology. The importance of anonymity and respecting workers during the artefact development was a key learning outcome from this case study deployment, although was not the result of empirical or qualitative measurement, but anecdotal experience based on multiple ad-hoc engagements with craft workers during the deployment.

REFERENCES


ADVANCING PREDICTIVE INDICATORS TO PREVENT CONSTRUCTION ACCIDENTS

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This discussion paper presents the concept of using predictive indicators and data analytics to identify and prevent future construction accidents and injuries. All contractors in the United States employing more than 10 people are required to collect and report work related safety and health incidents to government agencies. Often this is the extent of the health and safety data collected. Industry may compile this data into spreadsheets to conduct minor analysis and reporting. Through a literature review and a sampling of contractors the findings suggests that a key gap exists in awareness, identification, and utilization of predictive indicators and minimal use of data analytics for predictive purposes. Recommendations suggest that construction professionals and academics transform the discussion of leading indicators into predictive indicators and use data analytics for future incident forecasting and injury prevention.

Keywords: accident prediction, construction safety, leading indicators, predictive analytics, predictive indicators.

INTRODUCTION

Safety in construction
In the United States, construction is one of the largest industries, employing approximately seven million workers (BLS (a), 2017). Additionally, the construction industry has one of the highest rates of occupational health and safety fatalities. In 2006, there were 1,276 deaths in the United States (US) construction industry. In contrast, there were 780 fatalities in 2010, which represents the lowest number in recent history. However, this downward trend has not sustained, as the number of fatalities increased in 2015 to 937 reported fatalities. From 2010 to 2015, the fatality rate recorded translates to a 17% increase across the US construction industry (BLS (b) 2017). The construction industry routinely collects data and monitors trends and incidents; however, the high fatality rates suggest that the reporting of data is doing little to decrease the number of fatalities, suggesting there may be better ways to maximise the capacity of the data to enable reliable and timely incident prediction.

Reporting requirements
All US contractors employing more than 10 people are required to collect and report work related safety and health incident data to government agencies. Often this is the extent of the health and safety data collected by many constructors. Safety management professionals refer to these incident data as “lagging indicators”, and the

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data collected effectively lags behind the injury. Employers report injury and illness lagging data according to the OSHA 2017 standard:

- Log of work-related injuries and illnesses including the extent and severity of each case,
- Summary of work-related injuries and illnesses, and
- Injury and illness incident report.

At the project level, this data collection includes person, dates, description of injury, case relevant information, days away from work/restricted time (DART), and identification of injury or one of five illness categories. Also required is an Occupational Health and Safety (OSHA) calculation of incident rate (IR), also known as the total recordable incident rate (TRIR). Additionally, OSHA requires injury severity be reported to allow for a severity rate (SR) calculation. This after-incidence data capture offers little in preventing the originating occurrence, and thus has questionable value in predicting future incidents. Companies with 10 or less employees are required to only collect and report all work-related fatalities, all work-related in-patient hospitalizations, all amputations, and all losses of an eye within 24 hours.

The limitation of this approach is that companies collect incident-based data to comply with government reporting regulations, but do very little proactive manipulation with the data. Companies collect leading indicator data, yet it does not make its way back to the project in a meaningful manner. Leading safety indicators measure attitude, behaviours, practices, or conditions that influence construction safety performance. In effect, these leading indicators (LI) are a proxy for safety culture. Examples are the number of safety audits and training sessions done companywide, the number and frequency of safety meetings, and near-misses. This project level data is rolled up from project to company and then becomes a company’s leading indicator of safety performance. While this provides useful company data, its benefits are limited if not analysed in the context of the specific project as it lacks the potential to impact on accident prediction and subsequent prevention.

With the advent of powerful data-modelling and diverse construction safety data sets, future workplace injuries, and their severity can be reliability and accuracy predicted. However, current industry practices reflect a data management focus on lagging and leading indicators, and not on using predictive modelling for accident prevention.

**Moving from Leading Indicators to Predictive Indicators**

The definition of leading indicators varies among industry professionals. Several agreed upon components of the definition are that leading indicators are predictive and proactive (Hinze, Thurman, & Wehle 2013; Wurzelbacher, & Jin 2011), and preventative (Toellner 2001). The Campbell Institute (2013, p.7) defined leading indicators as “proactive, preventative, and predictive measures that monitor and provide current information about the effective performance, activities, and processes of an EHS management system that drive the identification and elimination or control of risks in the workplace that can cause incidents and injuries”. Given these definitions, there is a possibility that LI data can be used to predict accidents.

LI’s fall into two categories, with the first described as passive and second described as active. Passive leading indicators are safety strategies implemented before the construction phase begins intended to set up project success. Active leading indicators are safety related practices or observations measureable during the construction phase.
and able to be adjusted triggering positive responses (CII 2012). Recording and analysing active leading indicators on a project is recognition of their usefulness in a predictive, proactive, and preventative manner that offers an opportunity to avoid future project injuries, and fatalities. Hallowell, Hinze, Baud, & Wehle (2013) suggest that organizations with mature safety management processes have opportunities to extend this strength into a predictive leading indicator strategy by moving into an operational strategy that establish metrics and proactive responses. Lingard, Hallowell, Salas, & Pirzadeh (2017) tempers this by identifying that leading indicators have a complex cyclic interdependency, and that over a time period leading become lagging indicators and lagging become leading indicators. For example, as the number of inspections increase, incidences decrease. Over time as the number of incidences drop, the number of inspections also drops and the venomous cycle renews; incidences go up and the number of inspections increase in reaction to the rise in incidences. This cyclic predictability can also be useful in establishing a mechanism to analyse and predict project level accidents.

**Moving Toward a Discussion of Predictive Indicators**

Predictive analytics is a statistical modelling and analytic technique that can predict future events or behaviors (Nyce 2007). With appropriate indicator data, predictive analytics can predict project accidents about to happen. Predictive analytics incorporates the sciences of mathematics, probability theory, statistics, and computer science. Recent research using predictive analysis has focused on data mining and the identification of leading indicators to support predictive power in purchasing and sales (Siegel 2013). Predictive analytics is a systematic approach to quantifying data over time to granulate with higher levels of probability-associated risks. The fundamental technique used to conduct predictive analytics is focused on artificial intelligence and data modeling. This predictive analytic process systematically progresses through data collection and reporting (what happened), analysing (why it happened), monitoring (what is happening now), and the predictive analytic probability of incidence occurrence (what will happen). The power of predictive analytics provides organizations the capability to transition away from imprecise measures such as high/medium/low assessments to a numerical probability related to independent leading indicator variables (Liebowitz 2015).

Using a predictive analytics approach, Deloitte & Touche LLP (2014) investigated several thousand-safety incidents over a five-year period and tracked over 1.5 million employee workdays for one specific mining company (Stewart 2013). The data collection covered operations data, weather, production, demographics, economic factors, marital status, residential location, injury rates, age, tenure, job roles, safety training and attendance, absenteeism, and more, totaling over 792 million data points. Deloitte & Touche LLP (2014) analyzed the data and was able to predict a specific “pool” of high-risk employee conditions and behaviors. Because of this “big data” investigation, the subject company had the ability to revise its safety methodologies in an effort to minimize incidence risks.

**AIM**

The aims of this discussion paper are to further the conversation on transitioning from leading indicators to predictive indicators and to access the readiness of collecting predictive indicators on construction projects. For the purposes of clarifying the discussion, predictive safety indicators are indicators that are measurable, actionable, function at the project level, and have high correlation in predicting the future
occurrences of accidents, injuries, and/or fatalities. The intent of this paper is to identify predictive indicators having the greatest impact potential to improve project safety while minimizing data collection burdens and costs. By identifying and transitioning leading indicators into predictive indicators, management’s capability to proactively address and analyse more significant data streams can lead to more accurate and reliable incident predictability.

METHOD

A two-tiered investigative method is used to advance the discussion of collecting project-based predictive indicator data and using predictive analytics to analyse the data to prevent accidents and prevent injuries and fatalities. First, a critical review of academic literature, industry reports, government reports, organizational and consultant white papers, and trade literature to collect support data. Second, to access the ease of collecting predictive indicators on construction projects the authors conducted structured interviews with safety directors from three US construction companies as a pilot for future study. The interviews used an identical set of closed and open-ended questions followed by conversation and feedback. Two of the three contractors are self-performing general contractors, responsible for over $7 billion annual construction and the third contractor is a HVAC contractor employing over 1000 workers. The author has considered that three large self-performing national contractors with sophisticated safety cultures was an adequate sample to determine if predictive indicator project data is collected.

The literature review and structure interviews were framed using five criteria:

1. What safety data sets are commonly collected,
2. Can leading indicator analysis be used to predict future safety incidents,
3. Can predictive indicators be determined and identified,
4. If predictive indicators are routinely collected on company projects,
5. How collected safety data is monitored and analysed.

FINDINGS

At present there is limited academic literature involving predictive analytics in construction safety. Øien, Utne, & Herrera (2011) developed a conceptual framework on predictive risk indicators that address both safety and risk as early warning indicators. A leading indicators survey by Campbell Institute (2013, p.8) conducted among 18 safety experts representing multiple industries, including construction, confirmed that leading indicators are important to their organizations and actively used to anticipate, prevent or eliminate risks and enhance organizational safety performance.

Salas and Hallowell (2016) explore impact capacity rather than accident prediction in the oil and gas industry safety. Their study identified six leading indicators, 1) near-miss reporting, 2) job safety analysis (JSA) development, 3) JSA engagement, 4) contractor safety audits, 5) contractor project manager engagements, and 6) contractor safety representative engagements that are significant influences on incident rate (IR) and severity rate (SR). In later research covering a 5-year project, Lingard, et. al. (2017) conclude that leading indicators measured at one point in time may not be leading predictors of safety outcomes later. Lingard, et. al. (2017) discovered that as IR fluctuated up/down, they in turn influenced the frequency of subsequent safety
management activities and created a cyclical effect in safety management and IR. As a result, they suggest a rethinking of the types of safety indicators collected.

Other literature proposing and identifying predictive analytics in construction safety involves trade based articles or commercial white papers offering aspects of future accident predictability and thus the capability to take preventive action (Predictive Analytics 2012; Lartonda 2014). Predictive Solutions (2012) in conjunction with results from work done with Carnegie-Mellon University advocates “four safety truths” as predictors of workplace incidences, claiming accuracy levels of between 80-97%. Interestingly, this work appears consistent with the Lingard, et.al. (2017) conclusion that leading indicators may become lagging and that the traditional value discussion of leading and lagging indicators should give way to a discussion of predictive indicators. Predictive Solutions (2012) conclusions are also consistent with Salas and Hallowell’s (2016) identification of work in progress risk management, workforce engagement and monitoring, and leading factors as having the greatest value as predictive indicators.

Table 8: Moving to Predictive Indicators

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Lagging Indicators</td>
<td>Identified LI’s Matching PI’s (Lingard et.al. 2017)</td>
<td>Impacting LI’s (Salas and Hallowell 2016)</td>
<td>Impacting PI’s (Predictive Solutions 2012)</td>
<td>Routinely Collected Project Data Matching PI’s</td>
</tr>
<tr>
<td>Incident rate (IS)</td>
<td>Number of safety audits</td>
<td>Number of safety audits</td>
<td>Number of safety audits</td>
<td>Number of safety audits</td>
</tr>
<tr>
<td>Severity rate (SR)</td>
<td>Number of safety inspections</td>
<td>Contractor PM engagements</td>
<td>Number of inspectors</td>
<td>Number of inspectors</td>
</tr>
<tr>
<td>Days away from work, (DART)</td>
<td>Non-compliance</td>
<td>Contractor safety rep engagements</td>
<td>Diversity of inspectors</td>
<td>Diversity of inspectors</td>
</tr>
<tr>
<td>Workers compensation</td>
<td>Hazards reported</td>
<td>Job safety analysis development</td>
<td>Number of unsafe observations</td>
<td>Number of unsafe observations</td>
</tr>
<tr>
<td>Experience modification rate</td>
<td>Hazards closed out</td>
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<td>Near-miss reporting</td>
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<td>Citations</td>
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</table>

For advancing the discussion on predictive indicators, Table 1 identifies a transformative migration from lagging to an alignment of leading to predictive indicators. Column 1 identifies lagging indicators identified through the literature and verified by the pilot study contractors as being collected. These indicators are necessary components in measuring project safety outcomes to determine if incident rates are declining. Without this reference point, there is no basepoint and it is difficult to measure overall injury and incident reductions. Columns 2 and 3 are parsed results of the two recent studies that have quantified leading indicator’s influence and impact on injury rates and then aligns them with Impacting PI’s (column 4).

Column 5 is a result of parsing the responses of project-level safety data routinely captured by the three sample contractor organisations. This done to determine if there is alignment with any predictive indicators as identified in the literature. It is evident that routinely captured project safety data column 5, aligns well with both Salas and
Hallowell ‘Impacting LI’s’ and Predictive Solutions PI’s (columns 3 and 4). One can surmise and successfully argue that Impacting LI’s and Impacting PI’s (columns 3 and 4) are so closely aligned they are the same data with a different name.

DISCUSSION

The two aims of this paper were to further the conversation on transitioning from leading indicators to predictive indicators and to assess the readiness of collecting predictive indicators on construction projects. Concerning the first aim, there is evidence through industry and trade literature that industry has an awareness of predictive analysis as a safety management tool, and appears to moving toward this objective. Yet the academic literature appears non-existent. Some interest in using predictive analysis as a safety management tool by the US National Institute of Occupational Safety and Health is evident (NIOSH (Wagner 2014). Yet, since this 2014 posting, there has been little additional NIOSH activity. Thus, there appears to be scant literature and research activity on predictive analytics as a safety management tool.

Results are mixed regarding the aim of accessing the readiness of collecting predictive indicators on construction projects. Based on the results of the industry pilot sample there is limited to non-existent use of predictive techniques as a preventive safety management technique. One of the sample companies is using a predictive analytics approach and is still finding its role in their overall safety management program. The other two companies were aware of the concept but knew little on its implementation.

Findings suggest that a key gap exists in the identification and utilization of predictive indicators and a minimal use by the construction industry of data analytics to identify and predict potential project safety related incidents. All three companies in the sample maintained an in-house database but conduct limited analysis. This analysis consists primarily of trend analysis on incident identity and event frequency. From the sample results, there is an absence of industry usage involving correlation among indicators and incidents.

Using predictive analytics to assess project-level predictive indicators will yield a positive and sustained improvement on project level safety. Therefore, senior leadership is encouraged to integrate data collection and hazard analysis toward predictive indicators.

Hale (2009) articulates that useful safety management indicators need to be valid, reliable, sensitive, not be an indicator that can unfairly manipulate the scores, representative, and cost-effective. Although the literature has identified a wide range of leading indicators, each organization must identify their own leading versus lagging indicators and push their leading indicators forward to become predictive indicators. This is a function of the individual organization’s safety culture, maturity, and leadership.

A common challenge to the implementation of leading indicators is arriving at a common consensus of which indicators to measure and the skills and knowledge needed to implement studies from both computational standpoints and analytical synthesis, i.e. interpreting the results. This challenge compounds when one begins to assign specific indicators predictive powers capable of real time alerts of future incidents. Findings reveal that although industry collects and records predictive indicators as leading indicators they are underutilized for accident prediction purposes.
Regardless of company size, particularly in larger companies with hundreds of employees, extending data collection beyond OSHA required injury and fatality data could be overwhelming and thus resisted. Therefore, benefits returned by the addition of new data collection tasks requires defendable articulation.

**CONCLUSIONS**

Table I has identified leading and predictive indicators that have a positive impact on reducing incident rates. Also apparent from this study is that some fundamental and routinely collected project safety data are predictive indicators and thus the conversation needs to shift from leading indicators to the analytical use of predictive indicators.

There is evidence that predictive analytics is a successful science for predicting individual and group behaviours in many industries. There is no reason to believe that the same science cannot prevail within the construction industry. Therefore, there is an opportunity for forward thinking leadership to advance safety predictability to a science. Missing in the world of injury prediction in construction are the following elements: 1) easy to use computational tools, 2) identification and awareness of the appropriate indicator data that correlate with future incidence occurrence, 3) the ability to “read” and interpret the data, and 4) leadership’s ability to trust and act on predictive data.

From an academic perspective, there are many avenues of research including validating predictive indicators, finding the sweet spot in cost and time investments to maximize predictive pursuits, software developing for computational predictive analysis tools, case studies on injury prediction successes or incident reduction, and development strategies for aiding personnel in reading and analysing the computational results.

Although the inevitable argument surrounding the use of predictive analytics and validity of a predictive solution is proving something was prevented that never occurs. Nevertheless, the effort is well worth the prospect of eliminating death on the job.

**REFERENCES**


IMPROVING INFORMATION QUALITY AND COMMUNICATION EFFECTIVENESS IN HEALTH AND SAFETY MANAGEMENT OF REFURBISHMENT PROJECTS – A CASE STUDY APPROACH

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Alteration and refurbishment of buildings are fast becoming the norm in many urban centres around the world. This is underpinned by the need to upgrade buildings in order to both expand their capacity and/or improve their performance structurally and energy-efficiently. In a vast majority of cases, the buildings are usually existing spaces which could only be vacated for a fixed period of time for such works. This requirement means tighter timescales and strict budgetary provisions. However, it also implies that health and safety (H&S) management must be innovative in conceptualisation and implementation so as to ensure the desired degree of performance. Managing and communicating information qualitatively and effectively is therefore key to ensuring that a commendable H&S performance is achieved. With the advent of Building Information Modelling (BIM), information management is significantly enhanced and this thus facilitates a better H&S management regime. However, the use of BIM and other associated technologies are not yet as widespread and particularly with the subset of the supply chain that undertake most common refurbishment works at the present time and going by the trend in the industry this is likely to persist for a longer time unless it becomes mandatory. This project therefore examined two projects in busy areas of London, UK that involved extensive refurbishment works. The methods adopted to manage H&S information are used to demonstrate good practice for the enhancement of information quality and effectiveness in the H&S management of such projects and under such design circumstances. A framework of information flow is proposed and recommendations that can enhance the applicability of this framework were also made as a precursor to possible future research work.

Keywords: Alteration, Communication, Framework, Health and Safety, Information, Refurbishment.

INTRODUCTION

There is a continuous need to upgrade older buildings in the UK and other parts of the developed world. This method of construction is fast becoming the norm and is forming a substantial part of the construction activities in those countries. This is because the ever increasing need to upgrade older buildings so as to achieve better functional usage and energy (or even) structural performance standards are growing. In a vast majority of cases, the buildings are usually existing spaces which could only be vacated for a fixed period of time for such works. This requirement means tighter timescales and strict budgetary provisions. Also, due to the fact that in many cases, such older buildings usually have very little information available on the as-built (or

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historical modification) status; there is a need to ensure planning of the proposed works is effective so as not to compromise health and safety in any way.

The need to adapt buildings and other structures to accommodate new uses and to upgrade building performance are major reasons for alteration and refurbishment projects (Fernandez, 2011). Also, alteration and refurbishment projects would normally entail a significant amount of demolition, extension and modification activities – above and beneath ground. In some rare cases, and especially on the older stock, such works involve complete demolition and building up again as a new build project (Oloke, 2015). In either case, however, research continues to show that this trend is likely to continue in the foreseeable future as the industry continues to address the requirements of sustainable development (Thiemann, 2010).

The planning of alteration and refurbishment construction projects involves complex activities such as understanding a brief, collecting and analysing various information sourced from different parties but relating to the existing and proposed structure (McAleenan and Oloke, 2015). Furthermore, all building end-of-lifecycle operations have safety risks due to the many unknown conditions of the building (Professional Guidance No. 43, 2015).

Stability checks are required for all structures in both their permanent and temporary states and this is to be communicated effectively throughout the project. An unstable structure has a potential to significantly displace under a small disturbing force and this can also escalate with time or additional disturbance. It has been established that many construction failures occur when elements of the structures are necessarily not interconnected, or in building refurbishment/demolition when stabilising elements have inadvertently been removed out of sequence (Professional Guidance No. 50, 2015). Structural safety evaluation is therefore very essential throughout the lifecycle of the project. The need for designers to communicate relevant information (including assumptions made) on drawings and other project specification documents is quite important and this contributes to the development of the risk register. However, alteration and refurbishment projects (depending on the age of the structure) require a continuous re-evaluation of the information so shared due to variations that usually arise observed as the works progress.

In many cases, traditional risk assessments are usually more concerned with the work method and associated health and safety concerns. However, a major underlying factor of hazards in alteration and refurbishment project is stability of structures and this varies as work progresses on a structure (Thoday, 2004). This study thus highlights a project life cycle concept utilised for ensuring structural stability throughout a project. It is based on case study information collected from two key projects in the London, UK area. The case studies revealed the difficulties in coordinating information on these types of project throughout the various stages. Typical amongst these is the challenge of specifying structural provisions and envisaging associated hazards based on the level of information available at various stages of the project and as such a project cycle approach is introduced as a means of addressing this need in alteration and refurbishment projects. The project cycle assumes a Post-Planning Approval stage of implementation of the project cycle that comprises all the project stages and the processes involved the project completion and hand over. The proposed framework also incorporates an information flow procedure that is envisaged to ensure the improvements in information quality and
communication as a precursor to an enhanced risk management procedure on such projects.

**THE PROJECT CYCLE APPROACH**

The project cycle developed for the purpose of effectively managing this health and safety information requirement involves the: brief, initial assessment, initial design, initial strip out, construction stage 1, complementary designs, construction stage 2 and project completion and hand over.

**Brief**

The first case study (Case Study 1) is the development of a hotel which occupies a prominent location in South London. The property includes substantial alterations to the rear and the inclusion of a mezzanine floor constructed over lower ground, raised ground, mezzanine and four upper floors and comprises 88 bedrooms with several meeting and conference rooms totalling approximately 3,142 sq m (33,811 sq ft) of floor space. Planning consent was granted for the erection of an additional storey in the form of a mansard roof, together with a 2 storey rear extension at 3rd and 4th floor levels and an extension at second floor to the rear elevation. The existing lift shaft has previously been constructed to allow for these extensions and therefore did not need to be altered. However, a new lift was incorporated to replace one of the existing staircases. The consented scheme was thus to add approximately 24% to the area of the hotel and substantially expand the floor space to approximately 3,908 sq m (42,085 sq ft). The number of bedrooms are envisaged to increase from 88 to 126. The works were programmed for completion in 24 months.

Figure 1 – Figure 3 show various elevations of superimposed existing and proposed views, whilst Figure 4 is a typical section of the project after the brief and initial design stage. The design information available at that point was used to create the original concepts with the assumption that the structural modifications proposed will be achievable. This second project (Case Study 2) is a development which required the alteration and refurbishment of the basement of an existing 5 storey office complex in London, UK. The basement was originally an office building which needed converting to a large functional area with toilet facilities. There was also the need to have a side extension that was to be underground and adjacent to the existing basement. This extension was to serve as private conveniences and wash rooms. The building belonged to an Embassy who used all the spaces for Consular services all year long. Amongst several other performance specifications, the project was set a time frame of six months and all floors above the basement were to be in full operation throughout the duration of the works. This fairly short duration and operational requirement imposed other health and safety challenges to the project execution. The client subsequently passed this information to the Architect through the Principal Designer and this was used to provide the initial proposed layout, work method and overall project strategy.

**Initial Assessment**

The initial assessment entailed the physical evaluation of the structure to ensure that the proposed plans corresponds well with the existing structure – especially if both plans were generated for the sake of the project. With the age of most buildings of this nature, existing plans are usually not available and even when they are, they might not
necessarily have captured all the existing structural information of the building. Intrusive and non-intrusive investigations are therefore used to ascertain the true state of the structure and most importantly establish load paths and probable working load capacities of the various parts of the structure. The two case studies used for this study and considerations made for structural safety are thus hereby discussed.

**Case Study 1: Hotel**
Internally, a general inspection of the structure was conducted to observe the condition of the structure. Specifically, the load bearing walls were inspected to assess their status. No obvious defects were noticed on the walls that were inspected at the ground floor and basement floor levels. This is significant as these members would be part of the load transfer process that would be relied upon by the modified structure. Externally, as many accessible sides of the building were inspected along brick courses, window cills, lintels and general fittings and fixtures that can enhance our understanding of the structure. In general, the external walls and components appear to have sound structural integrity as no real or visible cracks were observed. An intrusive operation was also carried out to check the construction of the wall at the basement level and also to determine the likely thickness of the wall at that level. It was established that the wall was indeed of brickwork construction. In terms of the foundation investigation, a 1x1 x1m deep trial pit was dug to ascertain the foundation type and depth. Two appropriate sites were selected. The foundation type was a shallow strip type on gravelly clay layer of soil. The analysis of foundation adequacy was thus conducted on the basis of this. The load take down assessment was carried out to determine the estimated line loads of the existing structure. The estimated maximum line load on the foundation as a result of the superimposition of the new floors on the rear and front elevations was also conducted. Information so obtained was used to inform the structural design and to ascertain the possible configurations proposed by the architect. These were also used for the Health and Safety file.

**Case Study 2: Basement**
The inspection commenced with a visual observation of the superstructure to ascertain the form and also the general use of the 5 – Storey block. The inspection also entailed the assessment of the basement floor and particularly the walls that were to be removed. These were mostly structural walls supporting floors, walls and roof structures above the basement. This assessment enabled the understanding of the structural design in the light of the architectural brief and particularly the needs for structural safety of demolition works and temporary works.

**Initial Design**
The results of the initial assessment facilitate a regime of solutions that enable the design of the structural scheme that would facilitate the structural integrity of the building during and after the works.
Initial Strip Out

Initial strip out entailed the removal of plasterboard and other coverings that will allow the exposure of the structural elements to be removed. In refurbishment works, this stage enables the discovery of ‘hidden’ elements which may or may not have been discovered during the initial design stage. This is key to elements of work that should ensue as part of the construction phase re-design. In addition, as works are already on site, this assessment allows the redesign of both the temporary works and the provisions for structural stability of the permanent works.

Case Study 1

A significant amount of redesign was necessitated after the Initial Strip Out during this phase of the project. This process revealed a substantial amount of hidden structural elements which were part of older alteration works and the need to ensure that the structure remained stable was deemed essential. The changes were mostly internal and can be seen as illustrated in Figure 5 when compared to the section presented in Figure 4. Particularly, the structure revealed some existing structural elements such as steel beams which were installed as part of more recent
refurbishment links but unaccounted for in any existing information. This information was passed to the Principal Designers and the Designers for incorporation into programme designs. This also meant an upgrade to the risk register.

**Case Study 2**

After initial strip out on this project, it was revealed that some of the walls of the superstructure had secondary beam supports at the basement ceiling level. This is not unusual when there had been prior modification works that necessitated the provision of such supports. This also necessitated a re-work of the structural beam supports to accommodate all the revealed structural elements and the design information and risk assessments were also upgraded accordingly.

Figure 6 shows the layout of the Case Study 2 project after the initial strip out and design stage.

**Construction Stage 1 and Complimentary Design**

The need to proceed to construction in stages was underpinned by the importance of carrying out safe and stable out progressive removal of elements (whether they be structural or non-structural. However, the structural design will continue to be modified as the true structure is revealed fully in the sections to be altered. Case Study 1 had a lesser degree of alteration at this stage compared to Case Study 2. The amount of complementary design required at this stage will therefore vary from project to project. Factors that determine the amount of complementary designs required at this stage include: the accuracy of the existing and proposal drawings, previous alteration/refurbishment works undertaken and how documented and the degree to which the alteration affected the structural form and/or load path amongst others. In Case Study 2, matters bordering on structural form, modifying elements and architectural details such as headroom requirements, etc all had to be co-ordinated. These also informed the Contractor’s work method.

![Figure 5: Proposed Section after Post Strip out Design](image)

**Construction Stage 2**
The final construction stage ensued once all designs appropriate to the proposal have been made and is possible to achieve the finalised brief. This led to the preparation of final As-Built drawings for Building Information Modelling (BIM) model development. In both cases, this model is envisaged to form the basis for all future work.

**Project Completion and Handover**

This is the final stage of the projects and it entailed the completion of all works proposed and ensuring that hazards have been factored out or the residual risks they may still pose have been properly managed. In the UK as part of the CDM (2015) Regulations, it is expected that a Health and Safety file which documents all the relevant construction information and matters relating to health and safety management of the project. The two projects reviewed enabled the development of this file and facilitated the project handover processes quite substantially. Information quality and coordination was thus significantly enhanced using this method.

**Discussion and Proposed Framework**

Table 1 contains a list of the main hazard observed and the Duty Holders that were responsible for highlighting and/or mitigating the possible associated risks. Each of these were assessed and highlighted in the relevant documents – especially the drawings and work schedules. There were cases where the residual risk could not be eliminated completely however. Whilst all Duty Holder Roles were carried out by various parties, the Structural Designer was also the Principal Designer on the projects and this facilitated the systematic co-ordination of all relevant structural alteration information. As shown in the table, information about identified hazard identified was provided by the parties listed in the second column. The third column lists the party responsible for mitigating each possible risk. Each party was therefore responsible for ensuring that this information was updated from stage to stage of the project. For example, with respect to Hazard no. 1, access to the site was permitted through various points by the client to prevent unauthorised access by members of the public. This information was provided by the Client and implemented by the Contractor. However, as the project progressed, these access points were altered and the Contractor was again responsible for ensuring that the updated alternatives were implemented in such a fashion that unauthorised access to the public was prevented.

A typical information flow structure is presented in Figure 7. All Duty Holders have a responsibility to ensure that the relevant information to be captured at all project stages are developed, captured and communicated accordingly with the risk register remaining a dynamic document embracing the works associated with the developments. Information flow from the Duty Holders (shown in the first box) are expressed through the various documents (listed in the middle ‘Information’ box). As the work was being implemented in stages the Risk Register/Management Process (third box) was also updated by the Principal Designer based on the newer information available in the relevant documents in the Information Box. For example the Designers updated the As-built plans (originally supplied by the client) with more revealed structure as the strip downs continued from phase to phase.
On-going research work (Oloke, 2017) had led to the development of an integrated framework for structural stability of the refurbishment projects based on the procedure described above. A modified form of this framework is shown in Figure 8.

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Hazards and Outcomes (Population at Risk)</th>
<th>Party Responsible for Providing Information</th>
<th>Party Responsible for Mitigating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Unauthorised Access to the site (Public)</td>
<td>Client</td>
<td>Contractor</td>
</tr>
<tr>
<td>2.</td>
<td>Movement of Vehicles, plant and equipment (Contractors and Public)</td>
<td>Principal Contractor</td>
<td>Principal Contractor</td>
</tr>
<tr>
<td>3.</td>
<td>Tripping (Contractors and public)</td>
<td>Principal Contractor</td>
<td>Contractor</td>
</tr>
<tr>
<td>4.</td>
<td>Contact with Hazardous Materials (Contractors and public)</td>
<td>Principal Contractor</td>
<td>Contractor/Workers</td>
</tr>
<tr>
<td>5.</td>
<td>Asbestos, Noise and Dust (Contractors and public)</td>
<td>Client/Principal Contractor</td>
<td>Workers</td>
</tr>
<tr>
<td>6.</td>
<td>Tripping/Falling from height (Contractors)</td>
<td>Principal Contractor</td>
<td>Contractor</td>
</tr>
<tr>
<td>7.</td>
<td>Security (Occupiers/Public)</td>
<td>Principal Contractor</td>
<td>Principal Contractor</td>
</tr>
<tr>
<td>8.</td>
<td>Collapse (Contractors/Occupiers/Public)</td>
<td>Principal Contractor</td>
<td>Contractor</td>
</tr>
<tr>
<td>9.</td>
<td>Lifting Operations – Heavy Steel Members</td>
<td>Designer/Principal Contractor</td>
<td>Contractor</td>
</tr>
<tr>
<td>10.</td>
<td>Deep/Excavations</td>
<td>Designer/Principal Contractor</td>
<td>Principal Contractor</td>
</tr>
<tr>
<td>11.</td>
<td>In Use hazards</td>
<td>Principal Contractor/Client</td>
<td>Principal Contractor</td>
</tr>
<tr>
<td>12.</td>
<td>End of Life/Future Alterations</td>
<td>Designer/Client</td>
<td>Designers</td>
</tr>
</tbody>
</table>
Figure 7: Information Flow Framework for Alteration/Refurbishment Projects (Adapted from Oloke (2015))

Figure 8: Modified Integrated Framework for Structural Stability of refurbishment Projects (Adapted from Oloke (2017))
The process incorporates a typical information flow procedure that relies on the updated information between the stages and the Duty Holders. This comprehensive procedure assures improvement in information quality and co-ordination throughout the project. The proposed framework’s novelty lies in the structured approach it introduces into ensuring that health and safety information accompanies every updated technical information from stage to stage. The method also ensures that the project risk register is a live document that is more effective in the management of health and safety throughout the project as opposed to being a risk management document that only allows an effective take off of the project without being as effective during and after the project as is usually currently practiced. However, a cursory look at the Project Cycle approach proposed (Figure 8); it can be seen that by the time the project is being completed in Stage 7, the information contained in the Risk Register has the most updated residual risks and structural information that were fed into the Health and Safety File for the end users.

CONCLUSIONS AND FUTURE WORK

This work has highlighted, that older buildings usually have very little information available on the as-built (or historical modification) status and this can substantially increase the risks associated with carrying out alteration and refurbishment works in them. The need to plan the proposed works effectively to ensure that health and safety is not compromised in any way has been highlighted. This work has proposed a framework that covers how structural safety should be assessed before, during and after the works. These principles were incorporated into the entire project cycles. Furthermore, the coordination of information to aid quality and communication effectiveness was addressed. The modified framework provides a basis for Duty Holders to leverage the project lifecycle safety management approach proposed to improve the quality and coordination of relevant information and the improvement of risk management. Key learning points discussed included the comprehensive development of a risk register and health and safety file that represents a more significant enhancement over the originally held risk management information. It is envisaged that these outputs have contributed to knowledge and engendered wider debate in the subject area. Further work will entail the development of the risk register for such projects, improve assessment of health issues, and facilitate the development of current Guides and the utilisation of BIM models.

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IDENTIFYING THE COST DRIVERS FOR PRICING HEALTH & SAFETY (H&S) ON CONSTRUCTION PROJECTS

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For many years, the construction industry (CI) has been considered as one of the most dangerous industry due its H&S statistics expressed in terms of accidents and injuries which remain high. Notwithstanding the fact that many research studies have been conducted at both academic and industry level to find solutions, it can be rightly argued that the H&S performance in the CI is still questionable. One of the factors that have impacted negatively on the H&S performance in the CI is the competitive nature of the CI where most clients award their contracts based on price. Consequently, this practice has compelled contractors to lower their bid amounts leading to H&S being marginalised. The current study will identify cost drivers deemed necessary in pricing for H&S on construction projects as well as conduct an evaluation on the methods used by contractors to price for H&S on construction projects. Case studies were conducted wherein interviews and document analysis was conducted to establish the actual expenditure on H&S elements. Case studies were conducted in one organisation over six construction projects. The choice of the study organization was purposive and depended on the willingness to participate in the study. The findings show that contractors quantify the costs of H&S using an itemised breakdown and are aware of the importance of H&S specification in quantifying the costs of H&S on their projects.

Keywords: Construction projects, Cost drivers, Health & Safety (H&S), Pricing.

INTRODUCTION

The H&S performance level in the CI is still not satisfactory due to the high number of accidents and fatalities encountered on construction sites. As a result, the CI is labelled as one of the most dangerous industries when compared to other sectors. Such accidents have a negative impact on the victims’ lives, their families and the society at large. In most cases, an accident can result in partial or total disability or a fatality. Muiruri & Mulinge (2014) point out that H&S requires proper management control. However, management control does not seem to be evident as most perceive H&S to be costly. On the contrary and as observed by Rikhardsson (2005), neglecting H&S can be expensive and lead to financial losses. On the other hand, investing in H&S actually increases profitability and productivity, boosts employee’s morale and decreases attrition (Mohammed, 2003 cited in Muiruri & Mulinge, 2014). Accidents cost as a Smallwood (1999) puts it, the total cost is made up of direct and indirect costs. The direct costs when compared to the indirect costs account for much less of the total accident costs. The ratio of direct costs to indirect has been estimated to 1:4 meaning that the cost of indirect accidents equates to 4 times the direct costs (Heinrich, 1979). Therefore, not implementing H&S measures can be much costlier than what can be estimated from the direct impact of accidents.

In the United Kingdom, statistics revealed that in 2013/14, an estimated £14.3 billion with £9.4 billion from illness and £4.9 billion from injuries was incurred (HSE, 2015). In South Africa, a report by the Construction Industry Development Board (CIDB, 2009) recorded that the total cost of accidents for both direct and indirect amounted to

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R3.5 billion per year. Similarly, the European Agency for Safety and Health at Work (EASHW) has estimated that 4.6 million in costs for occupational accidents happen every year in the European Union (EU) resulting in 146 million lost working hours (EU OSHA, 2001). This means that approximately 2.6 to 3.8 percent of the collective EU Gross National Production (GNP) is lost every year. Richardson (2005) argues that the costs highlighted above can be avoided if accidents are prevented. Preventing occupational accidents should therefore make good economic sense for society as well as being good business practise to companies, remarks Dorman (2000).

One way of preventing accidents is to provide finance for implementing H&S. Accident costs are directly proportional to many factors, *inter alia*: project requirements, types, location accident costs, etc. Thus, reducing the number of accidents through the implementation of preventive measures by means of well-defined project-based H&S objectives, sounds H&S management systems amongst others can be seen as “game-changers” and help achieve better H&S performance. As a result, the current study aimed to identify cost elements designated as “H&S cost drivers” that should be taken into account in order to adequately provide for H&S on construction projects. In addition, identifying the costs drivers will contribute towards developing itemised trade lines in the Bill of quantities (BOQ). Having itemised H&S components in the BOQ will assist both clients and contractors to plan for and monitor H&S expenditure on construction projects.

**THE STUDY**

With regards to the research methodology, the study adopted a case study type. Secondary data was collected through literature review from journals, conference papers, technical reports and dissertations on H&S. The empirical data was collected through the review of project documents such as expense reports of projects. It was decided that it was the best method to use in order to collect the actual costs that had been spent on the projects. The purpose of conducting this study was to measure and quantify the exact cost of H&S on such projects and identify what elements had been provided for on construction projects. Data obtained was analysed using output descriptive statistics. The descriptive statistics included percentage ratios and rankings. Frequency count was used to identify the most frequent H&S cost drivers found on projects. Percentiles were used to quantify H&S cost expenditure to project expenditure ratios.

**H&S COST DRIVERS FROM LITERATURE**

Bokor (2010) defines *cost drivers* as factors which have a cause-effect relationship with costs. Cost drivers are any factors which cause a change in the costs of work performed in an organisation or in a process. A contextual application of the above definition to the current study, “H&S cost drivers” can be defined as “factors or elements” that have an impact on the costs of H&S on a given project computed as a sum of all items quantified and costed in accordance to the H&S requirements of the project as outlined in the H&S specifications. These factors or elements can be affected by various inputs *inter alia*: quantity factor (i.e.: number of personnel or equipments required), applicable rates (i.e.: fee scales, labour rates), project duration, etc.

The South African Construction Regulations (2014) addresses in detail client’ compliance regarding H&S measures. The client is required to, *inter alia*: prepare a
suitable, sufficiently documented and site specific H&S specifications; include H&S specifications in the tender documents (regulation (f)) and ensure that contractors submitting tenders have made adequate provision for the cost of H&S (regulation (g)). Therefore, without specifications, the planning, designing or pricing for H&S will not be adequate. In terms of budgeting for H&S on construction projects, various studies propose different methods. For instance, studies by Smallwood (2013); Wells & Hawkins (2009); Smallwood & Emuze (2014) recommended that the cost of H&S be included as a provisional sum in contract documents respectively. Additionally, Wells & Hawkins (2009) recommended that the cost of H&S be computed as Prime Cost Items. Additionally, Smallwood (2013) is of the view that H&S costs should be included in preliminaries and General (P&Gs) section of BOQ.

In contrast to the aforementioned pricing methods, a study the CIDB (2009) recommended that the cost of H&S should be quantified as an itemised trade in the BOQ. In support of this method, Wells & Hawkins (2009) are of the view that H&S must be priced in a special section in the BOQ.

In line with the recommendation from studies by the CIDB (2009) and Wells & Hawkins (2009), a critical review of literature was conducted to identify the cost factors which should be considered in pricing for H&S. The survey identified about 18 elements from literature and are summarised in Table 1.

**Table 1: H&S cost drivers matrix**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Cost Drivers</th>
<th>Literature</th>
<th>Cost determinants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H&amp;S Personnel</td>
<td>CR (2014) Regulation 7(2)(b); Smallwood &amp; Emuze (2014)</td>
<td>H&amp;S personnel (SHE officers, Managers, SHE reps, security officers, flags ladies, etc)</td>
</tr>
<tr>
<td>2</td>
<td>Personal Protective Equipments (PPEs)</td>
<td>Hashem et al. (2009); HSA (2010)</td>
<td>Purchasing new PPEs &amp; replacement costs, PPEs training</td>
</tr>
<tr>
<td>3</td>
<td>Safety Equipments (SEs)</td>
<td>Smallwood (1999); Sawasha et al. (1999)</td>
<td>Purchasing new equipments &amp; replacement costs</td>
</tr>
<tr>
<td>4</td>
<td>H&amp;S induction &amp; training</td>
<td>Hinze &amp; Gambatese (2003); Petrovic-Lazarevic and Perry (2004)</td>
<td>Costs of equipments; i.e.: orange cones, ladders, lifelines, etc</td>
</tr>
<tr>
<td>5</td>
<td>H&amp;S Inspections</td>
<td>Regulations 6(g) and 11(2)(a), CR (2014); Bhutto et al. (2004)</td>
<td>H&amp;S inspections (time based)</td>
</tr>
<tr>
<td>6</td>
<td>H&amp;S Audits</td>
<td>Regulations 5(o) &amp; (p) of CR (2014); Alli (2008)</td>
<td>Internal monthly H&amp;S audits</td>
</tr>
<tr>
<td>7</td>
<td>H&amp;S Incentives</td>
<td>Tang et al. (2010); Musonda &amp; Pretorius (2015)</td>
<td>Monetary, rewards, non-monetary, Others</td>
</tr>
<tr>
<td>8</td>
<td>H&amp;S Meetings</td>
<td>Bizzell (2008:29); Regulations 5(b) &amp; (c), CR (2014)</td>
<td>Attendance to H&amp;S meetings/DSTIs/Toolbox talks (time related)</td>
</tr>
<tr>
<td>9</td>
<td>Accident investigations and reporting</td>
<td>Kartam et al. (2000:177)</td>
<td>Legal costs; Time implications on investigations; Cost of accidents (i.e.: direct &amp; indirect costs)</td>
</tr>
<tr>
<td>10</td>
<td>H&amp;S Medicals</td>
<td>CR (2014:18), regulation (7) (g); HSA (2010)</td>
<td>Entrance, periodical &amp; Exit medicals</td>
</tr>
<tr>
<td>12</td>
<td>H&amp;S Campaigns</td>
<td>CIDB (2009)</td>
<td>H&amp;S campaigns, motivational speaker, team building functions</td>
</tr>
</tbody>
</table>
13 First Aid HSA (2009); Wells & Hawkins (2009) First aid training, first aid kits

14 H&S Promotions Hymel et al. (2011); Chu et al. (2000) Transport; eating facilities, water, electricity, etc

15 H&S Branding Musonda & Haupt (2011) Create H&S brand (marketing), promotional items (T-shirts, caps, stationaries, etc)

16 Security features Farinyole et al. (2013); Cho & Youn (2006) Access system, hoarding & fencing, surveillance, lighting protection

17 Emergency Preparedness WHO (2007); Wells & Hawkins (2009) Emergency training; Signage, Alarm system

18 Insurance costs Babu & Kanchana (2014); COID Act (1993, Clause 15; 22 & 23) Monthly insurance premiums, COID contributions

FINDINGS FROM EMPIRICAL ANALYSIS

For the empirical study, six projects were used as case studies to analyse how contractors are priced for H&S on their projects as well as what element were being priced for on the said projects. These projects included in the current study were all from the civil engineering construction sector. The projects were classified under two categories, namely: pipelines and roadworks. The project values ranged between R31 million and R687 million. In terms of duration, the shortest project period was 12 months and the longest 27 months (See Table 2).

Table 2: Project Types

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Project Names</th>
<th>Scope of work</th>
<th>Duration (months)</th>
<th>Labour (Peak)</th>
<th>Project Budget Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project A</td>
<td>Civil (Pipeline)</td>
<td>18</td>
<td>260</td>
<td>R 400 000 000.00</td>
</tr>
<tr>
<td>2</td>
<td>Project B</td>
<td>Civils (Pipeline)</td>
<td>12</td>
<td>120</td>
<td>R 195 000 000.00</td>
</tr>
<tr>
<td>3</td>
<td>Project C</td>
<td>Civils (Roadworks)</td>
<td>12</td>
<td>31</td>
<td>R 31 500 000.00</td>
</tr>
<tr>
<td>4</td>
<td>Project D</td>
<td>Civils (Pipeline)</td>
<td>27</td>
<td>600</td>
<td>R 630 000 000.00</td>
</tr>
<tr>
<td>5</td>
<td>Project E</td>
<td>Civils (Pipeline)</td>
<td>21</td>
<td>280</td>
<td>R 500 000 000.00</td>
</tr>
<tr>
<td>6</td>
<td>Project F</td>
<td>Civils (Pipeline)</td>
<td>18</td>
<td>450</td>
<td>R 687 000 000.00</td>
</tr>
</tbody>
</table>

Findings from the case study showed that contractors spent money on a number of H&s elements of which many of them were not necessarily priced in the BOQ. The costs of H&S breakdown were categorized into the following components: Personnel, Training, Equipment, PPE, Time and Environmental. Another breakdown received from a different contractor included a class referred to as the miscellaneous items.

Document analysis revealed that the actual expenses on H&S elements ranged from R900 thousand for a R30 million projects and about R34 million for a 650 million project (Table 3). In terms of the ratio between the actual expenses on H&S and the project values, it was found that the actual costs ranged between 2.39% and 4.90% (Table 3). It was also observed that projects with a higher project value of R500 million and above had a higher H&S expense to project value ratio. These projects
had a ratio of 4% and above. Of interest, however a R31 million value for project C. was this particular project spent about 3% of its projects value on H&S provisions.

Table 3: H&S expenditure ratios

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Project Names</th>
<th>Project Budget Expenditure</th>
<th>HS&amp; expenditure</th>
<th>% ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project A</td>
<td>R 400 000 000.00</td>
<td>R 9 553 995.79</td>
<td>2.39</td>
</tr>
<tr>
<td>2</td>
<td>Project B</td>
<td>R 195 000 000.00</td>
<td>R 5 203 248.74</td>
<td>2.67</td>
</tr>
<tr>
<td>3</td>
<td>Project C</td>
<td>R 31 500 000.00</td>
<td>R 957 454.78</td>
<td>3.04</td>
</tr>
<tr>
<td>4</td>
<td>Project D</td>
<td>R 630 000 000.00</td>
<td>R 25 690 909.42</td>
<td>4.08</td>
</tr>
<tr>
<td>5</td>
<td>Project E</td>
<td>R 500 000 000.00</td>
<td>R 20 688 493.19</td>
<td>4.14</td>
</tr>
<tr>
<td>6</td>
<td>Project F</td>
<td>R 687 000 000.00</td>
<td>R 33 664 777.73</td>
<td>4.90</td>
</tr>
</tbody>
</table>

H&S costs drivers

The cost drivers were identified from document analysis and interviews. A ranking of the most frequent factors was also done. The ranking was done using a regression scale with the most frequent element(s) ranked 1 with a score of 7 and the least frequent element(s) ranked last with a score of 0. The principle was that, the more a cost driver appears in different projects, the higher its score. Out of a total of six projects, the highest frequency score that an element could score was therefore 6 and 0 was the lowest that an element could achieve (Figure 1). The rank was therefore reliant of the frequency score, i.e.; the higher the frequency score, the higher the rank.

As shown in Figure 2, nine (9) elements were found to be the most frequent on the six projects. These expense factors included: H&S personnel, PPEs, safety equipments, induction and training, incentives, medicals, signage, first aid and H&S promotions. Incidents and investigations were ranked second with a score of 5. Security features was ranked third with a score of 4. H&S audits were ranked fourth with a score of 3. H&S inspection was ranked fifth with a score of 2. In sixth position were expenses to do with H&S meeting and attained a score of 1. Four (4) elements were ranked last with a score of 0. These include; H&S campaigns, H&S branding, emergency preparedness and insurances. These were the elements on which no expenditure was allocated for on all the projects. This was surprising but perhaps the explanation could be that the head office as opposed to the project provided for these costs.

As for the H&S elements for which actual costs were recorded, the findings show that all the projects recorded costs for at least ten H&S elements (Figure 3). Project F had more costs in terms of elements for which costs were recorded. Project F recorded 14 elements (Figure 3).
**Figure 1: Ranking of H&S cost drivers**

**Figure 2: Frequency scores**
DISCUSSION OF FINDINGS

From the study, it was clear that contractors provided finance for H&S elements of which a number of them had not been provided for in the BOQ. Findings from the study were that the actual cost spent on H&S elements ranged between 2.4% and 4.9% for projects above R500 million and about 3% for projects below R500 million. These values were found to be within the 5-8% range as indicated by the interviewees. Additionally, the H&S costs were found to be directly proportional to the number of items for which expenses were made on the projects. This implies that the H&S cost is directly proportional to the H&S requirements for the projects, the more the requirements and the costlier it was.

Findings by Wells & Hopkins (2009) show that H&S expenditure on projects ranged between 1% and 2% of the contract value for big and small contracts respectively. However, the current study found that the mean expenditure ratio for H&S elements to project costs equated to between 3 and 5% for the civil engineering projects. Elsewhere, a study by Smallwood & Emuze (2014) found that the mean percentage H&S allowed for in tenders was 2.5%.

CONCLUSIONS

The study identified the costs drivers that should be considered when allowing for H&S and how much should be allowed for. H&S cost drivers presented in the findings are regarded as the minimum to be priced for if it all H&S performance can be assured on construction projects. The generalisability of the findings from this study is however limited in that the case studies did not include building projects and were mainly sourced from one contracting organization albeit semi-autonomous. As an on-
going project, the study will therefore include additional projects and other organizations in order to increase the generalisability of the findings.

REFERENCES


EXPLORING STUDENT PERCEPTIONS ON SUSTAINABILITY CONSIDERATIONS IN PROCUREMENT DECISIONS IN ZAMBIA

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²School of the Built Environment, Copperbelt University, Kitwe Zambia

ABSTRACT
This paper investigated the perceptions of students on sustainability considerations in procurement decisions in Zambia. The Zambian construction industry is currently thriving with significant infrastructure projects as one of the major sources of construction activities. It is important, however, that as the construction industry takes strides to increase output, the need for a sustainable approach should be considered. The aim of the paper was therefore to explore the perceptions on sustainability matters associated with procurement decisions in the construction industry. The paper was seeking to investigate the potential influence of sustainability in procurement decision making as procurement is seen as key to construction performance improvement. It is considered that one of the measures that can help influence the sustainability agenda is education and training. As such the study was based on a survey of 121 students from all five programmes offered in the university offering various courses in the built environment and engineering schools. Results indicate that, in all cases students on the different courses, with exception of students on the planning course, viewed the sustainability as an economic problem. Further students on different programmes perceived the factors under discussion differently which is a critical factor that requires urgent attention. Results further indicated that there is need to incorporate sustainability related matters during the training of students because they are the future leaders of the construction industry. The study recommends that sustainability must be taught to university students as part of the curriculum in order to produce graduates that will have the correct perception and importance of sustainability.

Keywords: Procurement, sustainability, decision making, developing countries, contracting

INTRODUCTION
Sustainable construction is seen as a key part of the global sustainability agenda. This is more so that the construction industry is seen as a major contributor to greenhouse gas emissions. This study focuses on the role procurement plays in driving the sustainability agenda in the construction industry with a particular focus on the Zambian construction industry. The Zambian construction industry has, over the last 10 years, seen a steady increase in construction activity in various sectors including infrastructure, housing and retail. It is therefore important that the sustainability agenda is promoted in the Zambian construction industry. Procurement is seen as a key driver.
for performance improvement. It is therefore fitting to evaluate the perception of sustainability issues within this context.

The role of education and training, in particular universities in driving the sustainability agenda is acknowledged and has been a subject of research by many. As such the study is based on a survey of university students undertaking various built environment courses. Its primary focus was to explore students’ perceptions on the extent to which various sustainability concerns would influence procurement decisions. While there have been many studies on students’ perceptions towards sustainability issues, this study contributes to the wider body of knowledge as it places students sustainability perceptions in a specific procurement context. The implications of the findings on built environment education are considered.

LITERATURE REVIEW

This study as indicated above focuses on students’ perceptions. It is considered that these are the decision makers of tomorrow and therefore it is important that they graduate with the right knowledge for tomorrow. The role of institutions of higher learning in driving the sustainability agenda has been a subject of many studies. Some have, for example argued that universities train leaders of tomorrow and therefore have an influence on future decision makers. As such universities can have a significant part to play in creating a sustainable environment (Cortese 2003; Kalpana et al 2013). It can be argued that one of the catalyst for the need to take seriously sustainable development was the World Commission on Environment and development’s (or Brudtland’s) report which defined sustainable development as ‘development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs’ (WCED 1987). It is generally accepted that this definition is broad and encompasses three strands, namely environmental, social and economic sustainability (Zwinkle et al, 2014; Zeegers and Clark, 2014). The role of universities therefore in influencing thought on sustainability is key and institutions of higher learning should take appropriate steps in doing so. The need for incorporating sustainability in university courses, including built environment courses, has been a subject of many studies (Andamon and Iyer-Raniga, 2013; Ramirez, 2006).

There are many other contexts in which universities and sustainable development have been reviewed. Hanson-Rasmussen et al (2014) investigated the extent to which business students’ perceptions of environmental sustainability had an impact on their job search attitudes. They suggested that many millennials have expectations that employers will put in place sustainability measures. Thus sustainability education can be seen to be an influencing factor in forming attitudes of future employees. Others have explored the impact of students’ undertaking of sustainability related courses on their sustainability perceptions. Dagiliute and Niaura (2014) and Clark and Zeegers (2015), for example, examined the pre and post course attendance perceptions. Dagiliute and Niaura (2014) found out that generally there is a relatively high environmental consciousness after taking the course in comparison to pre-course enrolment. Clark and Zeegers (2015) also found that, while the pre-course perception was largely an environmental-centric view of sustainability, there was evidence that there was a shift towards a more holistic perception of sustainability including social and economic sustainability. However, they found that the environment-centric view was still the predominant view.

Others have used universities’ sustainability initiatives as case studies to examine the students’ perception towards sustainability (Sammalisto and Lindhqvist, 2008;
Bantanur et al, 2015; Kalpana et al, 2013; Abd-Razak et al, 2012; Emanuel and Adams, 2011). The perception of students towards their knowledge of sustainability issues has also seen a significant number of studies. Nicolaou and Conlon (2012) examined the level of knowledge and understanding of final year engineering students in three Irish higher education institutions, while Tan et al (2016) focused on perception of quantity surveying students. Similar studies have been undertaken in various contexts including: perception of Civil engineering students in the USA (Watson et al (2013) students at a UK institution (Kagawa, 2011); comparison of students perception between students in Australia and Singapore (Iyer-Ranga et al (2010), students on a chemical engineering course (Carew and Mitchell, 2002), interior design students (Stark and Park, 2016), apparel and textile undergraduates (Hiller Connell and Kozar (2012); retail sector (Reiter and Kozar, 2016) and many others.

This study contributes to this body of knowledge and considers the perception of built environment and engineering students at a higher education institution in Zambia. While many of the studies reviewed take a somewhat general context of sustainability, this study focuses on seeking to explore students’ perceptions of the impact that sustainability plays in influencing decision making in the construction industry. In particular, it focuses on the sustainability influences on procurement decision making.

As the construction industry world-wide strives to be more sustainable, it is argued that one of the key target areas should be the procurement process. Indeed, procurement is seen as key to performance improvement in the construction industry (Ofori, 2002). Construction procurement is a wide term that includes all processes required for the acquisition of a constructed facility. Belfit et al (2011) defined procurement as the ‘acquisition of goods and services’ which could include anything from office supplies, materials acquisition to the services of contractors and subcontractors. The generic procurement process can generally be represented as including six step. Viz: verification of need; assessment of need; development of procurement strategy; project delivery; and post project review (Construction Excellence, 2004). One can argue therefore that procurement decisions in each of these steps can take into consideration sustainability. Thus procurement can be seen to be the key driver for sustainable construction (Ruparathanan and Hewage 2013).

The evolving nature of procurement performance factors demonstrates the need for sustainability consideration in the procurement decision making process. Huang and Keskar (2006) traced the changes in supplier selection criteria over time and demonstrated that most literature from the 70’s and 80’s focused on cost performance, those in the early 90’s considered life cycle assessment, while the late 90s introduced the notion of flexibility. It is however in the 2000’s literature that we see the emergence of the importance of environmental sustainability. Similarly, Tamosaitien et al (2014) argued that previous research on supply chain management focused on quality, cost, flexibility and delivery as the key considerations in supplier selection.

Sustainable procurement is generally taken as the consideration of sustainability parameters in procurement decisions. Walker and Philips (2009) defined sustainable procurements as ‘the pursuit of sustainable development objectives through the purchasing and supply processes and involves balancing the environmental, social and economic objectives’ (p41). There are many other terms used in research that pattern to elements of sustainable procurement such as, green procurement (Testa et al, 2012); green supply chains (Srivastava, 2007) Green purchasing (Khidir, 2010); sustainable purchasing(M) environmental supply chain (Miemczyk, 2012) etc. Brammer and
Walker (2011) referred to sustainable procurement as the act of integrating environmental, economic and social dimensions within the procurement process. Sanches et al (2014, p1) considered green procurement as the ‘process of applying environmental considerations to planning, contracting and monitoring the project delivery including using environmental criteria in contractor selection’. It is argued therefore that sustainable procurement should take into consideration the triple bottom-line: environmental, social and economic dimensions of sustainability (Gopalakrishnan et al, 2012). Adetunji et al (2008) in describing sustainable supply chain management argue that it is important that sustainability issues are considered in the supply chain processes.

One of the limitations of the traditional procurement criteria is the lack of consideration of environmental or societal implications (Walker and Hampson, 2008). This study considers the perception of university students on the extent to which sustainability issues are considered in procurement decisions in the Zambian construction industry. A review of literature suggests a number of studies that have looked at the ranking of procurement criteria. Zimmer et al (2016) identified key criteria under 3 headings: environmental, economic and social dimensions. Huang and Keskar (2007) identified and developed a hierarchy of supplier selection factors which they grouped under reliability, responsiveness, flexibility, cost and financial, assets and infrastructure, safety and environment. Shaik and Abd-Kader (2011) developed a framework for green supplier selection. Ageron et al (2011) in their study evaluated a 17-item supplier selection criteria which include among others environmental related factors. Their results demonstrated that quality and price constituted the 2 most important criteria for supplier selection and that sustainability was one of the least concerns in supplier selection. This study took a similar approach and identified procurement related factors based on the three dimensions of sustainability: environment, economics and social dimensions. Considering that this was an exploratory study, the items used were loosely defined so that students could easily understand their contexts.

**METHODOLOGY**

This paper is based on data collected for a research project which investigated students’ perceptions on various issues in the Zambian construction industry. A survey approach using questionnaire, similar to many other studies on student perceptions (Abd Razak et al, 2012; Hanson-Rasmussen et al, 2014; Stark et al, 2016), was deemed the most approach as the researchers were able to seek responses from a relatively large sample size. In addition, comparable studies (such as Zimmer et al, 2016) on procurement selection criteria have used the survey methodology to get responses from a broader sample. The study was based on a purposive sample of students as the intention was to gather views of students from different disciplines. Tangco (2007) suggests that purposive sampling is effective when one wants to capture views on a certain cultural domain with knowledge experts represented in the sample. This approach ensured that students from different years of study and courses were represented in the study. The focus of the study was on students in their third, fourth and fifth year within a department offering degree courses in architecture, building, quantity surveying, civil engineering, planning and real estate.

**Results and Discussion**
The following section explains the results obtained from the questionnaire survey. Sample demographic data, sustainability perspectives and perceptions of students on sustainability influences on procurement decisions are discussed.

**Sample demography**

The first part of the questionnaire included questions that provided profile data of the sample. Table 1 shows the demographic make-up of the sample based on year of study (Year 3 = 41%; Year 4 = 27%; Year 5 = 32%). Students at the case study institution take a five-year degree course. Table 2 shows the different courses taken by the sample students. The study was based on a purposeful sampling approach and as can be observed, the sample included students from all six courses offered by the department. This demographic data is used in the next sections to examine whether their perceptions towards sustainability in general is influenced by the level and type of knowledge gained. The level of knowledge and understanding is deemed to be reflected by the year of study, while the type of knowledge acquired is reflected by the course undertaken.

*Table 1: Sample Demography - Year of study*

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3</td>
<td>49</td>
<td>41%</td>
</tr>
<tr>
<td>Year 4</td>
<td>33</td>
<td>27%</td>
</tr>
<tr>
<td>Year 5</td>
<td>39</td>
<td>32%</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Table 2: Sample Demography - Course*

<table>
<thead>
<tr>
<th>Course</th>
<th>n</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSc Architecture</td>
<td>22</td>
<td>18%</td>
</tr>
<tr>
<td>BSc Building</td>
<td>26</td>
<td>22%</td>
</tr>
<tr>
<td>BSc Civil Engineering</td>
<td>16</td>
<td>13%</td>
</tr>
<tr>
<td>BSc Quantity Surveying</td>
<td>11</td>
<td>9%</td>
</tr>
<tr>
<td>BSc Planning</td>
<td>25</td>
<td>21%</td>
</tr>
<tr>
<td>BSc Real Estate</td>
<td>21</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>100%</td>
</tr>
</tbody>
</table>
Sustainability conceptualisation

The data in table 3 provides indications of the perceptions of the context of sustainability. As discussed in the literature review section, sustainability is seen as comprising the three dimensions—environment; economic, and social context. Respondents were asked to rate three statements, among others, about whether sustainability should be construed as a scientific (environmental), economic or social problem. The rating was based on a five-point Likert scale (1=strongly disagree to 5 strongly agree).

The data that the predominant context of sustainability was the economic context. I.e. that sustainability should be looked at as an economic problem. Students from “year three” and “year four” placed a high score on the economic context of sustainability followed by the social context. On the other hand, “year five” students scored the social context highest followed by the economic context. In all three cases the environmental context was ranked the lowest. The data in table 2 also shows that in all cases students on the different courses, with exception of students on the planning course, viewed the sustainability as an economic problem. Students on the planning course considered sustainability primarily as a social concern. However, architecture students considered the environmental and economic contexts as most important.

Table 3: Comparison of perception of triple bottom line based on year of study

<table>
<thead>
<tr>
<th>Sustainability Dimension</th>
<th>Year of study</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Year 3</td>
</tr>
<tr>
<td>Environmental</td>
<td>3.2333</td>
<td>3.21</td>
</tr>
<tr>
<td>Economic</td>
<td>4</td>
<td>4.19</td>
</tr>
<tr>
<td>Social</td>
<td>3.6612</td>
<td>3.69</td>
</tr>
<tr>
<td>All</td>
<td>3.63</td>
<td>3.70</td>
</tr>
</tbody>
</table>

It is important also to note that the data does not suggest that students do not perceive the environmental context as unimportant, but that it reflects the relative ranking with which they see the context of the problem. Such perceptions can have an impact on the design of solutions to deal with the sustainability question.

Procurement decision factors

This section considers the perceptions of students on factors that can impact on procurement decisions. Students were asked to rate nine statements with respect to the extent to which they perceived that they would influence them when making procurement choices. These factors were derived from the three sustainability dimensions which are presented in table 3, 4 and 5 as key constructs. It is important to note that the data here is specific to perceptions of the influence of the nine sustainability factors on procurement choices. This is different from many other studies on student perceptions on sustainability issues. Table 3 provides a summary of the statements that students were asked to rate on a 5-point Likert scale (1=strongly disagree to 5 strongly agree).

The overall score for all students (column 3 in table 4) shows that of the top three factors, two are related to the economic dimensions of sustainability. A review of the aggregate
scores also show that overall, the economic dimensions would have the greatest influence on procurement decisions by the students, with an average score of 3.97 (social= 3.86 & environmental= 3.74). This is consistent with Ageron et al’s (2011) findings that quality and cost took precedence over sustainability considerations when making procurement choices. An interesting observation is made in table 5 in relation to differences in perceptions between students from different courses. The economic dimension is seen as a dominant construct amongst Architecture, quantity surveying and Real estate management students. The aggregate scores per construct for the social dimension is highest from students on the Building and Planning courses. However, the environmental consideration is seen to be a major factor amongst civil engineering students. One can argue that this is possibly a reflection of the content type of the different courses and the expected types of projects/work they would be involved with once they graduate.

Table 4: Procurement constructs, statements and coding

<table>
<thead>
<tr>
<th>Construct</th>
<th>Statement</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics</td>
<td>Profitability would be a major determining factor</td>
<td>Profit</td>
</tr>
<tr>
<td>Economics</td>
<td>Price would be a major determining factor</td>
<td>Price</td>
</tr>
<tr>
<td>Environment</td>
<td>The impact on the environment would be a major concern</td>
<td>Environment</td>
</tr>
<tr>
<td>Social</td>
<td>Meeting Industry standards on sustainability</td>
<td>Standards</td>
</tr>
<tr>
<td>Social</td>
<td>I would be concerned about its impact on future generations</td>
<td>Future</td>
</tr>
<tr>
<td>Environment</td>
<td>Sustainability concerns would be a major factor</td>
<td>Sustainability</td>
</tr>
<tr>
<td>Social</td>
<td>I would be concerned about the impact on immediate users</td>
<td>Users</td>
</tr>
<tr>
<td>Economics</td>
<td>Meeting minimal legal requirements</td>
<td>Legal</td>
</tr>
<tr>
<td>Environment</td>
<td>Only suppliers/contractors who have a documented sustainability policy should be involved</td>
<td>Suppliers</td>
</tr>
</tbody>
</table>

Table 5: Comparison of procurement decision factors based on year of study of course

<table>
<thead>
<tr>
<th>Construct</th>
<th>Year</th>
<th>All</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Arch</th>
<th>Bldg</th>
<th>Civil</th>
<th>QS</th>
<th>Plng</th>
<th>RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics</td>
<td>Profit</td>
<td>4.20</td>
<td>4.10</td>
<td>4.52</td>
<td>4.11</td>
<td>4.00</td>
<td>4.15</td>
<td>4.06</td>
<td>4.18</td>
<td>4.40</td>
<td>4.40</td>
</tr>
<tr>
<td>Economics</td>
<td>Price</td>
<td>4.01</td>
<td>4.04</td>
<td>4.18</td>
<td>3.85</td>
<td>3.95</td>
<td>4.27</td>
<td>4.24</td>
<td>3.73</td>
<td>3.96</td>
<td>3.86</td>
</tr>
<tr>
<td>Environment</td>
<td>Environment</td>
<td>3.95</td>
<td>4.27</td>
<td>3.59</td>
<td>3.87</td>
<td>3.26</td>
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CONCLUSION AND RECOMMENDATIONS
The primary focus of the study was to examine the extent to which sustainability is perceived as a key influencing factor in procurement decisions. The study provides a specific dimension to the understanding of sustainability issues by students as it focused on the influence of sustainability factors on procurement decision making. Procurement is seen as a key driver for performance improvement in general and attainment of acceptable sustainability standards. It is argued in this paper that it is important that education institutions of higher learning should take a key role in influencing decision makers of the future. The three sustainability dimensions were considered and it is clear that the students’ perceived the economic dimensions as the key most important factor in procurement decision making and that they would see environmental concerns as of a lesser influence. In examining the context of sustainability, the predominant context of the sustainability problem is seen to be as an economic dimension. While the findings in this study can appear to be inconsistent with many other studies that have examined student’s perception on sustainability where the environmental consideration is usually the primary context of sustainability, it is considered here that the type of questioning could have an impact on the answers given by the students. Of primary concern in this study was the context to which they saw sustainability as a problem. This is an important context as may be different from studies that have looked, for example, on students understanding of causes of global warming. Whilst the study does not pursue the question as to the reasons for the perceptions, it can be argued that the cultural or local setting can have an important factor in considering differences in perceptions. It is therefore recommended that student perception related studies should seek to examine the degree to which the cultural/social-economic setting of a sample would have an influence of the sustainability perception studies. The level of knowledge and understanding is deemed to be reflected by the year of study, while the type of knowledge acquired is reflected by the course undertaken. The study recommends that sustainability must be taught to university students as part of the curriculum in order to produce graduates that that will have the correct perception and importance of sustainability.

REFERENCES


BIM AND PEOPLE ISSUES: A SCOPING STUDY EXPLORING IMPLICATIONS FOR CURRICULUM DESIGN

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Abstract

Government sponsored reports have highlighted the need for improvements in people skills for those working in the UK construction industry. The mandatory use of Building Information Modelling on government projects by 2016 (Government Construction Strategy 2011) highlight these issues and bring their own specific challenges. It is in the construction organisation’s interest that they have to innovate and adopt BIM. However, evidence suggest that innovation is always met with resistance in organisations. One of the reasons for resistance is the expectation that innovation brings about the need for new skills and that some traditional skills become obsolete. The aim of this study was to get a better understanding of the ‘people’ related challenges when organisations are adopting BIM and particularly focuses on education and training requirements and the extent to which BIM implementation affects the dynamics of people skills. This is particularly crucial considering that some of the key features of BIM implementation (such as coordination, collaboration and communication) are people related issues. The research places the discussion within a quantity surveying professional practice context to see how representative organisations are addressing some of these challenges. A review of literature suggests that the adoption of BIM is relatively slow in UK quantity surveying organisations but does not find any evidence of resistance to adopting BIM as a management process or a set of digital technologies. The findings suggest that employers are generally not very concerned with BIM-specific technical training but wish to see the focus on providing education and methods of assessment for the BIM process, of collaborative working, communicating, independent working and ability to interpret data. The findings from this exploratory study are of relevance to both industry and academia. In particular, as BIM curricula develops, consideration needs to be taken of people skills. It is therefore recommended that more research be conducted on the impact of BIM on soft skills and how that can be reflected in course curricula

Key words: BIM Implementation, people skills, innovation, curriculum design, quantity surveying

INTRODUCTION

Since the mid-1990s successive Government and industry reports have acted as drivers for improvements, innovations and efficiency gains in construction (Latham 1994 and Egan, 1998). In 2011 a new approach that reframed earlier ideas and themes, as part of a vision for Construction 2025 (UK Government Construction Strategy, 2011), introduced a mandate for the use of BIM on Government projects by 2016. An RICS Guidance note published in 2014 addressed the impact of BIM to quantity surveyors from the perspective of tendering strategies (RICS, 2014) and suggest that the construction industry's adoption of BIM will dictate the impact it will have on all services in the construction supply chain. For example, they suggest that level 3 BIM promises a fully integrated and collaborative process enabled by 'web services' utilising 4D construction

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sequencing, 5D cost information and 6D project lifecycle management information. Such an approach improves the quality of design information available to all parties.

Like all other professions the role of the Quantity Surveyor is changing, particularly because of new and developing information and communication technologies and the need for new professional services arising from client demands. The traditional role of the Quantity Surveyor as a measurer and valuer of construction work remains but it is the introduction and development of non-traditional services which really show a changing profession. Arguably, BIM now sits at the heart of these changes. Services such as value management, risk management, whole life cost services and project management, for example, represent the future for the profession in a global market place and in an era of increasing automation. The digital world is one of connections and collaboration that is opening up new opportunities for the profession many of whom see the emerging new technologies as a means of elevating the status of Quantity Surveying and enhancing the range of services they are able to provide. Automated measurement and web-based collaborative resources for information sharing and documents management are in use and expanding. Increasingly, professional boundaries will dissipate as clients, in particular, look for single-point contact and responsibility from professionals who might have new designations such as ‘Process Engineer’. In terms of people challenges these changes and the emergence of BIM as a process and a series of technologies have clear implications for universities and professional bodies. They also present real challenges for commerce and for employers at all levels of the industry in terms of new ways of working and making choices and decisions for capital investment in IT systems.

Managers are responsible for helping organisations to achieve their objectives and for creating and implementing their plans. The challenge for modern managers is to deal with the need to change in order to survive Hannagan (2008). Both conventional management and change management require effective communications, recognised as vital to the morale and performance of any organisation. This is clearly an area where practice is changing rapidly thanks to new technologies, including BIM. Use of the internet and email has been common from the mid-1990s and many organisations now use intranets as a way of widening communications. These work at organisational and project levels. Important and urgent messages continue to be distributed via e-mail and daily or weekly bulletins are not unusual to managers who then relay the information to their teams. It is a natural progression for quantity surveying practices and organisations to extend their use of communications technologies to include BIM capabilities for automating the receipt of digital drawings, digital measurement and estimating, cost reporting and monitoring and general documents and project management.

Curricula design and the essential components of teaching, learning and assessment are major challenges for the HE sector and its partnerships with the professional bodies. Employers, too, should consider the annual goals and strategic initiatives for which their employees have responsibility and plan for employee education, training and development. To ‘do BIM’ people must have the ability to use new technologies, adapt to organisational change, work in flatter organisations in which cross-functional skills and knowledge are required, and work effectively in teams and other collaborative situations.
BIM is a particular challenge for educators since new technologies are integral to its adoption. The technologies (AutoCAD, ReVit, and NavisWorks, amongst a growing number of other providers) form an integral part of the collaborative working arrangements and management processes. Educators must think about how students can learn BIM (in terms of thinking about it and doing it) and be cognizant of their learning styles. For the younger students (the millennials) who have grown up with IT and are conversant with social media, getting information from online, processing, learning from it and engaging with wider online communities the challenge is to make it meaningful and relevant. For them learning about abstract theories and concepts from text books and being assessed on what they ‘know’ might not be too helpful and new ways of engaging them in their BIM education need to be found and shared (Self and Watkin, 2016). For older students and employees whose learning styles might favour more traditional methods of learning alternative approaches have to be considered.

This paper reports on the findings of a preliminary research project which took the form of a collaborative review with construction industry employers’ in the Yorkshire and Humber region to investigate current and future Quantity Surveying course provision. The project’s initial focus was on the BSc (Hons) Quantity Surveying course to identify which aspects of course provision could be improved or replaced. It was also expected that the findings of the project would help to inform the development of a new postgraduate award of MSc Quantity Surveying Commercial Management. The aim of the study was to explore the use of new BIM technologies in quantity surveying organisations, how BIM is impacting on the provision of traditional and non-traditional quantity surveying services and how course curricula can adapt to meet the expectations of employers on student education, ICT training, skills and employability are discussed.

LITERATURE REVIEW
The integration of theory, practice and the use of technology is fundamental to pedagogy and the implementation of BIM poses a number of challenges to both the HE and business sectors. BIM adoption for educators is inhibited by a number of limitations such as the availability of teaching time, knowledge development and the flexibility of the curriculum to adapt with a fast developing technology (Ghosh, Parrish and Chasey, 2015). Putting BIM into the context of work practice and organisation is similarly challenging for business since, while there appears to be no shortage of information about BIM, there is little guidance on implementation and how BIM impacts on day to day roles and responsibilities – putting BIM into the context of their work (Pittard and Sell, 2016). However, equipping students with BIM technology might not be the ultimate goal for educators since the collaborative process of using BIM to solve construction problems has emerged as key to individuals entering the industry (Zhou, et al, 2015). In terms of BIM adoption and implementation guidance there is emerging literature aimed at businesses, particularly smaller enterprises, inspiring and encouraging the adoption of BIM through a series of illustrated case studies (Klaschka, 2014).

But, it is the technology which is driving the process. Ashworth and Perera (2016) identified and summarised ways in which information communication technology (ICT) in construction could help to eliminate redundant, labour-intensive activities by adopting
enabling technologies and management techniques to drive innovation and to improve efficiency. Their work includes an extensive literature review and includes commentary on the drivers and barriers to ICT adoption in the industry. BIM is a key part of ICT adoption for the construction industry and its education providers to consider. The adoption of BIM is expected to impact on quantity surveying skills. For example, the people challenges associated with the implementation and adoption of BIM are considerable. Insights into the early BIM experience of QS firms and consultants worldwide, from Australia (Aibinu and Venkatesh, 2013), New Zealand (Ryan and Thurnell, 2014) and Ireland (Crowley, 2013) suggest that others are more advanced in the adoption of BIM than in the UK. The findings of Zhou et al, (2013) basing their work on a case study of a SME Quantity Surveying practice in the UK address readiness for BIM, are instructive, attest to difficulties at organisational and project levels and show that QS firms appear to be behind other professionals in adopting BIM despite the overwhelming benefits identified of better project coordination, accuracy of the project and improving efficiency. In education the US experience at Arizona State (Ghosh, Parrish and Chasey, 2015) concluded that pedagogy must combine fundamental learning of theory, practical experience and the use of technology in a collaborative environment to effectively implement BIM into an undergraduate curriculum.

The paper attempts to evaluate BIM, how it is impacting on the provision of traditional and non-traditional quantity surveying services and how course curricula can adapt to meet the expectations of employers on student education, ICT training, skills and employability.

METHODOLOGY
An extensive literature review and desk-top survey was used in the first instance and augmented by an online questionnaire survey, developed using Google Forms. Semi-structured interviews were then held with senior representatives of two employers’ organisations (both international cost consultants) with regional offices in Leeds. The interviews gave more scope to finding out how ICT and BIM technologies were being used and introduced to business activities, the skills issues identified and how much the employers felt this needed to be reflected in a BSc Quantity Surveying course content.

Both the questionnaire and the interview questions have been informed by a similar research exercise carried out by Marasini and Barfoot (2012). Their contribution to this paper is acknowledged. In their study, the methodology was based on survey questionnaires and industry workshops and presentations. That exercise was also wider in scope than this paper. Here, the range and type of questions were based on the Marasini and Barfoot (2012) template and used a Likert scale (Strongly agree to Strongly disagree responses) to record views to 20 questions that were based on the employers’ satisfaction levels with course content and with the technical and non-technical knowledge and skills areas found in recent quantity surveying graduates.

This qualitative approach to gathering data for descriptive and interpretive analysis attempts to develop a comprehensive view of BIM adoption from the perspective of practitioners and managers in quantity surveying practice and recognises that meaning is
socially constructed, negotiated between people and changes over time (Fellows and Liu, 2008). In this instance it was believed that an online questionnaire followed by semi-structured interviews with at least two representative employers would help to establish parameters for a later and more in-depth project with a larger population sample and provide some much needed phenomenon-based insights into what is happening in terms of BIM adoption and its attendant challenges within quantity surveying organisations.

DATA COLLECTION AND ANALYSIS
As an exploratory study, invitations were sent by email to 30 regional employers. The email contained a link to an online survey questionnaire. Disappointingly, only 8 responses were submitted, just over 25% response rate and more work is suggested on the questions used in this pilot survey to see if the questionnaire design needs some improvement. After the initial results had been received and disseminated two semi-structured interviews were held with regional professional quantity surveying firms at Senior Director level. Both interview participants had also completed the survey and had indicated that they would be prepared to assist the research project by participating in an interview. Interview questions were based on seeking more in-depth information from data captured in the questionnaire. The purpose of the study was to explore the expected skills levels of graduate Quantity Surveyors and to assess the perceived importance of BIM related people skills.

QUESTIONNAIRE RESULTS
Table 1 shows the participants responses with regard to their views on the appropriateness of a range of skills and knowledge which are suitable for fresh graduates to commerce employment. Respondents were asked to indicate the extent to which they perceived fresh graduates joining their practices exhibited appropriate levels of skill and knowledge. As can be seen, the majority of employers are agreeable as to the skills level of fresh graduates. Eighty-five percent of employers where either strongly or mostly agreeable on the range of skills suitable for fresh graduates with a quantity surveying degree.

<table>
<thead>
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<th>Criteria</th>
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<td>Strongly disagree</td>
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<tr>
<td>Mostly disagree</td>
<td>13%</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>13%</td>
</tr>
<tr>
<td>Mostly Agree:</td>
<td>63%</td>
</tr>
<tr>
<td>Strongly Agree:</td>
<td>13%</td>
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One of the objectives of this study was to explore the perception of the relative importance of various skills. A number of skills where identified based on a review of literature. These were also considered to be BIM-relevant. Respondents were asked to rate their levels of satisfaction with fresh graduates’ skill in the identified areas on a scale of 1 to 5 where 5 is Excellent and 1 is Poor. Figure 1 presents a summary of the findings. It is interesting to note that competence in IT skills and communication scored high. These two skills are particularly seen to be critical BIM skills. In addition, it can be seen that people-related skills are perceived important as in each case the score was above the 2.5 score. What is interesting also is that respondents felt that working independently and
multi-disciplinary team working are areas where graduates’ skills could be improved. It is possible that this can be as a result of the need for greater collaboration between parties on a construction project, a natural platform for effective BIM working.

Respondents were also asked to indicate other areas that they felt could be strengthened within undergraduate degree provisions. Table 2 lists some of the key skills. Cost estimating, contract knowledge and measurement were identified by most respondents followed by report writing, presentation, sustainability and negotiation skills. Answers to this question have provided further useful insights into aspects of education provision in terms of technical and personal skills. As can be seen in table 2, there is a mixture of both technical and people related skills. An examination of the data show that the priority areas for employers are technical skills. All soft/people related skills are seen to be medium priority. In addition, research, drawing and BIM software applications were seen to be of low priority for fresh graduates.

![Figure 1: Satisfaction with skills](image)

<table>
<thead>
<tr>
<th>Priority</th>
<th>Skill</th>
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<tbody>
<tr>
<td><strong>High priority</strong></td>
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<tr>
<td></td>
<td>Contract knowledge</td>
<td>Technical</td>
</tr>
<tr>
<td></td>
<td>Quantity surveying measurement and measurement principles</td>
<td>Technical</td>
</tr>
<tr>
<td><strong>Medium priority</strong></td>
<td>Report writing</td>
<td>People</td>
</tr>
<tr>
<td></td>
<td>Presentation skills</td>
<td>People</td>
</tr>
<tr>
<td></td>
<td>Environmental and sustainability issues</td>
<td>Technical</td>
</tr>
<tr>
<td></td>
<td>Practiced negotiation skills</td>
<td>People</td>
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<td></td>
<td>Research Skills</td>
<td>Technical</td>
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<tr>
<td></td>
<td>Drawing skills</td>
<td>Technical</td>
</tr>
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<td></td>
<td>BIM software skills</td>
<td>Technical</td>
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The questionnaire also provided an opportunity for respondents to make their own comments. These included maintaining education focus on the core subjects of measurement, estimating and commercial management. Increasing the emphasis on measurement in accordance with the NRM and with clear links to general construction technology so that students can see how the items they are being taught to measure fit together into the wider context of a construction project. Most of the respondents
commented on the importance of measurement and construction technology as ‘basic skills which underpin future progression in the industry and to enhance students’ technical understanding.’

Taken overall, these results are encouraging and show no real cause for wider quantity surveying education provisions. It is clear where some attention is required from the above data sets and qualitative comments. Interestingly, the highest score for employer satisfaction with their graduate students is in IT skills which shows that BIM adoption from a technological viewpoint should not be particularly onerous and this is also borne out by comments in the two semi-structured interviews, below. However, the lowest score in terms of satisfaction is with students’ ability to work effectively in teams, a key attribute for successful BIM adoption and this seems to emphasis that it is the interpersonal soft-skills sets rather than the harder, technical aspects of BIM that employers are concerned about most.

**Interview Results**

Two interviews were conducted with Directors in Quantity Surveying professional practices. The focus of the interview was to investigate their perception on the implications of BIM adoption on skills requirements. One of the concerns for many quantity surveying education providers is the identification of specific software packages suitable for training quantity surveying graduates. Therefore, to begin the conversation, the interviewees were asked to give an overview of software usage within their practices.

**Table 3: Software**

<table>
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<tr>
<th>Interviewee 1</th>
<th>Interviewee 2</th>
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<tr>
<td>‘I think the issue you’ll come across there … is that there are so many systems. So whichever one that you choose to teach them on, no doubt they’ll be not using that system in their office environment. For example, at the moment, we're using three systems ourselves for different clients. We use CATO, RIPCAC, and CostX. CATO's good for cost planning, but not as user-friendly for bills and quants. RIPCAC's not so good for cost planning but very good for bills and quants. And CostX is the system we are using with BIM at the moment’.</td>
<td>‘I think nowadays, it's a given that you're competent on, say, Microsoft Office. Obviously the two main programmes we use are Excel and Word. Some of the older guys are still without, that's because they're not used to it…. We do use CAD Measure and it's a completely different software …... and I think that will come further into it now that BIM's coming on board. And we also use QS software called CATO, but there are other programmes available. …’</td>
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Table 3 presents a summary of the respondents’ views concerning software packages in use. Both respondents use Microsoft for general business management and administration and find that most staff of all ages and levels, including new entrants, are conversant with the use of MS Word, Excel and Powerpoint. Both did not see the need for any course education or training on these software applications (although happy to see forms of assessment based upon MS exercises to be continued). Similarly, and interestingly, both interviewees did not see any need for the inclusion in course or modular content of any CAD teaching (e.g. AutoCAD, Revit, and Sketchup) for quantity surveying students.
The findings in the questionnaire survey suggests that the primary priority for fresh graduates should be the technical skills. Table 4 and table 5 below present a summary of respondent’s views on technical and people skills requirements for graduates. The general consensus seems to be that technical skills should take priority for fresh graduates. However soft skills are still looked at as an important component. For example, Interviewee 1 emphasised measurement and estimating skills as key technical attributes and communication skills in writing and presenting work to others as key non-technical features they require from their graduates. Similarly, interviewee 2 indicated the importance of technical know-how in addition to the relative importance of soft skills such as team working, communication and managing client expectations.

Table 4: Technical skills requirements

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<th>Interviewee 1</th>
<th>Interviewee 2</th>
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<td>‘Technical skills we require from graduates: measurement is a key underpinning factor. The ability to understand and measure from drawings and to be able to estimate the cost of the works measured is the key technical skill and a skill that underpins the whole service that we provide. Yes, it goes on to be much more than that but if you haven’t got the basic technical skill then we can’t depend that you could do the rest of it…’</td>
<td>‘An all-round knowledge of the building process, and how buildings are put together. ... I think the view from the market is current graduates don’t have the all-round knowledge of how buildings get put together. It wouldn’t do you any harm in getting key subcontracts in for the key elements-- say for cladding, cladding contractors come and tells you all about how it’s put together. Because that’s what we do here-- if there’s a new product on the market, we get the supply chain in, and they explain to us how it works, and how it integrates into a building-- say for foundations and things like that. Because ultimately, they’re the guys that have to detail it out. Another big one is mechanical and electrical. And just having that bit more interaction, it probably, I think, would help’</td>
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<td>Table 5: None-Technical Skills</td>
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<tr>
<td>Interviewee 1</td>
<td>Interviewee 2</td>
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| ‘It’s a factor of our industry that a lot of people who have the technical skills are not necessarily the most communicative of people.....you need to be able to communicate.to your client and/or to other stakeholders in a scheme in a coherent way, so there is an element of written communication and verbal communication that are key issues. ... we just measure things and price them...that’s a basic skill...people are looking to do that with the computer. Some graduates are very confident but their work is sometimes lacking. Others can produce excellent work and they just aren’t confident in putting it across.....but we try and encourage people to be both accurate in their work and confident in putting it across’. | ‘... obviously, a big part of the construction industry is working as a member of a team-- so ability and self-awareness, really, and being able to integrate into a team environment. And obviously a big one from a client point of view is managing people's expectations’.

Table 6: BIM Skills
Table 6 presents respondents’ views on BIM skills. When asked if quantity surveying courses should include teaching, learning and assessment on a BIM-compliant software product, Interviewee 1 was of the view that this is not a priority as long as graduates have the technical know-how since they will pick-up of use of specific software packages. Interviewee 2 saw no problems with graduates not having direct competence with particular BIM-compliant software products. Like the other interview participant his organisation was also using CAT and had just introduced Cost X and was engaged in training staff on its measurement, cost planning and reporting products and working on real-time BIM projects. In response to the question: How long does it take a novice, coming to you with a degree, have done measurement, but they don't know anything about CAD Measure. The general view is that graduates are likely to be fast learners as they are used to the digital platform. The use of specific BIM-related training seems to be a common feature in most organisations as reflected in interviewee 2’s comments. These views might not, however, meet current students’ expectations and it is inevitable that choices will have to be made to introduce into course curricula some element of hands-on practical experience of BIM-compliant software and/or internet applications as part of teaching and assessment.

CONCLUSIONS & RECOMMENDATIONS
The purpose of the study was to explore the people skills implications of the adoption of BIM by quantity surveying professional practices and also to consider the potential implications of such on quantity surveying courses curriculum design. The research found no resistance to the introduction of BIM, it is already accepted, but noted that its implementation was still in a relatively early stage with some uncertainty apparent about which capital investment choices to make and which staff training provisions to choose. These uncertainties also apply to higher education providers in designing and managing curricula against BIM and maintaining pace with the rate of change. Overall the findings suggest that employers are generally satisfied with fresh quantity surveying graduates as they generally have requisite basic skills and knowledge to embark on their career. The findings also suggest that students are effective working in quantity surveying teams but less effective in working as part of a multi-disciplinary team. One of the objectives of the study, was to explore the people skills implications of BIM adoption on quantity surveying practice and by extension on course curriculum. Employers in this sample are at a relatively early stage in BIM adoption but working on BIM projects. The findings suggest that employers are generally not concerned with BIM-specific technical training but wish to see the focus on providing education and methods of assessment for the BIM process, of collaborative working, communicating, independent working and ability to
interpret data. These are important people skills that quantity surveying education providers need to take into consideration in course designs.

This initial research appears to corroborate findings in other studies (Chou et al, 2015 and Crowley, 2013) that quantity surveying firms are behind other professionals and other countries in adopting BIM. The diversity and range of choice of BIM-compliant quantity surveying software and internet related products means that there is no ‘one size fits all’ approach to incorporating specific products and systems into university courses and teaching and learning methods. Employers want traditional quantity surveying disciplines to be retained in course curricula and will provide their own training for IT and BIM-related software applications. The interviewees’ views on not incorporating some technical aspects of BIM will have to be considered against the findings from the literature which suggest that combining theory, practice and use of technology in a collaborative setting will need to be a part of course curricula.

The study recognises the sample size as a limitation. However, given that this was a pilot study, key issues have been identified for further research. In particular, the study identifies the need for a further investigation of soft skills requirements in a BIM environment.

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HOW ECONOMIC CRISIS AFFECTS WORKPLACE CONDITIONS AND OCCUPATIONAL HEALTH

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The article analyses the influence of ‘business premises’ and ‘workplace design’ factors on employees’ satisfaction with the workplace, and with the ‘satisfaction of employees’ on the overall health of employees. The purpose of the research is, firstly, to assess the influence of business premises and, secondly, to facilitate the improvement of employee health through the application of base parameters and subsequent adequate changes of the workplace and work processes. The quantitative research was carried out in Slovenia in 2012 among 1038 employees from the service sector. The results were statistically analysed with factor analysis and an applied structural equation modelling. The results show that business premises factors of the workplace have an impact on the satisfaction of employees and consequently on their health. With the aid of factor analysis and analysis of structural equation modelling, the significant links with the following factors were established: ‘orthopaedic problems’; ‘past health problems’, ‘cardiovascular problems’ and ‘state of health’. The research covers a need that is becoming more important as the focus on Health and Well-being issues is increasing. Implementing better workplace condition aspects will introduce a better base of value for the employees and employers.

Keywords: employee satisfaction, overall health, Slovenia, workplace

INTRODUCTION

Employees spend a large part of their lives at work and as a consequence the workplace typically influences their health. Employees encounter working conditions problems related to environmental and physical factors in many organizations around the world (Pizam & Thornburg, 2000). Research on workplace health promotion, friendly workplaces, healthy organizations, job stress, high performance workplaces, strategic human resources management and leadership styles congregate around the importance of supporting employees to be effective in their jobs in ways that promote their health (Lippel et al, 2011; Vicher, 2008; Shain & Kramer, 2004). Work-related injuries and diseases represent serious and costly burdens to all countries and are a major challenge to managers, unions, governments and the workers themselves. Common health problems such as spinal pain, diseases, allergies, respiratory problems, physical limitations and mental illness, emerge at some point during a worker’s life (Ford et al, 2014). Today, employee health is becoming a hard, economic ‘factor of production’. Governmental agencies, businesses, and economists argue that workplace health

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and wellbeing ought to guide research and development, investment in technology, and customer relationship management. The issue not only affects the community in which the workplace is located, but also how the organization is managed (Stone et al., 2013). The negative impact of the financial crisis on Spanish employees’ perceived level of work flexibility, autonomy, stress and monotony is shown on work-balance (Gregory et. al, 2013). The long economic crisis in Slovenia poses an additional risk factor for mental health problems which clinicians should internalize and monitor using screening tests. Symptoms of depression and anxiety can be masked in high-utilizers of medical care with physical complains, reported injuries sustained at work or on the way to work, or psychoactive drug use (Avguštin et al, 2011). In Slovenia, because of the recession stress, depression and suicidal emotions are increasing (Margan & Dodič, 2015). This creates new pathology - health problems are connected with the reality of keeping and getting the jobs; health indicators show that the psychological problems are growing, consequences of stress are stronger, absenteeism and presentism of employees are bigger. The present research focuses on the analysis of specific elements of the work environment and behavioural habits of employees at their jobs with the aim to discover the characteristics of the workplace that have the most effect on the individual.

**Job satisfaction and Occupational Health**

Two acclaimed theories of workplace stress identify the following stressors as key factors in the onset of stress-related illness. First, the Demand-Control-Support model, predicts that high levels of job demands, low levels of job control, and low levels of social support are strongly associated with negative health outcomes (VanDoef & Maes, 2000). The second popular model, the Effort-Reward Imbalance model predicts that high levels of extrinsic effort, and intrinsic effort; and low levels of reward, will significantly predict negative health outcomes. These two models are found to be good predictors of physical and psychological health outcomes including heart disease, mortality, and depression in many occupational groups (Mark & Smith, 2012; Kinman & Court, 2010). Factors such as high levels of workload and job demands, low peer support, and poor working relationships in populations would certainly suggest that these populations may be at high risk from stress-related illness. When high levels of workload are present in a job, a person’s basic needs for personal growth and performance must be met in one way or another (Herzberg et al., 2011). Job satisfaction is also considered to be resulting from a set of factors, characterizing the context in which work is performed. Such are typically called company policies and administrative practices. Primary among these, are technical quality of supervision, interpersonal relations, especially with supervisors, physical working conditions, job security, benefits and salary (Maamari & Smith, 2012; Herzberg et al., 2011). On the other hand, dissatisfaction in a job may be caused by environmental factors, such as poor lighting, poor ventilation, poor working conditions, low salaries, and poor supervisory relationships. These are considered to be basic needs and for that matter, are the responsibility of the respective society, businesses and industrial institutions, which are expected to provide for their employees in order to self-
actualize (Temeljotov et al., 2015; Herzberg et al., 2011; Kalleberg, 2011). Although convenient workplace conditions are requirements for improving productivity and quality of outcomes, working conditions in many organizations may present lack of safety, health and comfort issues such as improper lightening and ventilation, excessive noise and emergency excess (Kalleberg, 2011). Pech and Slade (2006) identify an increase in so-called employee. They focus on symptoms of disengagement such as distraction, lack of interest, poor decisions and high absence, rather than the root causes. The working environment is probably a key root factor causing employees’ engagement or disengagement (McTernan, 2013). In recent years, employees’ comfort on the job, determined by workplace conditions and environment, has been recognized as an important factor for measuring their productivity (Johns, 2010). The greatest challenge is that this model requires employees and managers to think about the workplace far more holistically (Gilbreath, 2012; Chu et al, 2000).

The broader research is devoted to the analysis of specific elements of the work environment and behavioural habits of employees at their jobs, with the aim to discover the characteristics of the workplace that have the most effect on the individual. The objective of this study is to use the discovered parameters and consequential changes of the work environment and work processes to ensure a sustainable effect on the improvement of employees’ health. The bases of this research are three fundamental hypotheses within which we specify the sub-hypotheses:

- **Hypothesis 1**: Business premises and Workplace factors have a significant impact on the satisfaction of employees with the workplace.
- **Hypothesis 2**: Workplace design factors have a significant impact on the satisfaction of employees with the workplace.
- **Hypothesis 3**: Satisfaction of employees with their workplace has a significant impact on the health of employees.

**METHODS**

The researchers carried out a quantitative research using a broad host of questions, scales and differentials, whereby the majority of instruments were specially constructed with suitable measurement characteristics. The questionnaire demonstrated a high level of consistency according to the method of internal consistency or the Cronbach Alpha’s coefficient. The questionnaire comprises 160 variables divided into eight content sections: general questions, business premises and workplace, workplace design, habits, conditions in the workplace, organizational culture, state of health, and mental health condition. A part of the questionnaire includes questions with pre-set parameters to choose from, and the remaining part includes 3 or 5 component Likert’ scale items. For the collecting of data, the researchers designed an online anonymous survey questionnaire. It is the fundamental objective of the questionnaire to investigate the relationships among the selected factors of workplace, organizational culture, and the physical and mental health condition of employees. 1038 employees from Slovenia, from
organizations within the service sector responded, what is 98 % response rate. All respondents perform only office tasks and participated voluntarily with the assurance of their anonymity. The data were processed with the SPSS statistical software and subjected to factor analysis and structured equation modelling (SEM). The collected data were first processed with exploratory factor analysis, which was used to research the number of factors required for the presentation of specific information. It continued with a confirmatory factor analysis, which was used to test the quality of the metric and structural part of the model. The confirmatory factor analysis was also used to test hypotheses and the links and/or structure in exploratory factor analysis of specific factors. In the last stage the SEM method was applied, to overcome the restrictions of multi-variant techniques and to achieve statistically efficient and transparent assessment of relationships when dealing with several mutual relationships at the same time.

RESULTS

In the theoretical model of the researched influences, we included constructs: The workplace construct includes the ‘Business premises and workplace’, ‘Workplace design’ and ‘Conditions of workplace’ questionnaire sections, and comprises a total of sixty variables. The state of health is constructed by thirty-one variables.

‘Business premises and workplace’ section

The ‘Business premises and workplace’ section of the questionnaire comprised 20 questions or statements regarding the description of the building (building and workplace location, accessibility and use of public transport, parking possibility, age of building, building construction characteristics, renovation and maintenance information), and workplace specification (workplace location, type of office, location of the superior’s office, and cleaning information). Table 1 shows the connections of the remaining 11 variables (Variable/question) of the ‘Business building and workplace’ section with the following factors (Components): State of workplace, Orientation of workplace, and State of business premises. We confirmed the suitability of data for factor analysis and confirmation of typical correlations in the correlation matrix with the Bartlett test (p=0.000). The results of the KMO test (0.561) showed that the connection and suitability of variables are adequate.

Through the application of factor analysis and based on the Kaiser criterion, we selected a solution with three factors, which explain 51.79% of the total variance. Upon the completed rotation, we use the first factor of the section to explain 18.93% of the total variance, the second factor to explain 17.32%, the third factor to explain 15.54% of the total. The first factor State of workplace includes five variables: ‘the distance of window’, ‘the distance of the outer wall’, ‘location of my workplace’, ‘floor furnishing’, ‘kind of workplace’. The second one Orientation of workplace includes two variables: ‘sky orientation of the windows
and walls’ and ‘sky orientation of the window closest to my desk’. The third factor
*State of business premises* includes four variables: ‘refurbishment of the room’,
‘age of the building’, ‘regular maintenance’, ‘construction type’.

Table 1: ‘Business premises and workplace section’ Rotated Component Matrix*  

<table>
<thead>
<tr>
<th>Component</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The distance of window closest from my workplace is (less than 1m...more than 4m)</td>
<td>.838</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The distance of the outer wall from the place where I work (less than 1m...more than 4m)</td>
<td>.777</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My workplace is (in the basement, floor, et)</td>
<td>-.545</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>The floor of the room where I work is clad with (wood, textile, plastic, stone, other)</td>
<td>.505</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My workplace is in an office (alone, open plan office etc.)</td>
<td>.454</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation of a large share of windows and walls.</td>
<td></td>
<td>.972</td>
<td></td>
</tr>
<tr>
<td>Orientation of the closest window surface (north, south...</td>
<td></td>
<td>.971</td>
<td></td>
</tr>
<tr>
<td>The room where I work was last thoroughly refurbished (building, heating, ventilation…)</td>
<td></td>
<td></td>
<td>.705</td>
</tr>
<tr>
<td>Age of the building where I work (less than 5 years...older than 30 years, don’t know)</td>
<td></td>
<td>.700</td>
<td></td>
</tr>
<tr>
<td>The room where I work is regularly maintained (once a year... once in four years)</td>
<td></td>
<td>.609</td>
<td></td>
</tr>
<tr>
<td>The construction of the building where I work (reinforced concrete, wooden etc.)</td>
<td></td>
<td></td>
<td>.571</td>
</tr>
</tbody>
</table>


‘Workplace design’ section

This section, named as ‘The concept of my workplace’ in the questionnaire included 10 questions/statements on the possibility to control devices in the workplace. The Bartlett test (p=0.001) confirmed the suitability of data for factor analysis, while the result of the KMO test (0.655) indicates a sufficient connection and suitability of variables. We specified two factors for the ‘Workplace design’ section, which together explain 53.03% of the total variance. After rotation, the first factor explains 29.57% of the total variance, the second 23.46% of the total variance (Table 2).

The first extracted factor is named *Illumination of workplace* and it includes four variables: ‘windows with blinds’, ‘local regulation of blinds’, ‘direct sunshine’, ‘windows could be open’. The second factor is named *Heating/cooling of workplace* and it includes three variables: ‘central ventilation system’, ‘local regulation of ventilation system’, ‘air condition’.
Table 2: ‘Workplace design’ section, Rotated Component Matrix

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The windows are furnished with blinds</td>
<td>.750</td>
<td></td>
</tr>
<tr>
<td>The window blinds are controlled from the workplace</td>
<td>.744</td>
<td></td>
</tr>
<tr>
<td>The workplace is at least part of the day directly sunlit</td>
<td>.670</td>
<td></td>
</tr>
<tr>
<td>The windows can be open-end</td>
<td>.656</td>
<td></td>
</tr>
<tr>
<td>The room is ventilated by a central ventilation system</td>
<td></td>
<td>.790</td>
</tr>
<tr>
<td>The intensity of ventilating can be set with switch in the room</td>
<td></td>
<td>.763</td>
</tr>
<tr>
<td>The room is cooled/heated with an air conditioner</td>
<td></td>
<td>.599</td>
</tr>
</tbody>
</table>


‘Condition of workplace’ section

The ‘Condition of workplace’ section included 30 questions and/or claims, based on evaluation of the level of the satisfaction with different characteristics of the place, for example: indoor quality characteristics, ICT equipment, furniture condition, cleaning and maintenance characteristics, possible real estate characteristics as reasons for changing the job, overall satisfaction characteristics. The suitability of data for factor analysis was confirmed with the Bartlett test (p=0.001), while the result of the KMO test (0.893) shows a high level of connection and suitability of variables for examination. We specified three factors for the ‘Condition of workplace’ section which together explain 59.21% of the total variance (Table 3). After rotation, 15 variables are represented in three components.


‘State of health’ section

The ‘State of health’ section of the questionnaire includes 31 questions/claims from the perspective of health. It includes self-evaluation of state of health, as: being a disabled person/chronic patient; having an occupational disease, having pain in the back, spine, neck, or high blood pressure, headaches, rheumatism, problems with blood flow, allergies; being on sick leave/operation, or other.
Table 3: ‘Condition of workplace’ section, Rotated Component Matrix

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am pleased with the conditions of my workplace</td>
<td>.865</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My workplace is pleasant</td>
<td>.853</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel good in my workplace</td>
<td>.844</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The business premises are as new and pleasant to work in</td>
<td>.782</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The furniture and facilities assure pleasant feeling</td>
<td>.688</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The workplaces are clean</td>
<td>.667</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The standards of hygiene in business premises are high</td>
<td>.651</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation of the workroom is good</td>
<td>.613</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due to the conditions in workplace I am contemplating a change of employment</td>
<td>-.597</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is only exceptionally too high humidity in the workplace</td>
<td></td>
<td>.789</td>
<td></td>
</tr>
<tr>
<td>There is only rarely to dry air in the workplace</td>
<td></td>
<td>.734</td>
<td></td>
</tr>
<tr>
<td>The workplace is exceptionally uncomfortably hot/cold</td>
<td></td>
<td>.665</td>
<td></td>
</tr>
<tr>
<td>In workplace I exceptionally have concentration problems</td>
<td></td>
<td></td>
<td>.671</td>
</tr>
<tr>
<td>The arrangement of the workplace influence my feelings and work efficiency</td>
<td></td>
<td></td>
<td>.622</td>
</tr>
<tr>
<td>As a rule, I have no problem with performance in my workplace</td>
<td></td>
<td></td>
<td>.596</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 6 iterations

The typical correlations of the correlation matrix are confirmed by a Bartlett test (p=0.001), while the result of the KMO test (0.774) confirmed the suitability of the variables for examination. The criterion of own value determined 3 factors of the section. The first factor explains 25.53%, the second 14.83% and the third 10.17% of the total variance.

The information in 13 of the variables can be represented by 3 components as displayed in table 4. The first extracted factor is named ‘Orthopaedic problems’ and it includes 4 variables: ‘occasional pain in my back’, ‘occasional pain in neck’, ‘occasional pain in the spine’, ‘suffer from rheumatism’. The second one is named ‘Past health problems’ and it includes 4 variables: ‘sick leave’, ‘therapies in health institutions or spa’, ‘physician's help because of troubles at work’ and ‘a state of health’. Third factor is named ‘Cardiovascular problems’ and it includes 5 variables: ‘high blood pressure’, ‘regularly taking medicines’, ‘chronic disease’, ‘high blood sugar’, ‘blood circulation problem’.
Table 4: ‘State of Health’ section, Rotated Component Matrix

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have occasional pain in my back (muscle tension)</td>
<td>.877</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have an occasional pain in neck</td>
<td>.838</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have occasional pain in the spine</td>
<td>.831</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I suffer from rheumatism</td>
<td>- .383</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the last year I have been on sick leave because of my own diseases (0 days...more than 15 days)</td>
<td></td>
<td>.732</td>
<td></td>
</tr>
<tr>
<td>In the last three years I have had therapies in health institutions or spa (less than 7 days...more than 29 days)</td>
<td></td>
<td>.726</td>
<td></td>
</tr>
<tr>
<td>In the last five years I have sought a physician's help because of troubles at work (never...more over than three times)</td>
<td></td>
<td>.596</td>
<td></td>
</tr>
<tr>
<td>In the last 12 months my state of health has (remained the same, improved, deteriorated)</td>
<td></td>
<td>- .429</td>
<td></td>
</tr>
<tr>
<td>I have a high blood pressure</td>
<td></td>
<td></td>
<td>.734</td>
</tr>
<tr>
<td>Presently I regularly take pills, capsules, drops, salves</td>
<td></td>
<td></td>
<td>-.688</td>
</tr>
<tr>
<td>I suffer from a chronic disease</td>
<td></td>
<td></td>
<td>.601</td>
</tr>
<tr>
<td>I have high blood sugar</td>
<td></td>
<td></td>
<td>.599</td>
</tr>
<tr>
<td>I have a blood circulation problem</td>
<td></td>
<td></td>
<td>.446</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 5 iterations

Testing of hypotheses

Hereinafter we use the confirmatory factor analysis to test the quality of the measurement and structural part of the model. In the measurement part, we verified the compatibility of pattern data with the theoretic model. We applied the following suitability indicators: chi-squared ($\chi^2$), RMSEA, CFI, GFI and SRMR. Two main analyses are included in the model:
- Business Premises and Workplace $\rightarrow$ Satisfaction with the workplace $\rightarrow$ State of Health
- The Workplace Design $\rightarrow$ Satisfaction with the workplace $\rightarrow$ State of Health

Figure 1: A model

H 1: Business premises and Workplace factors have a significant impact on the satisfaction of employees with the workplace.

Through the application of factor analysis and on the basis of factor weight matrix we identified the following factors of the ‘Business premises and workplace’ section:
State of workplace, Orientation of workplace and State of business premises
**H2: The Workplace design factors have a significant impact on the satisfaction of employees with the workplace.**

Through the application of factor analysis and on the basis of factor weight matrix we identified the following factors of the ‘Workplace Design’ section: *Illumination of workplace* and *Heating/cooling of workplace*

For the ‘Condition of Workplace’ section the factor weight matrix, we identified the following factors: *Satisfaction with workplace*, *Climatic characteristics of the workplace* and *Performing at the workplace*

**H 3: Satisfaction of employees with their workplace has a significant impact on the health & health care of employees.**

Through the application of factor analysis and based on factor weight matrix, we identified the following factors of ‘State of Health & Health Care’ section: *Orthopaedic problems*, *Past health problems* and *Cardiovascular problems*

Model fit information: $\chi^2 = 5.9$; RMSEA $< 0.000$; CFI $\approx 1.000$; SRMR $= 0.010$

**Table 5: The achieved values of the SEM final model**

<table>
<thead>
<tr>
<th>Causal Path</th>
<th>Path Coefficient</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>STATE OF BUSINESS</td>
<td>-.217***</td>
</tr>
<tr>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>PREMISES</td>
<td></td>
</tr>
<tr>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>STATE OF WORKPLACE</td>
<td>-.165***</td>
</tr>
<tr>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>ORIENTATION OF WORKPLACE</td>
<td>-.033,.250</td>
</tr>
<tr>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>ILLUMINATION OF WORKPLACE</td>
<td>-.228***</td>
</tr>
<tr>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>HEATING/COOLING OF WORKPLACE</td>
<td>-.087,.003</td>
</tr>
<tr>
<td>CARDIOVASCULAR PROBLEMS</td>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>.085,.009</td>
</tr>
<tr>
<td>PAST HEALTH PROBLEMS</td>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>-.166***</td>
</tr>
<tr>
<td>ORTHOPAEDIC PROBLEMS</td>
<td>SATISFACTION WITH THE WORKPLACE</td>
<td>-.207***</td>
</tr>
</tbody>
</table>

***$p < 0.001$***

Based on the results of SEM shown in Table 5 we established that the ‘Orientation of workplace’ has a statistically significant ($p < 0.001$) and a positive ($\beta = 0.106$) impact on the *Illumination of workplace* and ‘state of workplace’ has a statistically significant ($p < 0.001$) and a middle ($\beta = 0.521$) positive impact on the *Illumination of workplace*. Moreover, ‘Illumination of workplace’ has a statistically significant impact ($p < 0.001$) on the *Satisfaction of employees with the workplace* with a negative standardized $\beta$ coefficient (-0.228).
Figure 2: Results of SEM

Following two factors also have statistically significant impact (p < 0.001) on the Satisfaction of employees with the workplace: ‘State of business premises’ with a negative standardized β coefficient (-0.217) and ‘State of workplace’ with a negative standardized β coefficient (-0.165). With β = -0.166 we established the negative link between the Satisfaction with workplace and the past health problems of employees. With β = -0.207 we established the negative link between the Satisfaction with workplace and the Orthopaedic problems of employees.

For the case all three hypothesis are confirmed

Hypothesis 1: Business premises and Workplace factors have a significant impact on the satisfaction of employees with the workplace. Two factors were found to be significantly important: ‘State of business premises’ (refurbishment of the room, age of building, regularly maintained room, building construction) and ‘State of the workplace’ (distance of the closest window, distance of outer wall, position of the workplace, floor finishing and office type - cell room or open space).

Hypothesis 2: Workplace design factors have a significant impact on the satisfaction of employees with the workplace. Factor ‘Illumination of workplace’ (windows with blinds, window blinds are local controlled, directly sunshine by the day, windows can be opened) was found as the one with the significant influence.

Hypothesis 3: Satisfaction of employees with their workplace has a significant impact on the health & health care of employees. The factor ‘Satisfaction with the workplace’ is characterized by 9 items: pleased with the condition, pleasant
workplace, feeling good, state of business premises, state of furniture, cleanliness, 
hygiene standards, ventilation, changing the job. The link between this factor and 
health factors ‘Orthopaedic problems’ (pain in back, pain in neck, pain in spine, 
rheumatism) and ‘Past health problems’ (sick leave, therapies, physician help, 
state of health) are found to be significant.

CONCLUSIONS

The main purpose of the study is determining the healthy workplaces from the 
employees’ perspective in Slovenia. It was important to find out the reaction of 
employees in the time of economic crisis, like in Slovenia. The theoretical and 
practical solutions, which identified in the reviewed literature are taken into account 
and results are compared. In the discussion, we stress that some of the findings were 
similar to the findings from the literature review part, and some are more specific.

Based on the SEM results, and similarly to previously reported research results 
presented in the theoretical part, the researchers defined that some of the business 
premises’ factors of the business-building construct have a significant impact on 
the satisfaction of employees with the workplace, such as: Orientation of 
workplace, State of workplace, and State of business premises. The researchers 
found that Business premises and workplace factors have a significant impact on 
the satisfaction of employees with the workplace (state of workplace, orientation 
of workplace and state of business premises). This is in line with what is reported 
in the literature reviewed, where the physical conditions of the working 
environment are reported to affect the job satisfaction (Kalleberg, 2011, Visher, 
2008). A factor ‘State of business premises’ includes the characteristics: 
refurbishment of the room, age of building, regularly maintained room, building 
construction. In Slovenian case, the main business area is in the city centre where 
the average business building’s age is more than 60 years, which should be 
renovated or refurbished, what is not possible during economic crisis.

Illumination of the workplace is a factor with a significant influence of Workplace 
design on employees’ satisfaction comprises characteristics: windows with blinds, 
window blinds are local controlled, directly sunshine by the day, windows can be 
opened. The effect of workplace lighting on employees, and the need for local 
regulation, were investigated by several researchers (Haldi et al., 2008; Nicol et al., 
2006; Galasiu et al., 2006; Veitch, 2006), while measuring quality of the indoor 
environment. These researches were focused on heterogeneous factors of Indoor 
Environment Quality IEQ, especially physical ergonomic conditions of the 
workplace. Many of them reported a positive correlation between the satisfaction of 
users and the importance of individual control of conditions in their work 
environment (Tøftum, 2010; Andersen et al., 2009; Haldi et al., 2008). Some of them 
claimed that in office buildings, users mostly complained about (too) low 
temperature, dry air, bad air or cold radiation next to windows, lack of sound 
privacy in open office spaces.
As predicted, we found that satisfaction of employees with their workplace has a significant impact on the ‘health of employees’. The factor ‘Satisfaction with the workplace’ is characterized by nine items: pleased with the condition, pleasant workplace, feeling good, state of business premises, hygiene standards, furniture and facilities assures pleasant feeling, cleanliness, ventilation. The link between this factor ‘Satisfaction with the workplace’ and three factors from Health & health care of employees’ section was found to be statistically significant. Those are: ‘Orthopaedic problems’ (pain in back, pain in neck, pain in spine, and rheumatism), ‘Past health problems’ (sick leave, therapies, physician’s help, and state of health), and ‘Cardiovascular problems’ (high blood pressure, taking pills, chronic disease, blood sugar, and circulation problem).

The results show the seriousness of the researched theme, especially from the health care perspective. It is obvious that employees show the symptoms of their health condition, including stress, depression, and cardiovascular diseases, as is reported by other researchers (Ford et al, 2014; McTernan et al, 2013; Drach-Zahavy; 2008; Noblet & LaMontagne, 2006; Shannon et al., 2001) and also connecting pain in the neck, spine and back as caused by stress. In the economic crisis it is hard to change the job, so the main motivation becomes job security, what leads to face low performance and occupational health diseases causing high absenteeism or presentism. Findings from the research should be taken seriously, as we are aware that synchronous stressor strain effects tend to strengthen over time, with stressor-psychological strain effects increasing especially when workers are constantly exposed to stressors (Ford et al, 2014). Even though the system of health promotion in the workplace is formally established in Slovenian companies and institutes, it still shows from managerial perspective, that a straight line relationship between employee’s productivity and wellbeing to keep them creative and healthy is not performed.

Major changes in economic situations nowadays focus future studies on a deepened research on impacts or connections between specific business premises’ factors and the occurrence of depression symptoms. The link between specific business premises’ factors and specific elements of organisational culture, the research on the link of satisfaction with the physical workplace, specific elements of organisational culture and research of the link between the perception of workplace and specific elements of organisational culture and possible positive influence on the employees, remain to be explored.

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THE RELATIONSHIPS BETWEEN PRODUCTIVITY, SAFETY, AND QUALITY
Wesley Butler, Syed Ahmed\textsuperscript{1} and Laura A. Russell

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This was an attempt to capture the broad spectrum of the interrelationships that exist between quality, safety and productivity in construction. Data was collected through surveys to identify advantages, disadvantages, levels of comfort, and ability to obtain certain levels in each area at a given point and time. Also a questionnaire was implemented to ascertain what could be done to improve the overall performance from both an employer and employee standpoint. As for the initial analysis of simultaneous positive coexistence, related case studies were examined and put into context of related material. In order to gather the most recent data as it relates to past as well as present methods of achieving high levels of all three areas a survey was administered to both employee and employer. By identifying the particular variables that exist, the results of the combinations that produce the best overall output were identified. It is shown that from this study certain variables exist in tandem with each other and produce the most desirable levels of quality, safety and productivity. It was possible to manipulate the variables in order to create a system to which quality, safety and productivity levels are proficiently managed and co-exist together.

Keywords: Productivity, Safety, Quality

INTRODUCTION

In a study that was conducted by John K. Robinson on the African based construction company Neil Muller Construction factors were identified that affected the organizations productivity. These factors were comprised of communication, trust between management and the workforce, limited tracking of productivity, lack of long term goals, employee involvement and limited supervision (Robin, John K 1998.) By identifying these problems Neil Muller Construction was able to establish 10 goals that would support the long-term vision of the organization. These goals consisted of changing company culture and creating a companywide vision, increasing companywide involvement, implementation of affirmative action programs, development of adequate monitoring and measuring controls systems of productivity, improvement of product quality and productivity, as well as improving profitability to increase interest of potential shareholders. From the beginning of this “Total Company Renovation” of Muller as referred to by Robinson problems areas within Muller were identified and addressed. (Robin, John K 1998.) One of the areas which affected the organization the most was the illiteracy rate throughout the organizations workforce. Hence, Muller’s goal # 7 was to improve every employee’s way of life and in this case would ultimately improve their overall productivity within the organization through training and education. Another area Muller focused on was dealing with an affirmative action program. In the past under the white minority government Black, Indian and other minority groups were not given the same opportunities as whites so by implementing an affirmative action program advancement opportunities were available throughout the organization. As for the actual implementation that the Muller Organization

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took in order to begin the “Total Company Renovation” as defined by Robinson the framework of the National Productivity Institute (NPI) 6M training package was used. The objective of the program was to educate and inform the entire company from top to bottom how certain criteria such a production and safety would affect the organizations bottom line. In general the purpose of this training was to show that resources utilized in one area would not be available to be utilized in another. Ultimately, areas such as waste, rework of faulty products, and other areas were efficiency was not being maximized. Additional tools were also implemented in an attempt to increase productivity. Attendance cards, guest speakers and defining completion requirements and goals for each group of employees were implemented.

The purpose of daily meetings was to inform the different levels of employees the activities being performed on site, the financial status of the project and the elements which determines why duties and tasks were being performed in certain manners. In doing organizational transparency was created which in turn helped support organizational unity. By focusing on individual involvement the goal of overall organization success could be achieved. Taking this approach of empowering individuals to be able to control their own destiny within an organization leads them to take pride and be more involved in the overall welfare of the organization and its success.

**PRODUCTIVITY**

Based on the one-day study conducted by John K. Robinson the perception obtained was that Muller Construction was taking the right approach in order to increase the productivity, quality and safety of the overall organization. Results were supplied by the organization to support Robinson’s perception of the organization. These results showed absenteeism decreased, safety rating increased, shareholder profits doubled in comparison to increasing overhead and overall sales per individual increased as well. The use of more ergonomically safe equipment and cleaner work areas as avoid unnecessary mishaps due to overcrowding could also be avoided. The measurements that were found to solely affect productivity were the rate at which certain tasks were performed. The faster the task was expected to be performed the higher the productivity rating was but ultimately had the adverse effect on safety making it lower with more accidents occurring.

When the foremen on the site were asked to give their thoughts on the factors that had the greatest impact on productivity and safety their opinions varied from the other groups. The foremen put more of an emphasis on safety than the others groups due their knowledge and responsibility dealing with safety on a jobsite. The measures that held the most merit to foremen were that of increased awareness of safety issues, more thorough accident investigations, deceleration of production timetables and more safely designed tools. Based on the statistical differences the largest variation dealt with longer time allotted for task completion and increased safety measures for equipment. When participants were asked to give their opinion on what the top 5 measurements for improving productivity and safety were from the 26 original measurements the following given. For the increasing productivity the top rated measurements were improvement of machines, an increase in skilled labor, increase in training for individuals, more ergonomically designed work areas
as well as the cleanliness of those areas. (Salminen and Saari 1995) Particular portions were given to the various groups such as employee to employer and safety to production.

SAFETY
When dealing with safety within the construction industry there are many opportunities that incidents can occur. The construction industry has one of the highest accident rates as compared to other industries. This is due in large part to the nature of the construction industry in general. For starters the construction industry utilizes a massive amount of machinery, material and manpower to manage various projects. The safety culture of an organization and how it is structured is an indication of how effectively safety will be managed out on a given a project. In study conducted by (Ho & Zeta 2004) the safety culture was examined in an attempt to display the actual components of a safety culture within an organization. When developing the structure for this analysis EFQM (European Foundation for Quality Management) a most frequented study of TQM (Total Quality Management) was implemented. The components EFQM consisted of 5 enablers and a group of 31 attributes that were grouped with a particular enabler. A total of 220 questionnaires were administered with 118 respondents. The Enablers consisted of Leadership (Lds), Policy & Strategy (Pol), People (Ppl), Partnerships & Resources (Prs), Processes (Pro) and Goals. The Leadership enabler if defined by the leaders’ ability to develop a goal, develop a strategy to achieve that goal and implement the strategy by the lead by example approach. (Dea & Flin 2001). The Policy & Strategy enabler is how the organization actually implements such strategies so they align with stakeholder’s interest in mind and by incorporating any relevant/current information as well as supporting the future direction of the organization (Lingard and Blismas, 2006.). The People enabler is how an organization utilizes its human resources department so that from an individual, team-based and organizational-wide level, information can be properly developed, distributed and implemented in order to ensure constant growth within the organization. (Niskanen, T. 1994). A Partnership & Resources enabler deals with how an organization cultures its partnerships with outside individuals as well as resources needed to support its day to day activities. (Wright, M.S, 1999). The Process enabler is how an organization creates an environment of continual growth that can be observed by customers, employees and stakeholders. Larder, R. 2001). As a result of the examination between the safety enablers and safety attributes the enablers were determined to have direct and indirect relationships among each other. Leadership was found to have a direct relationship with People, Policy and Strategy thus suggesting the importance that leaders should lead by example, rigorously monitor day to day operations and develop/maintain realistic standard operating procedures.

INTEGRATED MANAGEMENT SYSTEMS
In the construction industry implementation of a new operating system can at times be challenging. Even trying to adjust/integrate an already active system for improvement takes a considerable amount of effort. Construction projects in general are complex systems that require enormous amounts of planning, coordination, installation and commissioning of the final products. In order to have all of these areas coincide for a final product certain measures need to be implemented. Various quality management systems exist so as to provide guidance in areas such as quality and safety ultimately leading to the integration of both. Commonly used management systems standards are used in an attempt
for standardization throughout the world. The Geneva Based International Organization for Standardization has over 140 national standards of which ISO 9001 QMS (Quality Management Systems) and OHSAS 18001 (Occupational Health and Safety Assessment System) are commonly used in the construction industry. Many organizations have adopted these standards and integrated them into their Total Quality Management System (TQM).

As of now the ISO 9001 covers the productivity and quality aspect while the Occupational Health and Safety Assessment Standard (OHSAS 18001) covers the safety aspect. In the construction industry quality and safety programs that have been successful had several elements in common. By integrating the ISO 9001 standard with the OHSAS 18001 standard three main benefits have been a byproduct of this union. Risks of a business can be minimized, Occupational Health and Safety cost can be reduced as well the nurturing of positive organizational relationships both internally and externally. Other benefits that have been associated with this integration optimized management systems, increase involvement of stakeholders, increase resource utilization, enhancement of management methods, increased motivation of staff just to name a few. Challenges include identification of systems variation, implementing various systems in ever changing cultures and perception that simply compiles operating procedures and guidelines of various programs will not foster a union of the quality and safety without additional guidance (Wilkinson and Dale 1999).

The time element within an IMS system can be considerably shorter than a non-integrated management system. The time to actually construct an IMS system is substantially shorter due to the requirements that can be slightly modified based on the standard requirements that somewhat coincide with other standards. The time required to ensure that the integrated systems stays in compliance with standard requirements is also shortened. This is possible by eliminating the number of audits that are required in order for the organization to maintain it certification. When audits are conducted within an organization the productivity of that company can be affected negatively in terms of liquid damages. The cost associated with an IMS system generally refers to the maintenance of the system. When maintaining a standard within an organization and IMS system is considerably lower. By packaging multiple standards together in an IMS the effort to maintain its compliance is reduced therefore reducing the overhead gained from individuals taking on additional work and affecting their main job performance areas. Out of the total cost associated with implementing an IMS 10% -20% of that cost is allocated for registration and training of personnel. (Low & Yeo, 1998). The next element associated as benefit of an IMS system being implemented within an organization is that of manpower. Implementing and IMS allows the manpower to be reduced from actual system controller’s standpoint and that of top management because of it being all in one manual. Ultimately by reducing the time, cost and manpower the paperwork involved with document control of and IMS system within an organization are substantially reduced.

In a study which included 96 construction firms the integration of ISO 9001:2000 and OSHAS 18001: 1999 were evaluated. Within this study the possibilities, benefits and cost for the integration of OSHAS 18001 into ISO 9001. A two part questionnaire was sent out being the first part was to determine if an organization had been OSHAS 18001
certified. The second part of the survey inquired from the organizations the difficulties, benefits and cost implementing OSHAS 18001. In recording the data a 5 point Likert scale was used. The results of the first survey had a 95% rating of organizations that were not OSHAS 18001 certified. The 5% of organizations that were OSHAS 18001 certified stated the system was an integrated with the ISO 9001. Out of the 95 percentile only 43% percent of the organizations would consider implementing OHSAS 18001. From the 43 percentile that considered implementing OSHAS 18001 79% would be implementing it as an integrated system while 18% said it would be introduced as a stand-alone system. One organization was undecided which made up 3% of the participants.

The second part of the survey addressed organizations that were OHSAS 18001. The organizations were asked if it were possible to integrate OHSAS 18001 and rate the difficulty at which it would take to integrate the system. A 5 point Likert scale was used 1 being the easiest and 5 being the most difficult. The possibility of integration and difficulty of integration was based on the 20 elements of OHSAS 18001. Overall 72% of the respondents considered integration of OHSAS 18001 with ISO 9001. As for the degree of difficulty perceived by organizations on integrating OHSAS 1800 with ISO 9001 the general perception was generally in the middle of easy and difficult. As for the respondents that were not neutral most elements were easy to integrate except for 5 elements which where solely for OHSAS 18001 and therefore incompatible with ISO 9001. The benefits associated with the integration of ISO 9001 and OHSAS 18001 was agreed upon by a majority respondents. As for the cost associated with the integrated system both additional and reduced cost will be experienced in different areas which will not visually be seen by individual departments but rather by upper management who then would determine and implement necessary changes if needed.

**COMPARATIVE ANALYSIS**

Out the various studies that were conducted each study contributed in some way to the development and overall analysis of how the three crucial areas interact with each other within a construction organization. The areas of productivity, safety and quality have been evaluated based on their similarities and differences amongst the various studies that have been reviewed. In the productivity study conducted by John K. Robinson on Neil Muller Construction several factors where identified that affected the organizations productivity. These factors consisted of communication, trust between management & the workforce, ability to track productivity, lack of long term goals, employee involvement and limited supervision (Robin, John K 1998.) Based on this finding of this study illiteracy rates of the workers had the greatest impact on the productivity of the overall organization. (Robinson, John K 1998).

Another area that was found to increase productivity had to deal with the space management that was implemented in an individual’s area. This particular area not only dealt with productivity but it also incorporated safety as well. More space for an individual to perform a task was found to increase productivity levels (Salminen and Saari 1995). Unlike the study conducted by Robinson external elements beyond the actual individual were found to increase the level of productivity and individual was capable producing. When an individual has ample space to develop, organize and perform a particular task a safer and controlled environment is produced giving an individual the opportunity to develop a
working system that allows them be as proficient and maintain their comfort zone. In the construction industry as a whole productivity and safety has always been a vital part of an organization’s success. These two areas can mean the difference between a successful organization and non-successful organization. An organization can drastically affect the profitability of that company by identifying the areas within its operating procedures, employees and management of those employees. By implementing corrective measures to each weakness that is identified the organization can restructure in a positive way that can improve the organization both in productivity and safety. The studies referenced in this paper identified key areas both from internal factors that affect a single individual as well as the external factors that simultaneously affect the organization and individual as whole.

RESEARCH METHODOLOGY
The study conducted consisted of five construction projects in the commercial sector. The study group consisted of 4 general contractors and 1 construction manager. Three of the project were new construction while two of the projects where renovations. A total of 223 individuals were interviewed, issued surveys and observed in the day to day activities in the field. Out of the 223 individuals 191 individuals responded for a response rate of 85%. Out of 191 individuals there were 15 upper level managers, 25 supervisors and 151 laborers that provided input. The participants consisted of upper management, supervisors and laborers from electrical, plumbing, mechanical, steel erecting, framers etc.

The Gaillard Project entails the renovation of an existing auditorium that has been demolished completely with the exception of a few walls and the existing foundation. From the beginning accurate drawings and design were crucial so as to ensure that the coordination of various trades would be able to come together in a group effort. All the general trades were involved in the project and being that the project was a financed through special funding and grants the contractors that were selected to perform the work were obligated to have minority participation included in their base bid. Generally speaking, the labor that was available on hand was not sufficiently adequate in most cases for performing the technical work that was scheduled to be completed by the various subs. This requirement of minority participation affected the productivity of seasoned crews due to the amount of rework both minor and major that was encountered due to having to train unskilled worker in the various trades. Ultimately the work environment was drastically altered affecting the normal procedures of experienced crews. Caesarstone, a new construction project which is the first U.S base quartz surfaces manufacturers. This particular project deals more with the industrial manufacturing sector of construction. This project’s design from day one has spared no expense in designing, developing and constructing such a state of the art facility. This particular project consists of specialist in various fields of the construction industry due to the high technicality of the facility’s operations. Therefore, the importance of accurate drawing and skilled worker was critical to the success of this project. This project also required a very experienced manager to oversee the operations. An onsite engineer was present daily throughout the duration of the project. The site in general was very spacious and the amount of room were trades could perform their scope of work was adequate. The general contractor provided excellent scheduling to support the project and all trade involved.
Chestnut reverts back to a renovation of a government office building which has lain abandoned for quite some time. The entire building has to be gutted leaving the exterior shell as the only remnants of its prior existence. This particular project is being renovated in a small confined making management and scheduling a crucial element. Other factors that will affect the outcome are beginning to surface such as lack of proper evaluation and estimating. Based on the brief interactions observed onsite management seems to lacking in experience of various trades of work and methodically thinking through the project from start to finish. Renovations in general require substantial amounts of experience to avoid rework and in coordinating the various subs so as to bring the project in under budget and on schedule.

Brightmore is in the commercial sector of residential dwellings. This project is new construction. This particular project seems to have an abundance of well qualified staff and experience management. The coordination of the project appears to be marginal due to this project being owned by and owner who is indecisive in how the project should appear overall. Upper management was given a questionnaire which asked 5 questions. The first was “can productivity exists at an optimal level in unison with safety?” The second asked “can quality and safety exist at optimal levels simultaneously?” Third can quality and productivity exists at optimal levels simultaneously?” Fourth “Do you think an integrated management system would succeed for this particular project?” Fifth “would the benefits outweigh the cost of a multiple integrated system?”

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Gaillard</th>
<th>Caesarstone</th>
<th>Chestnut</th>
<th>Brightmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Q2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Q3</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Q4</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Q5</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

As the results from the questionnaires were compiled upper management responses where consistent for the type of project that they were currently managing. Table 1 displays the most commonly occurring responses tallied from all the managers on each project.

**PRODUCTIVITY AND SAFETY**

On the various projects included in these survey supervisors from various trades were given a survey to fill out based on determination which factors of productivity affect safety in respect to their trade. The trades consisted of electrical, mechanical, plumbing, concrete, roofing, waterproofing and precast. The data was then compiled for the all the trades and compiled in table 2. Supervisors were asked to rate on a Likert scale of 1 to 5 with 1 being the lowest and 5 the highest for greatest effect on the various areas in the construction operations of their current Project. These factors are assumed to help identify the relationships that co-exist between productivity & safety, quality & safety, and quality and productivity. In doing so the qualitative information will provide a positive or negative correlation that exist between the various areas in construction. The assumption is that based on information gathered from the various projects that the effects of each factor can be ranked identifying how each area is affected by a factor from another area and vice versa.
**Table 2** What Factors of Productivity affect Safety Supervisors (Rating 1 -5)

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Gailliard Score/Rank</th>
<th>Caesarstone</th>
<th>Chestnut</th>
<th>Brightmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework</td>
<td>2.42/6</td>
<td>4.0/4</td>
<td>3.33/5</td>
<td>4.25/3</td>
</tr>
<tr>
<td>Accurate Drawings</td>
<td>4.0/1</td>
<td>4.2/3</td>
<td>4.67/1</td>
<td>4.25/2</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>3.85/2</td>
<td>4.6/2</td>
<td>3.67/3</td>
<td>3.25/6</td>
</tr>
<tr>
<td>Working Environment</td>
<td>2.85/4</td>
<td>2.5/5</td>
<td>2.3/3</td>
<td>2.75/7</td>
</tr>
<tr>
<td>Manager Skill/Experience</td>
<td>2.0/8</td>
<td>1.71/8</td>
<td>2.67/6</td>
<td>4.75/1</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>3.14/3</td>
<td>5.0/1</td>
<td>4.0/2</td>
<td>3.25/5</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>1.71/10</td>
<td>2.0/9</td>
<td>2.0/10</td>
<td>2.5/10</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>1.8/5/9</td>
<td>1.6/10</td>
<td>2.33/8</td>
<td>2.5/9</td>
</tr>
<tr>
<td>Work Scheduling</td>
<td>2.57/5</td>
<td>3.0/6</td>
<td>3.33/4</td>
<td>3.5/4</td>
</tr>
<tr>
<td>Temperature</td>
<td>2.14/7</td>
<td>2.8/7</td>
<td>2.33/9</td>
<td>2.5/8</td>
</tr>
</tbody>
</table>

Laborers were also given a similar survey that consisted of a 5 point Likert scale as it relates to more of the day to day physical activities. The laborer’s survey differed slightly in the fact that only the factors that were dealing solely with the actual physical part of the scope of work being performed. Laborers where more inclined on how to respond so as to provide a viable response.

**Table 3** What factors of Productivity affect Safety - Laborers (Rating 1 -5)

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Gailliard Score/Rank</th>
<th>Caesarstone</th>
<th>Chestnut</th>
<th>Brightmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework</td>
<td>3.08/4</td>
<td>3.67/3</td>
<td>3.33/3</td>
<td>4.03/3</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>3.71/1</td>
<td>4.11/2</td>
<td>3.55/2</td>
<td>4.12/2</td>
</tr>
<tr>
<td>Working Environment</td>
<td>3.34/3</td>
<td>3.57/4</td>
<td>3.16/4</td>
<td>3.96/4</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>3.42/2</td>
<td>4.53/1</td>
<td>3.94/1</td>
<td>4.31/1</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>2.51/7</td>
<td>3.21/6</td>
<td>2.61/7</td>
<td>3.18/7</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>2.62/6</td>
<td>2.92/7</td>
<td>2.88/5</td>
<td>3.56/6</td>
</tr>
<tr>
<td>Temperature</td>
<td>2.72/5</td>
<td>3.35/5</td>
<td>2.67/6</td>
<td>3.68/5</td>
</tr>
</tbody>
</table>

The calculation for areas of productivity and safety in relation to the job characteristics that affected them were compiled in tables. Both supervisors and laborers were asked to relate these to areas in relation to how they would be affected in relation to their day-to-day task. From these calculations a cumulated average was compiled of the total job characteristics as they ranked form the most effective to the least.
Table 4  What factors of Productivity affect Safety –Supervisors  (Rating 1 - 5)

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Accum. Avg./Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate Drawings</td>
<td>7</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>11</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>13</td>
</tr>
<tr>
<td>Rework</td>
<td>18</td>
</tr>
<tr>
<td>Work Scheduling</td>
<td>19</td>
</tr>
<tr>
<td>Working Environment</td>
<td>23</td>
</tr>
<tr>
<td>Manager Skill/Experience</td>
<td>23</td>
</tr>
<tr>
<td>Temperature</td>
<td>31</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>36</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>39</td>
</tr>
</tbody>
</table>

RESULTS

In the surveys that were conducted on how productivity affects safety 19 supervisors were asked to rate the various areas that could be related to productivity as to how they directly or either indirectly affect safety. These particular individuals came from projects that were of various types of construction, project sizes, site conditions management types and overall procurement methods. Based on each projects quantitative data was compiled from multiple contractors that were onsite and a trend as to what job characteristics were projected to have the most affect in terms of productivity effect on safety were projected. Based on the finding the top five-rated job characteristics were accurate drawings, proper tools and equipment, skilled workers, rework and work schedule as noted in Table 4. Out these 5 characteristics the assumption could be made that four out of the five could be considered to directly affect safety in terms of being productive and one characteristic that being accurate drawings could indirectly affect safety. Ultimately all projects benefit when more time and effort is put into the design and planning phase so as many obstacles can be eliminated on the front end.

Table 5  What Factors of Productivity affect Safety  Laborers (32)

<table>
<thead>
<tr>
<th>For all jobs</th>
<th>Accumulative Avg.</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper tools and equipment</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Rework</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Working Environment</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Temperature</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>27</td>
<td>7</td>
</tr>
</tbody>
</table>

In a similar study conducted in order to capture the actual laborers’ standpoint of how safety is affected by productivity, characteristics dealing directly with their job description on a project were administered. The following characteristics impacts were ranked from highest
to lowest. Proper tools and equipment, skilled workers, rework, working environment, temperature, work accessibility, and time constraints. Productivity is measured by how much of a task is completed in the allotted time that was estimated in the budget. By laborers being supplied with effective tools and equipment as it relates to the task at hand not only is productivity increased but the opportunity for injury due to improper tool usage or faulty equipment is drastically reduced. Based on the findings in table 5 skilled works are an intricate part of properly and effectively using a tool at its peak efficiency and safely. The same job characteristics of proper tools and equipment, skilled workers, rework, working environment, temperature, work accessibility and time constraints all share the same ranking provided by the supervisors and laborers. When comparing table 5 and 6 the job characteristics almost provide a mirror image of each other with the exception of accurate drawings, manager skill/experience and work schedule. These characteristics were not administered to the laborers due to these tasks not being associated with a laborers general job description.

QUALITY AND SAFETY

Table 6 Determinants of Quality that affect Safety Supervisors (Rate 1-5)

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Gaillian Score/Rank</th>
<th>Caesarston Score/Rank</th>
<th>Chestnut Score/Rank</th>
<th>Brightmore Score/Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework</td>
<td>3.8/6</td>
<td>1.67/10</td>
<td>3.75/5</td>
<td></td>
</tr>
<tr>
<td>Accurate Drawings</td>
<td>3.71/2</td>
<td>4.8/2</td>
<td>2.0/9</td>
<td>4.25/2</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>4.28/1</td>
<td>5.0/1</td>
<td>4.0/2</td>
<td>4.75/1</td>
</tr>
<tr>
<td>Working Environment</td>
<td>2.85/4</td>
<td>4.6/4</td>
<td>2.67/7</td>
<td>3.75/4</td>
</tr>
<tr>
<td>Manager Skill/Experience</td>
<td>1.57/7</td>
<td>3.0/8</td>
<td>4.33/1</td>
<td>3.0/7</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>3.14/3</td>
<td>4.8/3</td>
<td>3.67/3</td>
<td>3.75/3</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>1.14/9</td>
<td>1.8/10</td>
<td>2.3/8</td>
<td>2.25/9</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>1.42/8</td>
<td>2.4/9</td>
<td>3.0/5</td>
<td>2.5/8</td>
</tr>
<tr>
<td>Work Scheduling</td>
<td>2.42/5</td>
<td>4.2/5</td>
<td>2.67/6</td>
<td>1.5/10</td>
</tr>
<tr>
<td>Temperature</td>
<td>2.14/6</td>
<td>3.2/7</td>
<td>3.67/4</td>
<td>3.25/6</td>
</tr>
</tbody>
</table>

In preparation for structuring the ranking of key job characteristics all of the participants’ responses were gathered and grouped together so a percentage of each individual characteristic could be identified and ranked accordingly. This was represented based on the two areas of quality and safety. Both the supervisors and the laborers were given a study that was to be based on the correlation between the two areas and how the job characteristics affected each of them.
Table 7 Determinants of Quality that affect Safety Laborers (Rate 1-5)

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Gailliard Score/Rank</th>
<th>Caesarstone Score/Rank</th>
<th>Chestnut Score/Rank</th>
<th>Brightmore Score/Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework</td>
<td>3.34/5</td>
<td>3.57/6</td>
<td>4.0/1</td>
<td>3.81/5</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>3.45/3</td>
<td>3.85/4</td>
<td>3.88/2</td>
<td>4.12/2</td>
</tr>
<tr>
<td>Working Environment</td>
<td>3.48/2</td>
<td>3.64/5</td>
<td>3.5/4</td>
<td>3.53/7</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>3.65/1</td>
<td>4.25/1</td>
<td>3.27/6</td>
<td>4.28/1</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>3.14/7</td>
<td>3.96/3</td>
<td>3.22/7</td>
<td>4.03/4</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>3.28/6</td>
<td>4.03/2</td>
<td>3.33/5</td>
<td>3.68/6</td>
</tr>
<tr>
<td>Temperature</td>
<td>3.34/4</td>
<td>3.35/7</td>
<td>3.77/3</td>
<td>4.03/3</td>
</tr>
</tbody>
</table>

When the evaluation for the affects that quality had on safety was being considered supervisor participants were asked to indirectly think of how quality would affect safety on a project and rate the job characteristics impact from highest to lowest in relation to such. The accumulative average was calculated of the job characteristics that were the most effective. Basically, the lower the accumulative average the higher the impact a particular job characteristic had on quality in relation to safety. As table 8 indicates, a manager’s skill/experience has the greatest safety impact in their day to day job activities that affect safety. The explanation for this assumption resides partially in the manner and attention to detail that a manager must implement in the design and planning phase of a construction project to ensure proper safety precaution are included in the budget.

Summary of Quality and Safety

Table 8 Determinants of Quality that effect Safety Supervisors

<table>
<thead>
<tr>
<th>Company issues</th>
<th>Accumulative Avg.</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager Skill/Experience</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Rework</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Work Scheduling</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Accurate Drawings</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>Temperature</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>Working Environment</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>31</td>
<td>8</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>36</td>
<td>9</td>
</tr>
</tbody>
</table>

Safety on construction projects can be very costly and can be the difference in turning a profit on a project or closing the doors to the organization due to hefty fines, lawsuits and worker compensations claims. Rework is also another problem area where the manager’s work schedule could eliminate high risks trades from work in and around other trades unless absolutely necessary. The quality of planning on the part of a manager can ultimately change the conditions of the working environment leading to less stress on the workers which may already be feeling the pressures of tight working conditions along with shortened time constraints. When the results from table 8 and 9 are compared to one another in terms of a supervisors’ perception as to that of laborers in relation to how quality affects safety the actual work atmosphere that exist on the site tends to be where comparison can
be. It is assumed that rework is at the top of the list for both supervisors and laborers for the matter that rework generally requires extra hours, shortened time constraint that theoretically increases stress.

Table 9  Determinants of quality that effect Safety  Laborer

<table>
<thead>
<tr>
<th>Company issues</th>
<th>Accumulative Avg.</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper tools and equipment</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Rework</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Working Environment</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Temperature</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>20</td>
<td>6</td>
</tr>
</tbody>
</table>

Quality and Productivity

Table 10  What Factors of Quality effect Productivity Supervisors Rating 1-5

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Gailliard Score/Rank</th>
<th>Caesarstone</th>
<th>Chestnut</th>
<th>Brightmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework</td>
<td>4.42/3</td>
<td>3.0/7</td>
<td>2.0/8</td>
<td>4.28/2</td>
</tr>
<tr>
<td>Accurate Drawings</td>
<td>4.71/1</td>
<td>3.2/5</td>
<td>1.3/10</td>
<td>4.57/1</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>4.42/2</td>
<td>4.0/2</td>
<td>3.0/4</td>
<td>4.0/3</td>
</tr>
<tr>
<td>Working Environment</td>
<td>3.42/7</td>
<td>2.2/10</td>
<td>2.67/5</td>
<td>3.0/7</td>
</tr>
<tr>
<td>Manager Skill/Experience</td>
<td>3.42/8</td>
<td>4.6/1</td>
<td>4.33/1</td>
<td>3.71/5</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>3.0/1</td>
<td>4.0/3</td>
<td>2.0/7</td>
<td>3.28/6</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>4.0/5</td>
<td>3.0/6</td>
<td>1.67/9</td>
<td>1.71/10</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>3.57/6</td>
<td>2.6/8</td>
<td>3.67/2</td>
<td>2.28/9</td>
</tr>
<tr>
<td>Work Scheduling</td>
<td>4.28/4</td>
<td>3.6/4</td>
<td>3.67/3</td>
<td>3.71/4</td>
</tr>
<tr>
<td>Temperature</td>
<td>2.57/10</td>
<td>2.6/9</td>
<td>2.0/6</td>
<td>2.71/8</td>
</tr>
</tbody>
</table>

Table 11  What Factors Quality effect Productivity - Laborers (Rating 1 -5)

<table>
<thead>
<tr>
<th>Company Issues</th>
<th>Gailliard Score/Rank</th>
<th>Caesarstone</th>
<th>Chestnut</th>
<th>Brightmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework</td>
<td>3.51/5</td>
<td>4.03/4</td>
<td>3.77/2</td>
<td>4.31/3</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>3.42/6</td>
<td>4.03/3</td>
<td>3.0/6</td>
<td>4.18/5</td>
</tr>
<tr>
<td>Working Environment</td>
<td>3.71/1</td>
<td>3.82/5</td>
<td>3.94/1</td>
<td>4.31/4</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>3.34/7</td>
<td>4.35/1</td>
<td>3.77/3</td>
<td>4.09/6</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>3.71/2</td>
<td>3.42/7</td>
<td>3.27/5</td>
<td>4.53/1</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>3.67/3</td>
<td>4.28/2</td>
<td>3.38/4</td>
<td>4.43/2</td>
</tr>
<tr>
<td>Temperature</td>
<td>3.54/4</td>
<td>3.67/6</td>
<td>2.94/7</td>
<td>4.06/7</td>
</tr>
</tbody>
</table>
Summary of Quality and Productivity

<table>
<thead>
<tr>
<th>Table 12 What Factors of Quality effect Productivity Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>For all jobs</td>
</tr>
<tr>
<td><strong>Company issues</strong></td>
</tr>
<tr>
<td>Skilled Workers</td>
</tr>
<tr>
<td>Work Scheduling</td>
</tr>
<tr>
<td>Manager Skill/Experience</td>
</tr>
<tr>
<td>Accurate Drawings</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
</tr>
<tr>
<td>Rework</td>
</tr>
<tr>
<td>Work Accessibility</td>
</tr>
<tr>
<td>Working Environment</td>
</tr>
<tr>
<td>Time Constraints</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
</tbody>
</table>

Based on the findings that are displayed in Table 12 the indirect elements of quality as they relate to productivity are documented to show the correlations between quality and safety. Skilled workers were determined to impact productivity in terms of quality. This is assumed to be in large part due to the attention to detail skilled workers provide when performing a task to ensure it is done properly the first time. In doing so, the work schedule which is implemented by the supervisors will be supported reducing the amount of rework that will have to be done in the event minor details are not recognized.

Table 13: What factors of quality effect productivity - laborers

<table>
<thead>
<tr>
<th><strong>Company issues</strong></th>
<th><strong>Accumulative Avg.</strong></th>
<th><strong>Rank</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Environment</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Work Accessibility</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Rework</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Time Constraints</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Proper tools and equipment</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Temperature</td>
<td>24</td>
<td>6</td>
</tr>
</tbody>
</table>

Based on the findings that were compiled on the effects that quality has in relation to productivity the working environment was rated as number 1 in having the most impact. Second was the work accessibility followed in third place by rework. These job characteristics can also be more easily controlled by the laborer without involvement from managers. Therefore, laborers can have a sense of pride about the work they provide on a quality and productivity basis.

CONCLUSION

In the construction industry there are many aspects that can define the success of a project and ultimately the organization that is awarded the responsibility of managing it. Typically the management of a project is measured based on three variables that are good status indicators of the project. Productivity, safety and quality all measure various job characteristics which in turn measures and broadcast the overall success or failure of a project. The purpose of this study was to identify the relationships that co-exist between all three areas both directly and indirectly. By identifying the various characteristics and how each one impacts productivity, quality and safety a general assumption
can be made that these three areas are intertwined and correlate with the other two. By providing job characteristics that impact all three, the interactions can be identified and improved upon. Also input was provided from onsite personnel as well as field observations as to the relationships that exist between productivity, safety and quality.

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BARRIERS OF IMPLEMENTING AN INTEGRATED PROJECT DELIVERY METHOD VERSUS THE TRADITIONAL DELIVERY METHOD
Gene C. Deese, Syed Ahmed, and Laura A. Russell
East Carolina University, USA

Research studies show that the manufacturing industry productivity rate is continually increasing while the construction industry productivity rate is progressively decreasing. A small percentage of the construction industry has recently implemented a project delivery method that can improve these industry statistics, the Integrated Project Delivery (IPD) method. The purpose of this study is to show how successful IPD projects overcame barriers such as multi-cultural and diversity issues, in an effort to achieve wider adoption of IPD by the industry, and to provide lessons learned to industry professionals interested in implementing IPD as a delivery method. This research study analyzed the results of a qualitative survey that was sent to eight lean construction companies in an effort to study how successful IPD projects overcame the lack of appropriate legal structure, including allocation of risks and insurance products, cultural barriers within the industry, allocation of financial incentives, and technology limitations. In an effort to achieve increased acceptance of the IPD by the construction industry, these barriers are analyzed to show common successful approaches through integration of people and technology. In construction, it is challenging for some companies to overcome the barriers of implementing an IPD after years of utilizing a traditional method (i.e. design-bid-build, design-build, etc.) This research study indicates that successful IPD projects are achieved by utilizing early education of the individuals working on the project, preliminary and continuous collaboration of all interested parties, and constant communication and respect for people across all disciplines.

Keywords: Construction, Procurement, Project Delivery

INTRODUCTION

Since 1964, the productivity rate within the industrial and manufacturing market sectors have more than doubled. Yet during this same period of time, the productivity rates in the construction industry has fallen by nearly 50 percent. Despite all of the advancements in equipment, technology and materials, the construction industry is less productive today than it was in 1964. These rates are staggering and disconcerting to construction professionals who are actively seeking new and innovative means for the construction industry to thrive.

“If you look at curves of labor productivity, the manufacturing industry has been taking off for quite a long time at a rate of five to six percent a year,” says Stanford University Civil and Environmental Engineering Research Professor Emeritus Paul Teicholz. “If you look at the growth data for the whole construction industry, if anything, labor productivity is getting worse” (Teicholz 2013).

In figure 1, labor productivity for the construction industry as a whole slightly declines over this time period (with some minor exceptions), and that there is some variation,

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depending on which deflator is used. However, the general rate of decline is about the same: a linear trend line shows a -0.32% per year decline, while the trend for all nonfarm industries is positive 3.06% per year. The net impact over the forty-eight-year time period is very significant. Current conventional construction delivery methods such as design-bid-build, design-build, and construction management services do not address the inefficiencies that exist in the construction industry. Seemingly, they mask these inefficiencies and give the purchaser of construction and construction-related services a false sense of security. The introduction of Integrated Project Delivery (IPD) targets and minimizes some of the inefficiencies that exist within the construction industry by merging all of the necessary knowledge, skill and expertise in a manner that ensures individual needs are aligned with the project goals.

The construction industry is comprised of architecture, engineering and construction (AEC) professionals. However, many industry professionals are dissatisfied with project outcomes and argue that projects often run over-schedule, over budget, and are of low quality (Lichtig, 2006). The problem this study researches is with the AEC industry in that each discipline is responsible for its own silo of work and within the respective silos, they attempt to maximize profits. This system has proven to be disjointed, unproductive, and very oppositional to construction productivity efforts.

As a new project delivery method, integrated project delivery (IPD) attempts to address the problems of waste, inefficiency, and adversarial relations in the AEC industry, and to increase the likelihood of project success (Autodesk White Paper 2008; DeBernard 2008; Lichtig 2006). Using ideas developed by Toyota in their Toyota Production System, the integrated project delivery method is designed to solve key construction problems. From an integrated project delivery standpoint, effort is made to help the owner understand what value is gained by working towards delivering that value while eliminating the waste from the design and construction process.

The basic requirements for an Integrated Project Delivery system begin with creating a business entity and then forming an integrated agreement with clients and suppliers. The new focus in an IPD is the final value created for the owner, which would be the finished building. With the idea of each participant focusing exclusively on their part of construction without considering the implications on the whole process, the IPD method brings all participants together early with collaborative incentives to maximize value for the owner, (Integrated Project Delivery 2014).
The Integrated Project Delivery is a delivery method that includes the expertise of project professionals in the early stages of the project. Professionals from every discipline are present from the very beginning of the project ensuring that the major design decisions are agreeable to the entire project team. Although several professional organizations support the advancement of IPD, and prior research efforts demonstrated its benefits and challenges, the number of projects using IPD remains relatively small (Kent and Becerik-Gerber 2010; Sive 2009). Barriers that have been identified as reasons why this new method has not yet been adopted on more projects include, this idea remains relatively small, uninformed attitudes and experience levels regarding IPD have not yet been established. These barriers have caused the break-in period for IPD to extend longer than expected.

In review of this research study, this paper aims to identify the best IPD practices that assist with overcoming the barriers related to IPD implementation in an effort to achieve more widespread adoption within the industry. In order to facilitate a faster transition to IPD, it is necessary to overcome the most prevalent barriers to its implementation (Sive 2009). This paper reviews four barriers that have been identified as reasons why the adoption of IPD has not been encouraged: (1) lack of appropriate legal structure, including allocation of risks and insurance products, (2) cultural barriers within the industry, (3) allocation of financial incentives, and (4) technology limitations.

**PURPOSE STATEMENT**

Research Question: How do architecture, engineering, and construction professionals overcome the most prevalent barriers of implementing Integrated Project Delivery versus the Traditional Delivery Methods of Design-Bid-Build, Design Build, and construction management services? Purpose: To investigate how successful IPD projects overcome legal, cultural, financial, and technological barriers in an effort to achieve wider adoption.
of IPD by the industry and to provide lessons learned to industry professionals interested in implementing IPD as a delivery method.

LITERATURE REVIEW

When researchers write about project delivery methods, one of the most important things they want to know is the difference between traditional delivery methods and the integrated project delivery method. To make these comparisons, we first must have a clear understanding of each method. There are three traditional delivery methods to be compared in depth, which are: design-bid-build, design-build and construction manager at risk. We first must understand that each of these project delivery methods carry a different level of risk for the owner. Generally, the level of control retained by the owner is related to the level of risk, and those levels typically have an inverse relationship to the risk and control levels of the contractor. No single delivery method is right for every project. For each situation, there will be advantages and disadvantages in the use of any specific method. The owner should carefully assess each projects requirements, goals, and potential challenges to find the delivery method that offers the best opportunity for success.

A study was conducted that compared design-bid-build and design-build project delivery methods. Hale, Shrestha, Gibson, and Migliaccio (2009) defined design-bid-build as a project delivery method in which the owner enters into a contract with an architect/engineer (A/E) firm that provides design services based on the requirements provided by the owner. The A/E deliverables include plans and specifications for the construction of the project. The owner has the basis to make a separate contract with a construction company then uses these documents. Although many methods are used for awarding this contract, the most common approach is to begin by soliciting bids from multiple construction companies. The company providing the lowest bid will then build the project based on the documents produced by the A/E and therefore, owners complete one construction project, including two solicitations and procurement steps, utilize two separate contracts, with two separate entities.

The first contract is the owner-designer contract, which involves planning, design and construction administration. The second contract is the owner-contractor contract, which involves construction. An indirect third-party relationship exists between the designer and the contractor, as a result of these agreements. This is a familiar method as design-bid-build projects are an easier sell, and are easier to manage because the scopes and stages are strict and well defined. The owner has a greater degree of control over the process and the bidding naturally returns the best price. There are disadvantages of the design-bid-build method. The cost of a design is not determined until the bids are received, estimates can change during the design process due to financial factors and exceeded bid budgets, and the linear schedule makes this the slowest among the three traditional methods. The design-bid-build delivery method is a good choice for simpler projects that are budget sensitive and unlikely to change.

Hale, Shrestha, Gibson, and Migliaccio (2009) defined design-build as a project delivery method in which the owner provides requirements for the specified project and awards a contract to one company who will both design and build the project. Therefore, there is
only one procurement step to select one entity to complete the project, and one contract between the owner and this entity. There are three main advantages to a design-build contract. First, the construction team is motivated to work with the design team to develop a practical design. The team can find creative ways to reduce construction costs without reducing the function of the final product. The second major advantage has to do with scheduling as many projects are commissioned with tight timelines. With a traditional contract, construction begins after the design is finished and the project has been awarded to a bidder. In a design-build contract the contractor is established from the outset, and construction activities proceed simultaneously with the design. The third major advantage is that the design-build contractor has an incentive to keep the combined design and construction costs within the owner’s budget. One of the problems with design-build contracts has to do with the issues that surround conflict of interest. Under standard contracts designers are responsible to the owner to review the builder's work, ensuring that the products and methods meet specifications and codes. Other problems that could arise are as follows; an independent builder may pick up design flaws that could possibly go unnoticed (or unmentioned) if the builder is also the designer. The owner may get a building that is over-designed to increase profits for the design-builder, or a building constructed with lesser-grade products to maximize profits. If speed is of upmost importance, design and construction contracts can be awarded separately; bidding takes place on preliminary plans in a not-to-exceed contract instead of a single, firm design-build contract. The design-build delivery method is most useful in time sensitive projects that have either small user groups or they particularly excel in projects with specialized or technically complex scopes.

Construction Manager at risk is a delivery method, which entails a commitment by the construction manager to deliver the project within a Guaranteed Maximum Price (GMP). The construction manager acts as a consultant to the owner in the development and design phases (preconstruction services), and as a general contractor during construction. When a construction manager is bound to a GMP, the fundamental character of the relationship is changed. In addition to acting in the owner's interest, the construction manager must control construction costs to stay within the GMP. An At-Risk delivery method is best for large projects both complete construction and renovation that are not easy to define, have a possibility of changing in scope, or have strict schedule deadlines. Additionally, it is an efficient method in projects containing technical complexity, multi-trade coordination, or multiple phases.

The American Institute of Architects (AIA 2007) defines integrated project delivery as a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all project participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication and construction. Some characteristics that make a distinction between IPD and traditional are: a multi-party contract, early involvement by key participants, collaborative decision making and control, shared risk and rewards, liability waivers, and jointly developed project goals. All the above characteristics must be incorporated in a project for IPD to be realized in its purest form (Sive 2009). There are fundamental differences between
traditional and IPD such as terms of contracts, project team relationships, and compensation structures.

**METHODOLOGY AND RESULTS**

To prove that barriers do exist and impede the implementation of integrated project delivery, a questionnaire survey was sent as a quantitative investigation. Each of the industry respondents were asked specific questions that identified their current delivery methods and how they overcame identified IPD barriers. Interview questions were categorized according to identified barriers: legal, cultural, financial, and technological and others. Of the 95 questionnaire surveys distributed, almost 18.9% (18) were completed, 18 of 18 (100%) have been started and completed, and 50% (48) were opened. The results of the survey are as follows:

**Q1** Which of the following categories fits your current role?
- Architect (1)
- Construction Manager (2)
- Engineer (3)
- Other (4)

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Architect</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>2</td>
<td>Construction Manager</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>3</td>
<td>Engineer</td>
<td>5</td>
<td>28%</td>
</tr>
<tr>
<td>4</td>
<td>Other</td>
<td>5</td>
<td>28%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>18</td>
<td>100%</td>
</tr>
</tbody>
</table>

In the current role question, 33% of the respondents were Construction Managers, 28% Engineers and Others, and 11% of the surveys were Architects.

**Q2** Other, Please Specify

<table>
<thead>
<tr>
<th>Text Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
</tr>
<tr>
<td>afsfc</td>
</tr>
<tr>
<td>Project Development (BD, Preconstruction, owner satisfaction)</td>
</tr>
<tr>
<td>Materials Support</td>
</tr>
<tr>
<td>Academic</td>
</tr>
</tbody>
</table>

In the “Other, Please Specify” category, for an answer to question ,1 there were 5 total responses as you can see in the results above.
**Q3** How many years of experience do you have in the construction industry?

- < 5 (1)
- 6-10 (2)
- 11-15 (3)
- 16-20 (4)
- 21-25 (5)
- > 25 (6)

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
</table>
| 1  | < 5        | 3        | 17%
| 2  | 6-10       | 2        | 11%
| 3  | 11-15      | 1        | 6%
| 4  | 16-20      | 5        | 28%
| 5  | 21-25      | 0        | 0%
| 6  | > 25       | 7        | 39%
|    | Total      | 18       | 100%

As you can see the largest majority of participants (39%) have more than 25 years of experience in construction, followed by 28% with 16-20 years, 17% with less than 5 years, 11% with 6-10 years and 6% with 11-15 years of experience in the construction industry.

<table>
<thead>
<tr>
<th></th>
<th>Always (1)</th>
<th>Sometimes (2)</th>
<th>Never (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design-Bid-Build (1)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Design-Build (2)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Construction Manager at Risk (3)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Q4** Before you or your company implemented the Integrated Project Delivery method which construction method was used? Answer the following by choosing the frequency of each.

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
<th>Total Responses</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design-Bid-Build</td>
<td>7</td>
<td>11</td>
<td>0</td>
<td>18</td>
<td>1.61</td>
</tr>
<tr>
<td>2</td>
<td>Design-Build</td>
<td>2</td>
<td>16</td>
<td>0</td>
<td>18</td>
<td>1.89</td>
</tr>
<tr>
<td>3</td>
<td>Construction Manager at Risk</td>
<td>2</td>
<td>12</td>
<td>4</td>
<td>18</td>
<td>2.11</td>
</tr>
</tbody>
</table>

The project delivery method most utilized before trying the Integrated Project Delivery method was Design-Bid-Build (with 7 always responses), then Design build (with 16 Sometimes responses), and Construction Manager at Risk (with 4 Never Responses) being used the least of the three.
Q5 Which project delivery method do you prefer?
- Design-Bid-Build (1)
- Design-Build (2)
- Construction Manager at Risk (3)
- Other (4)

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design-Bid-Build</td>
<td>3</td>
<td>17%</td>
</tr>
<tr>
<td>2</td>
<td>Design-Build</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>3</td>
<td>Construction Manager at Risk</td>
<td>5</td>
<td>28%</td>
</tr>
<tr>
<td>4</td>
<td>Other</td>
<td>4</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>18</td>
<td>100%</td>
</tr>
</tbody>
</table>

In Q4 the participants were asked what delivery method they used before using IPD, here in Q5 the answers represent what method is preferred by the participant, the results are design-build (33%), Construction Manager at Risk (28%), other at (22%) which (16.6%) of those were IPD, and Design-bid-build was at (17%).

Q6 Please specify your project delivery method preference:

Text Response:
- IPD
- Integrated IPD

As stated above the other category in Q5 represented 22% of which 16.6% of those responses were for the Integrated Project Delivery.

Q7 What are some of the barriers you have faced while implementing the Integrated Project Delivery method? (Check all that apply)
- Cultural (1)
- Financial (2)
- Technological (3)
- Legal (4)
- Other (5)

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cultural</td>
<td>14</td>
<td>78%</td>
</tr>
<tr>
<td>2</td>
<td>Financial</td>
<td>9</td>
<td>50%</td>
</tr>
<tr>
<td>3</td>
<td>Technological</td>
<td>10</td>
<td>56%</td>
</tr>
<tr>
<td>4</td>
<td>Legal</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>5</td>
<td>Other</td>
<td>4</td>
<td>22%</td>
</tr>
</tbody>
</table>

Q8 Please list any other barriers:

Text Response:
aefgsve sdfswfgs
Q9
Once these barriers were identified how did you and / or your company overcome this barriers?

Text Response
Education
Much too complicated to include in a survey
Education of project team members
Completely adopt the new approach that is integrated project delivery
Address them as early in the process as possible.
Sometimes you can't; some jurisdictions/municipalities simply do not allow for integrated contracting in their public contracting laws.
Collaboration and Understanding
Brought multiple disciplines together to discuss
I
Appointing an external consultant/coach
Thru good communication with team and owner
Tried to sell harder

Q10 Which of the following describes your attitude toward lean construction?
☐ I love it! (1)
☐ I somewhat like it. (2)
☐ Neutral. (3)
☐ I somewhat dislike it. (4)
☐ I strongly dislike it. (5)

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I Love It!</td>
<td>11</td>
<td>61%</td>
</tr>
<tr>
<td>2</td>
<td>I somewhat like it.</td>
<td>4</td>
<td>22%</td>
</tr>
<tr>
<td>3</td>
<td>Neutral.</td>
<td>3</td>
<td>17%</td>
</tr>
<tr>
<td>4</td>
<td>I somewhat dislike it.</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>I strongly dislike it.</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>18</td>
<td>100%</td>
</tr>
</tbody>
</table>

As a general overall response to Q10, the attitude toward lean construction is a very positive one. 83% of the participants like and or loved lean construction.

Q11 Would you like a copy of my research upon completion? If so, I will email you a final copy.
☐ Yes (1)
☐ No (2)

<table>
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<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>15</td>
<td>83%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>3</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>18</td>
<td>100%</td>
</tr>
</tbody>
</table>

For this survey, participants were pre-selected based on their involvement with construction companies that had been recognized for their lean project design and delivery method actions as noted on the Lean Construction Institute website. All participants were high-ranking management officials in their company. All contact was done by email. After pre-selecting each participant, there was no doubt that all interviewees had sufficient enough
knowledge to respond to the survey in relation to their companies’ delivery methods. Also, to increase the response rate, an anonymous version of the survey was distributed on the professional networking site LinkedIn.com under the Lean Construction Institute’s group discussion board. The survey was executed with online survey software called Qualtrics. Qualtrics can be used to capture survey results from a publicly available survey, or from users who are specifically given access to a survey. Qualtrics software enables users to do many kinds of online data collection and analysis including market research, customer satisfaction and loyalty, product and concept testing, employee evaluations, and website feedback (Qualtrics 2015).

Of all the firms invited to participate in this survey, two (BSA LifeStructures, Devenney Group) were architectural and engineering firms and the other six (Boldt, CG Schmidt, Holder, Sundt, Pankow, Linbeck) were construction management and general contracting firms.

BSA LifeStructures is a national leader in designing complex facilities for learning, discovery and healing. The firm boasts a focus on strategic support through a collaborative planning and design process results in facilities that meet project goals in line with the mission and vision of each client (BSA LifeStructures 2015). BSA LifeStructures is a multidisciplinary design firm with professionals specializing in planning, architecture and engineering. The firm’s three locations support this balance of design services with offices in Chicago, Indianapolis and St. Louis.

Holder Construction deeply values the importance of partnerships with design firms and trade contractors. These relationships are essential for building a high-quality project on time and within budget. Devenney Group Ltd., Architects is a leading healthcare architectural firm with nearly 50 years of experience. As a firm that is 100% dedicated to healthcare design, they are innovative leaders in the use of Revit and Building Information modeling, LEED, Lean Design Principles, and Integrated Project Delivery Methodologies (Devenney Group Architects 2014). The entire team is specialized in healthcare design issues – particularly in areas of code/regulation research, evidence-based and sustainable design, construction processes, patient safety, and basic research.

The Boldt Company is a fourth-generation, family-owned professional construction services firm that has been in operation since 1889. They provide a variety of world-class construction services, including Integrated Lean Project Delivery, construction management, general construction, design/build, real estate development, program management, consulting and technical services (The Boldt Company 2015).

CG Schmidt is a values-based construction management and general contracting firm driven by their core value of caring. Through this value, they offer a great building experience – from world-class pre-construction services to craftsmen who know the meaning of excellence (CG Schmidt 2015). Their approach is unique from most construction firms in that they emphasize accountability, innovation and integrity. With proven experts in multiple building types, they work hard from the first project meeting to understand and align any expectations with a reliable outcome. Sundt is a full-service general contractor with expertise that spans the entire lifecycle of construction. They have the knowledge and the experience to customize a solution to meet the specific needs of the project (Sundt 2014). Sundt takes pride in being a builder. They build projects in a collaborative team environment, using innovative techniques to improve productivity.
reduce costs and give clients the best outcomes and project possible. Pankow was instrumental in the founding of the Design Institute of America and is a national leader with the Lean Construction Institute (Pankow 2015). They have committed to revolutionizing project delivery to find the game changer our industry needs to bring the most value to their clients. Linbeck is a Texas-based, technology-driven building construction firm offering construction management at-risk, design/build, and integrated project delivery services (Linbeck Group 2015). Using a suite of commercial and proprietary digital technologies and its unique Lean Operating System, Linbeck helps institutional and select private clients mitigate risk and minimize waste to achieve optimal outcomes for their organizations.

DISCUSSION

For this study, the authors adopted the following definition set forth in AIA California Council (2007), at a minimum; an integrated project includes tight collaboration between the owner, architect/engineer, and builders that are ultimately responsible for construction of the project, from early design through project handover. In this research, barriers exist that impede the implementation of IPD as a new delivery method for the interviewed survey participants. These barriers included issues involving; cultural, legal, financial, and technological limitations or challenges.

Cultural Barriers
The reference to cultural barriers includes the refusal of the industry to change from its traditional way of doing things. The challenge is overcoming the inertia and changing the mindset built on the traditional hierarchy (AIA California Council 2008; Lichtig 2006). Fitting project personnel into the design and construction process as early as possible could be one way to minimize cultural barriers. In traditional projects, a team member might be brought on late in the design process or during construction. Typically, incompetence results; as newcomers are unlikely to be well synchronized with the rest of the team. Even though collaboration between the owner, architect, and the contractor takes place for all the companies investigated, reaping the benefits of IPD was found only to be possible when the subcontractors were brought into the design and construction process as early as possible. A second way to minimize cultural barriers is to have continuous IPD training. IPD training plays an important role on most of the companies investigated and proved to be a crucial element in overcoming cultural barriers. The training was achieved at two levels, both at the organizational and at the project levels. Training at the organizational level involves general training regarding IPD and was done as part of a company’s voluntary transition toward IPD. Project-level training refers to a series of activities completed early on or as the project progressed. These activities were completed at the discretion of the owner and after teams were put together. By using internal and external resources, the owner established a continuous learning plan throughout the course of the project. A third way to minimize cultural barriers is to have trust building activities and tools. This concept has been observed in many companies trying to implement IPD. The idea is to build confidence toward each other through collaborating at the beginning of a project, coordinating communication between team members, sharing team confidence based on individual capabilities, and openness, honesty, transparency between all team members.
Financial Barriers
Financial barriers refer to the challenge of selecting compensation and incentive structures commensurate to the unique characteristics of the project and its participants (Cohen 2010). One way to minimize financial barriers is to have a compensation structure just for IPD. Traditional contract structures tend to inhibit collaboration by only providing incentives for each individual firm. The review of industry cases (table 2) revealed that most IPD projects follow guaranteed maximum price (GMP) or estimated maximum price (EMP) for the compensation on their projects. EMP is similar to GMP in the sense that parties involved are paid based on a cost plus a fee with a difference that in EMP the owner will share the costs in excess of the estimated amount (Darrington & Lichtig 2010).

Another way to minimize financial barriers is to share cost savings and overruns. This happens when project team members agree upon a target budget and share the savings taken in on the project. These schemes became more evident when the majority of the subcontractors participated in this risk/reward and bonus program. Participating in profit pooling is another way to minimize financial barriers. Profit pooling involves project teams placing a percentage of their fee or profit in a pool and withdrawing the funds at project conclusion, with a possibility of increased bonuses if the specified targets are met.

Legal Barriers
The legal barriers associated with IPD are issues of liability and insurance. The ability to sue one another is eliminated or reduced, so the collaborative effort is increased. Current insurance products are designed to assign liability to each participant and the liability issue makes the insurance and bonding requirement more complicated (Cohen 2010; Sive 2009; Pelberg 2009). While the biggest fear for industry professionals concerning adopting IPD is the issue of insurance and risk allocation (Kent and Becerik-Gerber 2010). One way to minimize legal barriers is to select contracts that fit into traditional insurance products. There is no single insurance product that will fit every single project, but some of the products used are comprehensive general liability (CGL), project specific professional liability, contractor controlled insurance programs (CCIP), and in some instances all parties waive all claims against each other except for fraud and gross negligence.

Technological Barriers
Technological barriers refer to the legal challenges of ownership, liability and interoperability concerns in the integrated use of technology to achieve collaboration on IPD (Kent and Becerik-Gerber 2010; Hess 2009; Ashcraft 2008). One way to minimize technological barriers is for technology to be as integrated as possible. The use of the building information modeling (BIM) can be defined as a means to integrate different discipline models during each phase of a project. A collaborative use of BIM was seen as a great tool for enhancing communication, transparency, building relationships, reducing costs, and accelerating processes in all projects. Confidence can be gained by using the visualization and simulation capabilities of BIM. In many instances, BIM collaboration will allow several different disciplines to work together and solve clashes that are sometimes contained in the original project design. Other issues addressed by the literature are translation, interoperability concerns, model ownership, and liability when
BIM becomes a platform for data sharing and collaboration among the project teams (Hess 2009; Ashcraft 2008).

Limitations
One of the limitations revealed in this research study was the prominence of IPD project examples. The idea of integrated project delivery is still fairly new to the construction industry therefore, there are very few companies willing to tackle the barriers to try and implement this new project delivery method. A second limitation that became evident during this research study is the survey that was distributed and completed received very little response from the eight companies that were targeted. The low response rate may be because the targeted group was such a niche part of the construction industry and respondents were very difficult to acquire. To get an adequate representation of integrated project delivery, IPD would need to have more wide spread adoption. The discussion of technology in this study was limited to collaborative use of different discipline models; there is a need for more detailed exploration and use of different modes of BIM use.

CONCLUSIONS
In the aforementioned research study, the focus was on investigating how successful lean construction companies overcame the barriers that impeded them from the implementation of integrated project delivery (IPD) method. The study explored eight different construction companies that had previously integrated project delivery practices within the lean construction industry. Each case, through research showed that they had different methods of implementing IPD, each company is unique, and that implementing IPD is different for each company. To employ IPD principles, each company should be studied on a case-by-case basis.

To achieve a fully integrated project, some criteria must be present in each stage of implementation. This practice involves the following: organizational anticipation, the training of individuals, and a collaborative framework within the IPD teams. This criterion was found to be crucial for achieving a successful transition into integrated project delivery. The objectives of the research have been successfully achieved through the questioning of qualified survey participants. By statistical analysis through a very limited survey, we see that 67% of the more experienced construction professionals understand enough about integrated project delivery to be able to answer a survey about it. When required to execute construction methods through their company, design-bid-build is used always to sometimes, design-build is used sometimes, and construction manager at risk is utilized sometimes to never. When asked what construction method that they preferred, design-build was the top response with 33%, then construction manager at risk with 28%, and design-bid-build with 17%. This one difference shows the fact that what the participants are required by their company to use and what they would personally use are two different methods. When asked about what barriers impede implementation of IPD the answers were anticipated and expected. The only difference would be the issue of complexity. Complexity as a barrier would suggest that the IPD method is still new in some aspects, and that the respondent might work at a smaller company that has not put the method into practice yet. The final question that needs to be discussed is Q9, which asks, “Once barriers are identified how your company overcame
these barriers?” The underlined themes that resonate through these responses are as follows. Education of the team members is imperative, bringing the disciplines together early in the process is essential, and collaboration of all members of the team is deemed necessary to overcome the barriers of implementing integrated project delivery.

REFERENCES


Stagner, Steve. "Design-Build and Alternative Project Delivery in Texas" (PDF). Texas
DESIGNERS' RESOLUTION OF LACK OF COMMITMENT RELATIVE TO PROJECT DELIVERY IN SOUTH AFRICA

Ayodeji Aiyetan and John Smallwood

Clients seek for designs that are void of revision during the construction stage. This eliminates numerous problems that are associated with low quality design. This study aims to assess factors influencing quality of design at the stage through a system thinking approach. The study was conducted in South Africa. Respondents for the study are architects, builders, quantity surveyors, and engineers. Random and systematic sampling technique were employed in the selection of samples. A total of eighty-eight questionnaires were analysed for the study. Inferential statistics was employed for the analysis of data. Findings include that conflicting design information, missing information, and timeliness in revision of design are factors that determine the quality of design. These causes lack of commitment of designers to design and hence, low quality design. Recommendations include that the construction industry should provide quality management guide lines, which should be enforced by consultants on projects. Designers should commit to providing a quality service, conducting design verification through design analysis reviews, and conducting constructability reviews.

Keywords: Buildability, Commitment, design, Project delivery

INTRODUCTION

Construction activities arises from design; therefore, design is critical relative to construction of a facility. As a result, design must be functional, of good aesthetics, and buildable. Therefore, to fulfil these functions, a design entails many stage before it is given to the contractor to realise. In addition, Chan et al. (2004) assert that the amount of ideas that are incorporated into design at the design stage, determines the construction speed.

Clients are dissatisfied (Phua, 2005), when designs are revised at the construction stage. This attracts additional cost, and may lead to the delay of the completion of the project regarding. A design that is impeccable reveals the competency level of the designer and indicates the relative ease of build of the design, the construction speed, increases (cost and time) with respect to delivery. These factors also reveal the competitive advantage of the designer. Clients requires an optimal facility, procured with least cost, and delivered at the stipulated time, so that returns on the investment of the facility can begin to accrue.

1 ayodejia@dut.ac.za
Based on the foregoing, a study to assess commitment of designers to design, was initiated with a view to mitigate challenges stemming from designs.

**CONTEXT**

**Quality of design at the design stage**

The numerous problems with design and planning are the major causes of change orders, which lead to delays in the delivery of projects (Hsieh et al., 2004). Other researchers indicate that poor drawings were another cause for poor productivity (Makulsa-Watudom & Emsley, 2001). Design management is a tool which Bibby et al. (2006) propose corporations and managers use to enhance project performance. It is a process that includes open forum presentations, a style that allows discussion of issues by all project team members, and has the capacity to ensure a faultless design. Santoso et al. (2003) assessed risks in high-rise building construction in Jakarta, and determined that risks related to design and management are the most significant factors which affect construction performance. Factors that influence quality of design at the design stage, are discussed below.

Conflicting design information

A study conducted by Acharya et al. (2006) revealed that ambiguous specifications are one of the six critical construction conflicting factors in the Korean context that affect project delivery time negatively. This refers to an item having double representation either in numerical value or in statement. For clarity and smooth flow of work, designs should be checked more than once before they reach the contractor. It is also advised that designs should be checked by the contractor for clarity and to avoid ambiguity upon receiving the award. If these exercises are not conducted, it may lead to delays. Oyedele and Tham (2006) conclude that architects should improve on design quality to satisfy their clients’ requirements and ensure successful project delivery.

Timeliness of issuing of revised drawings

Yakubu and Sun (2009) reached the conclusion that design change(s) is(are) the most influential factor inhibiting the delivery of projects on time in the United Kingdom construction industry from the perspective of the contractor and the consultants. Walker and Shen (2002) declare that a delay in design documentation was ranked the second most influencing factor that negatively affects project delivery. Time should not be wasted in the process of issuing revised drawings. The joint contract tribunal (JCT) specifies that revision of drawings should not take more than three days, after which the contractor can claim for extension of time. This could increase the final project cost to the disadvantage of the client, which the client might not want to incur. Revisions of designs should be done promptly.

Missing information

The production of poor design and documentation quality negatively affect the construction process (Andi and Minato, 2003). Further, Álaghbari et al. (2007) identify incomplete documents as one of the top ten factors causing delays in the delivery of projects in the Malaysian construction industry. Missing information interrupts the
smooth flow of work. Contractors are employed to build in such a way that they adhere to
design and specification. Assumptions should not be made while constructing, therefore
missing information should be brought to the notice of the designer and a quick response
should be given to address same.

Dimensional inaccuracies

Mistakes in design form part of the contractor-related factors, which were ranked second
in terms of contributions to delays in the delivery of projects, identified by Walker and Shen (2002). This was supported by Acharya et al. (2006), indicating that design errors
are one of the six critical construction conflicting factors in the Korean context.
Dimensional inaccuracies are to be brought to the notice of designers and these should be
resolved promptly, to avoid delays in the delivery of projects. JBCC Clause 17.1.2
bestows the responsibility on the principal agent to issue the contractor instructions with
regards to the rectification of discrepancies, errors in description, or omission in contract
documents other than this document.

Expediting shop drawings

Out of forty-four causes of delays identified by Faridi and El-sayegh (2006) in the United
Arab Emirates, preparation and approval of drawings is the most influential. Delay in the
release of shop drawings could affect speedy completion of work sections. Shop drawings
should be delivered to the contractor whenever the need arises with no delays. Clause
32.5.1 of the JBCC states that the failure to issue or the late issue of a contract instruction
following a request from the contractor entitles the contractor to claim for the expense in
loss incurred, having notified the principal agent within forty working days from
becoming aware, or from when he / she ought reasonably to have become aware of such
expense and loss.

METHODOLOGY

A survey was conducted to assess the commitment of professionals relative to the quality
of management given to design at the design stage. Descriptive statistics in the form of
frequencies and a measure of central tendency in the form of a mean score (MS) were
generated from the analysis of the data. Ratings relative to ‘does not’ and a range of 1
(minor) to 5 (major), were converted to percentages, and a MS ranging between 0.00 and
5.00. Given that effectively a six-point scale - ‘does not’ linked to a five-point scale was
used, and that the difference between 0 and 5 is five, the midpoint of the range is 2.50. In
terms of ranking, where factors had the same MS, the factor with the lower standard
deviation was afforded priority in terms of ranking. The sample consisted of: architects
(9), master builders (18), quantity surveyors (23), structural engineers (23), clients (12),
and others (3). With respect to sample selection, the recommendations of Leedy and
Omrod (2010) were adopted. The probability sampling technique was employed for
sample selection. A random sampling technique was employed, except for the quantity
surveyors and structural engineers, because of respondents’ distribution with respect to the
sample frame. Systematic sampling techniques were used for the quantity surveyors, and
for the structural engineers the entire sample was surveyed. The research instrument used
was a questionnaire survey, which was administered to respondents by means of the
postal service in the case of the architects, master builders, structural engineers, and e-
mail in the case of the quantity surveyors. These were received through the same means.
A Cronbach’s coefficient test and validity test were performed and were found satisfactory. A Cronbach’s alpha of ≥ .81 and factor loading of >.60 for samples sizes 85-89 were obtained.

The total number of questionnaires used in the analysis was eighty-eight (88), representing 6.1% response rate achievement recorded on questionnaire administration. Inferential analysis was used as the statistical tool for data analysis. The respondents were mostly from the private sector (74%), over the age of thirty, and their average working years was 17. In terms of qualification, Bachelor’s degree (25%) predominated, and they have handled not less than six different types of projects. Based on these demographic findings, the data can be deemed reliable. This was followed by a system thinking approach to develop causal feedback mechanisms among the factors that contribute to the quality of design at the design stage. Senge (2006) describes a system as a perceived whole, whose elements hang together because they affect each other over time and operate toward a common purpose. Further, it is a discipline for seeing wholes, a general principle / framework for seeing interrelationships instead of linear cause-effect chains, and patterns of change rather than static ‘snapshots’. This results in seeing the deeper patterns lying behind the events and the details and this simplifies life.

Findings

Table 1 presents factor categories (problems) influences based upon their average mean scores. These factor categories were the twelve main parameters of a study titled 'Influences on Construction Project Delivery Time', of which this is a part. From Table 1 it can be concluded that most of the factors that contribute to delaya in project delivery are construction related. It can be deemed that poor performance is the main reason for project delays.

Table 1: Ranking of problems (factor categories) influence by their average mean score on project delivery

<table>
<thead>
<tr>
<th>Factor category</th>
<th>Mean score</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction planning and control techniques</td>
<td>3.98</td>
<td>1</td>
</tr>
<tr>
<td>Management style</td>
<td>3.92</td>
<td>2</td>
</tr>
<tr>
<td>Economic policy</td>
<td>3.76</td>
<td>3</td>
</tr>
<tr>
<td>The quality of management during construction</td>
<td>3.73</td>
<td>4</td>
</tr>
<tr>
<td>Site access conditions</td>
<td>3.54</td>
<td>5</td>
</tr>
<tr>
<td>Site ground conditions</td>
<td>3.49</td>
<td>6</td>
</tr>
<tr>
<td>Motivation of workers</td>
<td>3.40</td>
<td>7</td>
</tr>
<tr>
<td>Constructability of designs</td>
<td>3.37</td>
<td>8</td>
</tr>
<tr>
<td>Socio-political conditions</td>
<td>3.16</td>
<td>9</td>
</tr>
<tr>
<td>Client understanding of the design, procurement and construction processes</td>
<td>3.12</td>
<td>10</td>
</tr>
<tr>
<td>The quality of management during design</td>
<td>3.06</td>
<td>11</td>
</tr>
<tr>
<td>Physical environmental conditions</td>
<td>2.87</td>
<td>12</td>
</tr>
</tbody>
</table>
From Table 1, the quality of management during design has a mean score greater than 3, from a scale of 0 – 5. This indicates that the factor has a moderately high influence in the effectiveness of designs with regards to the construction of a facility. Therefore, it is important to identify factors that influence design at the design stage, with respect to having designs void of revisions at construction stage, having integration of buildability issues into designs at the design stage.

Table 2: The influence of quality of management during design factors on project delivery time

<table>
<thead>
<tr>
<th>Factor</th>
<th>Unsure</th>
<th>DN</th>
<th>Minor..............................</th>
<th>Major</th>
<th>Mean score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conflicting design information</td>
<td>2.3</td>
<td>1.2</td>
<td>13.8</td>
<td>9.2</td>
<td>23.</td>
<td>24.0</td>
</tr>
<tr>
<td>Missing information</td>
<td>1.2</td>
<td>2.3</td>
<td>11.6</td>
<td>15.1</td>
<td>25.6</td>
<td>20.9</td>
</tr>
<tr>
<td>Timeliness of revised drawings</td>
<td>8.1</td>
<td>1.2</td>
<td>14.0</td>
<td>12.8</td>
<td>23.3</td>
<td>21.0</td>
</tr>
<tr>
<td>Expediting shop drawings</td>
<td>5.8</td>
<td>4.7</td>
<td>14.0</td>
<td>18.6</td>
<td>18.6</td>
<td>29.1</td>
</tr>
<tr>
<td>Dimensional inaccuracies</td>
<td>2.3</td>
<td>3.5</td>
<td>20.9</td>
<td>12.8</td>
<td>32.6</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Table 2 presents the respondents' rating regarding the influence of quality of management during design, on project delivery time. All factors in this category have MSs > 2.60 ≤ 3.40, which indicates that these factors have between a near minor to moderate / moderate influence on the project delivery time.

The factor that has the most significant influence in the category of quality of management during design is conflicting design information. The probable reason for this is the process it will take to correct a mistake. It may require checking the design from the beginning, which may take longer than expected. The second most significant factor is missing information. This factor may lead to delays because of carelessness or incompetence in design. Missing design information will inhibit the smooth flow of operations on site, therefore introducing delays to the scheduled project completion date.

The least significant factor in this category is dimensional inaccuracies. Although this factor is the least influential in this category, it does not imply that its effect is negligible because of the time it takes to clarify inaccuracies that may result in delay in the delivery of the project.

The right-hand ellipse in Illustration 1 indicates that certain practices and / or the downstream of a lack of designers’ commitment may result in the schedule deadlines not being met. However, the late revision of design, late resolution of design ambiguity, late provision of information, late issuance of instruction and slowness in approval of works could result in the project being behind schedule.
Illustration 1: Designers’ resolution of lack of commitment vicious circle

The right-hand ellipse in Illustration 1 indicates the holistic role of designers to improve design, and TQM in overall performance, directly and indirectly, and ultimately the image of the construction industry. Clients are the initiators of a project. Whatever affects the client has a direct or indirect effect on other professionals in the industry. A lack of client commitment facilitates a lack of designer and contractor commitment to the processes of construction.

A lack of designer commitment manifested in, inter alia, the lack of design QA also constitutes poor practice.

The left-hand ellipse indicates that the only way to break the cycle represented by the right-hand ellipse, represented by the break in the arrow between poor performance and designer owner dissatisfaction, lack of designers’ commitment is for the industry and the primary construction industry stakeholders to acknowledge that poor performance can be remedied. The acknowledgement of a problem and the fact that the problem can be remedied is a prerequisite for commitment.

Designer commitment engenders the implementation and practice of design QA as well as for effective constructability reviews. An appropriate procurement system facilitates constructability reviews and buildability of design and engenders the pre-qualification of contractors. Design QA complements constructability reviews and the practice of TQM.
CONCLUSIONS

Conflicting design information, missing information, and timelessness in revision of design are the main factors that adversely influence the quality of design and are indicators to lack of commitment of designers. Relative to the system thinking approach, the lack of designer's commitment results in poor quality designs, and it is recommended that the construction industry should provide quality management guidelines, which should be enforced by consultants on projects. Stakeholders should be committed to quality management; designers are strongly advised to adhere to this. Designers’ quality management should focus on the following: commitment to providing a quality service, production of correct and complete drawings and specifications, coordinating and checking of design documentation, conducting design verification through design analysis reviews, and conducting constructability reviews.

REFERENCES

THE IMPACT OF ORGANISATIONAL SAFETY CULTURE ON SAFETY HEALTH AND ENVIRONMENT (SHE) IN ZAMBIA’S ELECTRICITY DISTRIBUTION OPERATIONS INDUSTRY

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Organisational Safety Culture has increasingly come to the fore as an important aspect of Safety, Health and Environmental (SHE) Management. Diminutive literature could be found on the application of the concept within the electricity industry in Zambia. Literature reviewed showed that the state of safety in Zambia’s electricity industry has been placed under the spotlight after a number of accidents that caused an outcry among workers. The study evaluated the impact of organisational safety culture factors on SHE management and sought to improve electricity safety in the Zambian electricity distribution operation. Further, the study developed a theoretical model from the literature available that evaluated safety culture of an electricity distribution operation. The approach for the research was quantitative and descriptive. The empirical study was done by using a questionnaire as a measuring instrument. The target population consisted of operational staff, which included managers and employees, of a government electrical distribution operation company, one private owned company and the contractors that render services to these power companies. The convenience sampling method was applied when identifying participants. Statistical analysis was performed using SPSS. Descriptive statistics was used in compiling results. Further analysis compared the perceptions of various groups within the sample, which included contractors, managers and workers. The relationships between some of the factors were also explored to gain a better understanding of the dynamics of organisational factors that influence safety management. The findings yielded a useful model for evaluating the safety culture of the electricity distribution operation, and highlighted strong relationships between shared safety values, management involvement and the safety culture of the organisations. The research also showed that there was no significant difference in the culture perceptions of contractors and employees working in the electricity sector. Significant differences were however found between managers’ perceptions of safety culture and the perceptions of workers. The importance of the study is that it will help managers understand the embraced values that can be used to steer the organisation towards an improved safety culture.

Keywords: electricity, distribution, model, operation, organisational, safety culture.

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INTRODUCTION

The electricity industry experiences incidents that can be fatal to people and costly to the organisations. Although electricity is treated at a high level in Zambia, accidents do happen. Additionally, electrical accidents are implied to be rare according to statistics, but most of them still remain unreported, this leads to lack of information about safety related issues in the organisations averting conformance of preventive actions (Mihai & Sorin, 2010). According to Rutter (2010), the current measures to escalate electrical safety are not effective enough without considering the electricity firms’ safety cultural aspects. In the past, several fatalities and serious accidents have occurred to workers working on electrical infrastructure from energized conductors and equipment, lifting of poles and falling from heights to mention but a few (ZESCO Limited, 2015). IRCA Savenda (2015) in their report highlighted that most investigation on the causes of fatalities and accidents are lack of certain safety procedures that are not carried out before any work is conducted or during the process of carrying out that work that is attributed to human error. Other errors are due to violations caused by deprived approach towards safety. The missing feature in the management of SHE in the electricity industry therefore is attributed to the lack of a positive organisational safety culture in distribution operation. This lack of organizational safety culture in SHE management culminates into chain of events that could have been happening for a long period of time. Most underlying causes or immediate causes are related to human factors according to Mihai and Sorin (2010).

Systems failure and major accidents in a high hazard industry such as the electricity industry is an indication that there is need for an organisational safety culture to mitigate these incidences. Literature reviewed from other countries indicate that organisational safety culture approach in the SHE Management had been used to reduce unsafe behaviours that lead to incidents, or accidents and fatalities in the electricity distribution industry.

The purpose of this study therefore was to establish the impact that safety culture in organisations can have in the management of SHE in the electricity distribution industry operation. The findings could assist the practitioners, management and workers to entrench a safety culture. Having emphasized the need for safety culture on SHE management, the assertion of the problem is that the Zambian electricity industry in managing SHE focuses only on regulations, policies and processes and not on inculcating the safety cultural challenges that influence the provisions of the SHE management system in the electricity industry distribution operation. Lack of indication if organisational safety cultural approach is being used in the industry, is a course for concern. Consequently, this study has contributed to the understanding of organisational safety culture in the management of SHE in the Zambian electricity industry.

The Importance of Organisational Safety Culture

The importance of creating a safe working environment cannot be overemphasised. The effect of fatalities and injuries due to accidents cannot only be measured by costs associated with the compensation paid by the Workers Compensation Control Board in Zambia and the injured workers including the families, can also be measured on the economic cost of productivity (Rutter, 2010). According to Hopkins (2009), improvement can be made to the safety of workers by the organisations in the electricity industry
creating a positive safety culture. Even though investing in technology or training is costly, for high risk industries such as the electricity industry, the austerity of the consequences of disaster implies that a short-term monetary standpoint would be inapt for its sustainability. Work in the electricity industry is the most hazardous if not properly managed and can affect the economy of the country (Du Toit, 2012). Despite the importance of the electricity industry to the development of Zambia, the sector is one of the most hazardous industries that have been affected by incidents in terms of safety and occupational health and environmental management in the delivery of electricity (IRCA Savenda, 2015). Safety culture in organisations, need to be at a greater focus through management to frontline workers’ total commitment and active participation at all levels of the organisations concerned.

Safety Culture in the Electricity Distribution Industry

The industry, consequently exposes workers to tasks where dangers are not always easily judged (ZESCO Limited, 2015). This is attributed to workers not having the ability to cope with complex tasks and uncertainty, coupled with the time frame of dealing with that incident. The current approach to the SHE management does not take into account the variable nature of how a worker perceives safety and the climate in which it can be created. Understanding safety culture in the management of SHE in the electricity distribution operations industry is an important factor to avert potential risks. A genuine consultative process from top-down and bottom-to-top in the design and implementation of safety cultural change program is required to move out the ‘blame the victim’ approach by management as evidenced in most institutions (Rutter, 2010). Nonetheless, management should seek to identify factors of casualty in safety incidents and rectifying the root cause of hazards identified. Hence, considering this background factor and since work related problems can lead to poor quality of service provision, increased risk, workplace health diseases and a poorly managed environment, it is imperative to understand the impact that safety culture in organisations can have in the management of SHE in the electricity industry operation (Zou & Sunindijo, 2015). This study sought to analyse the impact of organisational safety culture in the management of SHE in the electricity distribution sector and as a subsector of the industry, this is where more accidents are experienced compared to that of the generation and transmission (Energy Regulation Board, 2014). This can be attributed to the high level accidents recorded culminating from the distribution sector as indicated in the Energy Regulation Board Report (2014)

The Zambia Auditor General’s Report (2015), specified that the highest number of fatalities were from the Mining and quarrying industries which had a total of fifty-nine (59) fatalities representing 14.7% followed by Personal Service and hotels which recorded fifty-four (54) fatalities, representing 13.4% of total fatalities in the period under review. The electricity industry is the seventh with a recording of twenty-eight (28) fatalities representing a 6.9% as indicated in Table 1.

Nonetheless this indication does not imply that electrical accidents are low and can be ignored. The fact that they occur with others recorded and others not reported means that there is need to hasten the safety culture in this high-hazard environment in order to lower the cost of dealing with fatalities, injuries and insurance after an incident. This information does not show the major causes if the incidences to compare performance
accurately. However, this information provides motivation to investigate organisational safety culture in the electricity distribution industry more thoroughly.

Table 9: Number of Fatalities by Industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>Totals</th>
<th>% Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture Forestry, etc.</td>
<td>4</td>
<td>15</td>
<td>14</td>
<td>18</td>
<td>51</td>
<td>13.6</td>
</tr>
<tr>
<td>Banking, Finance and Insurance</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>Building Construction</td>
<td>5</td>
<td>18</td>
<td>11</td>
<td>18</td>
<td>52</td>
<td>13.9</td>
</tr>
<tr>
<td>Charities, Regulations. Political, and Trade orgs.</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td>Chemical Industry, etc.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Educational services</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>Electricity</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>11</td>
<td>28</td>
<td>11.2</td>
</tr>
<tr>
<td>Entertainment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Food, Drink and Tobacco</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>16</td>
<td>4.3</td>
</tr>
<tr>
<td>Glass, Brick, Tiles, Asbestos, etc.</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Iron, Steel Industries, etc.</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>13</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>Leather Industries</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Medical Services</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mining, Quarry Industries</td>
<td>13</td>
<td>10</td>
<td>10</td>
<td>26</td>
<td>59</td>
<td>15.7</td>
</tr>
<tr>
<td>Personnel Services, etc.</td>
<td>8</td>
<td>11</td>
<td>15</td>
<td>20</td>
<td>54</td>
<td>14.4</td>
</tr>
<tr>
<td>Printing, Publishing and Paper Industry</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td>Professional Services etc.</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>12</td>
<td>3.2</td>
</tr>
<tr>
<td>Textiles Industries</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>Trade and Commerce etc.</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>21</td>
<td>5.6</td>
</tr>
<tr>
<td>Transport and Communication</td>
<td>4</td>
<td>0</td>
<td>14</td>
<td>11</td>
<td>29</td>
<td>7.7</td>
</tr>
<tr>
<td>Wood and Furniture industry</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>1.6</td>
</tr>
<tr>
<td>Unregistered</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>72</td>
<td>82</td>
<td>111</td>
<td>137</td>
<td>402</td>
<td>111</td>
</tr>
<tr>
<td><strong>% Increase</strong></td>
<td>0</td>
<td>14</td>
<td>28</td>
<td>49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Safety Culture

Safety culture affects attitude, perception and beliefs or values of workers and management, and the organisation as a whole in the electricity and impacts on reduction of incidents and accidents rate additionally. According to Guldenmund (2007), safety culture are aspects of the organisational culture that have eventual impact on attitudes and behavior and values to increase or decrease safety risk. Positive influence can be inculcated on workers by good management systems on the SHE process. There is limited information on the management of SHE in the Zambian electricity industry and safety culture. Baarts (2009) highlights that organisations whose principal objectives is to
eliminate incidences and accidents, the need to focus on safety culture to influence SHE. Rutter (2010) inflates on this factor that development and effectiveness of SHE management system is linked with the right culture necessary to make safety systems work. Therefore, organisational safety culture must exist in all departments and functions including the board to be effective, and not just in one distinct part of the organisation. There is need to have a degree of trust as a vital component of a good organisational culture, between workers and management at all levels of the organisation.

**Pointers of a Safety Culture**
The need to measure whether a safety culture is existing in an organisation is a component that has not been countered. A series of measurements need to be developed to recognize the sociological and psychological attitudes and behaviours necessary for a safety culture to be in existence in an organisation (Power, 2007). SHE audit processes questions workers on the awareness and knowledge of safety policies, procedures and acceptable practices at work that can reveal their safety awareness. As suggested by Fuller and Vassie (2004) there are six levels of organisational development of safety culture model and include:

- **Continuous improvement and Motivation** – SHE and incident prevention being ideal to the activities a company undertakes such as continuous awareness and training.
- **Co-operation values** – management should adopt corporation as an economic perspective and adopt a positive active approach to SHE.
- **Workers involvement** – workers’ involvement and accident causation models formulated to know the consequence of reluctance to safety culture.
- **Management involvement and leadership style** - physical and management controls are vital, were accidents are viewed as a consequence of workers’ unsafe acts and omissions (blame the victim).
- **Emergent and communication** – compliance to procedures, guidelines and management.
- **Usage of Accident Information** – lessons learnt and preventive and corrective measures.

Similar organisational cultural factors were identified as indicators of safety by Mengolini and Debarberis (2008) and were adopted in this study. Organisations successful in emerging and sustaining a culture of safety, which is safety mindfulness endeavour to achieve the intolerance of incidents causing fatality and injury to people (Breaking the Barriers of Insider Research on Occupational Health and Safety, 2009). The beneficial resultant is a retained healthy workforce that is skilled, and a reduction in economic costs causes due to losses from compensation insurance and lost productivity; additionally, personal and family impact of injured worker. Building up on the efforts being taken to further reduce and eventually eliminate incidences can be achieved with the safety culture pointers by self-appraising.

Therefore, it is evident that workers in the electricity industry are at risk of exposure to incidents that can lead to fatalities and injuries. And despite these risks cited earlier, the industry appears to do very little about the adopting organisational safety culture.
RESEARCH METHODOLOGY

Weigmann et al (2004) states that quantitative approaches especially surveys of individual responses, are more practical in terms of time and cost effectiveness. With time and practicability in mind, the study used a questionnaire survey and the approach was quantitative and descriptive. Hopkins (2006: 878), also agrees to the use of questionnaire surveys as an effective research methodology to identify and measure an organisation’s safety culture. Fuller and Vassie (2004)’s six factors of organisational development of safety culture model was used as themes for the development of the questionnaire. Similar themes have been used by Rutter (2010). Therefore, the questions based on the six themes developed via the literature reviewed were thus developed. The study was inclined to the management and workers of a government electrical distribution operation company, privately owned company, and contractors that render electrical services to the industry in Zambia. The research used the management and employees of a government electrical distribution operator, since it is the only company that distributes and supplies 90% of electricity in Zambia.

The sample came from a non-random cross section of operational staff that included managers and employees of a government electrical distribution operation company, one privately owned company and the contractors that render services to these power companies. In the questionnaire, six factors which are also major global indicators of safety culture were used and modified to fit the electricity industry according to Gibbons et al (2006) as cited by Pyoos (2008). The indicators included continuous improvement and motivation, corporation values and organisational commitment, workers’ involvement, management and leadership style, emergent and communication, and usage of accident information. Accountability factors were also considered but analysed separately. The questionnaire was distributed to the subject matter experts who included safety managers of the companies to validate the content. Distributed questionnaires were in total of 200 and completed during one of their safety sessions and a total of 151 responses were received of which 12 were spoiled. The remaining 139 responses account for 69.5% response rate. A model of similar themes as adopted by Fuller and Vassie (2004) were used and emanated from the questionnaire responses, in collecting and analysing the data.

Table 10: Demographic Distribution of Respondents

<table>
<thead>
<tr>
<th></th>
<th>Government Owned Company (G)</th>
<th>Privately Owned Company (P)</th>
<th>Contractors (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Supervisors</td>
<td>15</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Artisans/Technologists</td>
<td>31</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>General workers/operators</td>
<td>21</td>
<td>14</td>
<td>13</td>
</tr>
</tbody>
</table>

RESULTS

Outcomes from the questionnaire results led to the supposition that the organisational safety cultural factors are pertinent within the context of SHE management in the electricity industry. While culture is a dynamic concept, it is different from organisation
to organisation and has the ability to change within an organisation. Table 3 below shows the mean, standard deviations and significant differences between the three entities using the Likert analysis of principal questionnaire survey. The contractor had significantly lower factor compared to the other two players, with highest continuous improvement and motivation, usage of accident information/communication and usage being scored by the government owned company.

Table 3 indicates that the degree of importance to respondent's organisations with six different indicators in terms of the mean score of 5.000. It is notable that the mean scores of continuous improvement by contractors and the privately owned company; and workers’ involvement in the private sector are below the midpoint score of 5.00. This indicates that these respondents do not perceive these factors as important as the Government owned company. Given that the mean for continuous improvement and workers involvement is >4.921 > 4.953, the respondents can be deemed to perceive them to be between not important to less important. Therefore, it can be asserted that this connotation of organisational safety culture is applied in the electricity industry.

However, both the respondents from the management of the private electricity company and the contractors agreed that there was not an affirmative connection that existed between organisational safety culture with indicative factors of continuous improvement and workers’ involvement. This deduction was derived from the notion that if safety is a highly shared value in the organisations then the safety culture approach has a strong positive relationship with the values of the organisation. On workers’ involvement, the
government owned company showed a higher mean of (5.359) than that of contractors and private owned company mean scores.

Furthermore, it can be noted that management and leadership style for the contractor's organisational safety culture has a mean of 4.989 which is ranked last in that row indicates that the current management style and leadership is not seen as a motivation for better SHE Management. The results of the mean score of > 5.00 indicates that the government owned company embraces all the factors, perceives them to be important in the management of SHE and embraces the organisational safety culture as important to very important compared to the privately owned company and the contractors.

According to Pyoos (2008) correlations using Pearson correlations between various factors are performed on the reviewed factors to test the validity of the data and explore the relationships. The minimum correlations between factors used according to Weigmann et al (2004) and Pyoos (2008) is (correlation > 0.3). Furthermore, to evaluate the relationship of management involvement with regards the six safety value factors, a Pearson's correlation was used to find the relationship that exists between these factors. The study adopted practical significant relationships (correlation >0.3) found between Management involvement in safety systems and Safety Values whose relation was found to be (correlation = 0.31). This indicates that the relationship is weak to moderate. More significant correlations (>0.40) are found between the following factors: continuous improvement and motivation (0.46), workers’ involvement (0.44), and Management and leadership style (0.57). The strongest correlations can be found for the usage of accident information (0.70). It is important to note that even for very weak correlations, all the correlation figures are positive and thus related to management involvement in organisational safety culture for the management of SHE.

Table 12: Correlation figures of Management Involvement in Safety Culture

<table>
<thead>
<tr>
<th>Continuous improvement and motivation</th>
<th>Corporation values</th>
<th>Workers involvement</th>
<th>Management and Leadership style</th>
<th>Usage of accident information</th>
<th>Emergent and communication of Safety System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Values</td>
<td>0.46</td>
<td>0.45</td>
<td>0.44</td>
<td>0.57</td>
<td>0.70</td>
</tr>
</tbody>
</table>

The construction of the Pearson's correlation table for the six factors explored the significance of the differences between management involvement perceptions of safety cultural values. Therefore, in safety culture, values are a profoundly embedded characteristic in an organisation behaviour, and a worker can either be rewarded or punished based on the actions taken in enhancing safety. Regarding safety systems and guideline, respondents felt that their safety culture was dependent upon management commitment on safety, employee empowerment and incident documentation practices. Management involvement is highly dependent on these factors and the reporting structure adopted in the organisation for a preventive action.

DISCUSSION

In-terms of awareness of safety culture by workers in the contracted firms who are not permanent workers compared to those in the electricity companies, safety culture is
dependent on the host organisations streamlining the difference between the workers of the contractors and those in the electricity firms that are permanent. If contractors are not considered as part of the organisational team, safety culture alignment is difficult. Contractors who are not permanent members of the host organisation perceive a greater level of enablement than what the permanent members of the organisation do. This is because of the short time score that the contractor workers spend in the organisational culture, which does not allow them to build interactions and create stability inside themselves. The research also found that contractors had difficulty to report incidents to the host company in most cases due to fear that they are not fully aware of the existing structures to report incidents or that they do not want to be perceived as jeopardies. This is in relation to what Fuller and Vassie (2004) found that the alignment of cultures of partnering organisations bring about harmony where employees feel respected, are optimistic and give their best. If contractors are not considered as part of the team, and no incentives are provided for contractors to give of their best, such cultural alignment may be difficult, if not impossible.

In responding to the perception that managers have on safety culture compared to that of workers, the results indicated that there is a difference in these factors. Clark (2006) postulated that there is a substantial dissimilarity in the views of the safety culture between managers and workers in a vehicle industrial plant. This study showed that there is a substantial difference in perception on safety culture between managers and workers. Managers seemed to have a higher perception of safety culture compared to the workers. The involvement of senior managers and middle managers is personal when it comes to safety in the management of SHE. They involve themselves in safety meetings, risk assessments and green area meetings.

Management involvement measures the extent to which middle and senior managers get personally involved with issues pertaining to safety. However, workers only involve themselves in safety measures according to the number of times they see the managers in their work areas engaging them on safety and showing concern for safety. These involvement and engagements with workers leave more positive impact on the average worker than does written instructions and procedures from the manager. On the issues of the role management plays with regards to safety, it was found that there exists an exponential relationship between the safety culture factors and the level of management involvement. Hence leadership and culture are issues that are intertwined in safety.

The analysis of accountability as a factor in itself, gave rise to two distinct sub-factors that include the effect of accountability and regularity of accountability. In relation to Wiegmann et al (2004), issues of accountability in an organisation are very important to indicate the existence of safety culture and how they are regularly applied. 55% of the respondents felt that shared safety values have minimal impact in ensuring that the organisations implement and communicates consistently what has been documented. Nonetheless, since the results indicated no significant difference in terms of the accountability factors and recompense and penalty, implies that the system is indeed effectually communicated and the indulgent is the same across the organisations visited.

Findings of the research gives the impression that there is a noteworthy linear relationship between the safety culture and the values of the organisation. It has nevertheless revealed
that not all the factors that institute organisational safety culture is well-versed by a reinforcement of shared safety values.

This study has provided a basis for arguing that within the electricity industry, both permanent workers in the government and privately owned companies, and contractors have the same perceptions of safety culture. Such alignment makes it easier to manage the safety aspect of the electricity industry, by providing effective management leadership style that will enable continuous safety improvement.

Nienaber and Roodt (2008) found that management and leadership issues are associated with the role played by managers. And therefore this study indicates that management has a big role to play in entrenching safety values, and safety systems in the organisation. Additionally, the findings are therefore consistent with the results from Weigmann (2004) and Pyoos (2008) which are independent researches to determine the perspective of management compared to workers within the context of organisational safety culture. This can be seen in the lack of significant difference in the reporting practices that measures the extent with which workers report near misses and accidents in which they are involved. Therefore, there is a positive impact of organisational safety culture in the management of SHE in the electricity distribution industry.

CONCLUSIONS

The overarching aim of the research was to determine whether there is an impact of organisational safety culture in the management of SHE in the electricity distribution operation industry. Having developed a literature base from similar work done in industries other than the electricity industry, a measurement tool was developed for the organisational safety culture. The elements identified in coming up with the results show clear linkages of safety culture in the electricity industry. The research showed that there is a relationship between management involvement and organisational safety culture in the management of SHE in the electricity distribution industry. The safety factors used in the study and based on the literature reviewed are applicable in driving a positive impact in the management of SHE.

While culture is considered to be a very self-motivated notion, it is perceived to be different from one organisation to the other depending on each organisational values. Implementing safety culture in the organisation can be asserted as a means of reducing accidents and incidences and helps management implement SHE systems in high hazardous environment of the electricity distribution. An organisational safety culture centred approach identifies fundamental perceptions and outlooks, allowing management to take discourse on the root cause of safety problems.

The research has unlocked prospects for management and managers in charge of safety such as Safety Managers, to harness additional tools in SHE Management to fight against incidents in the electricity distribution industry. This is because safety culture focuses on the receptiveness and attitude to the work environment, organisational systems and social structures. It is recommended that simpler models based on safety culture in organisation be developed from the more complex model used in this study. One of the factors used in this research, which is management involvement can be used as a bench mark for safety culture in organisations, making inference on the strength of the connection among the
factors. This allows for databank trending in intermittent periods to be used for future safety interventions.

Once a safety culture approach is used in the management of the SHE, it is recommended that an automated data capture processing tool to fast track the analysis be implemented. Additionally, it allows for faster reaction by management to change the trends and open for re-audits. It is also recommended that managers be well vested in understanding the gap between the shared value and the embraced values are as it will help them steer the organisation towards an improved safety culture.

REFERENCES


THE ROLE OF PERSONAL VALUES IN BEHAVIOURAL-BASED SAFETY: EVIDENCE FROM UK & THAILAND INQUIRIES

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⁵ Nick Bell Risk Consultancy, UK.

Whilst behavioural-based safety (BBS) is not new and even becoming increasingly common especially among large construction organisations, research on BBS is yet to explore the potential effect of innate triggers of behaviour such as personal values. This study addresses this gap, by presenting findings from two exploratory surveys (in UK & Thailand) into the influence of workers' personal values on occupational safety and health behaviour (OSHB). Data analysis, revealed from both surveys that higher-order dimensions of personal values have statistically significant relationships with OSHB. For instance, in the Thai study, conservation was positively related to occupational safety and health (OSH) participation, while in the UK survey, self-transcendence was also positively related to OSH compliance. Overall, the findings from the different national contexts provide some evidence of the predictive influence of personal values on OSHB. The research outcomes therefore highlight the significance of workers' personal values to BBS.

Keywords: behavioural-based safety, personal values, survey, Thailand, UK.

INTRODUCTION

Occupational safety and health (OSH) has become one of the key industrial concerns in many countries including the UK and Thailand. Despite representing only about 5% of UK employment, the construction industry accounted for up to 30% of fatalities at work with an average of 43 fatalities per year over the past five years (Health and Safety Executive (HSE), 2016). Thailand has similar high rates of accidents despite evidence of some improvement over the past decade (Occupational Safety and Health Bureau, 2012). In Thailand, there were up to 21,021 reported accidents in 2007 and 10,619 in 2011 for construction and machine installation industries (Occupational Safety and Health Bureau, 2012). Whilst construction accidents are multi-causal (Haslam et al., 2005; Manu et al., 2014) there is the general view that worker behaviour is a major contributor to accidents.
in construction (Ismail and Hashim, 2012; Shin et al., 2015). In an accident causation study by Haslam et al. (2005), worker actions/behaviour were found to contribute to nearly 50% of the 100 accidents that were investigated.

According to Pybus (1996) the first phase of attaining OSH maturity as an organisation or society is often as a result of the application and enforcement of rules and regulations. Subsequently, further improvement can be attained by more technical safeguarding, management systems and engineering controls. While these significantly reduce the occurrence of accidents, they are also often limited in terms of completely eliminating all OSH issues. Thus, there is a need for an innovative phase of OSH intervention, through the total integration of OSH within the culture and thought processes of organisations. At this phase, people and behavioural issues become central to achieving any further improvements in OSH performance (Talabi et al., 2015). In view of this, there is growing emphasis on behavioural-based safety (BBS) programmes in construction and other industries (Talabi et al., 2015; Dekker and Pitzer, 2016). BBS programmes are based on a principle of identifying and promoting safe behaviour and attitudes among workers (Ismail and Hashim, 2012). An understanding of the drivers of OSH behaviour is therefore important. However, BBS interventions have often given limited consideration to innate human factors that could affect behaviour (Manu et al., 2017) although studies have shown relationships between innate human characteristics (e.g. personality traits) and safety behaviour (Sing et al., 2014). Manu et al. (in press), building on studies in psychology regarding human values and behaviours (i.e. Schwartz, 2009), reported empirical linkages between human values and OSH motivation. However, empirical linkages between human values and OSH behaviour in construction is yet to be reported within the extant OSH literature. This study therefore explored the relationship between workers' personal values and OSH behaviour (OSHB) in construction. The following section presents a review of literature on human values and OSHB. This leads to the development of a conceptual model to guide the empirical phase of the study. The research methodology, findings, discussion and conclusions are subsequently presented.

LITERATURE REVIEW

Human Values

Rokeach (1973) refers to values as enduring belief(s) that govern an individual's mode of conduct. Schwartz (1992) subsequently described values as desirable, trans-situational goals that serve as guiding principles in people’s lives. Personal values therefore represent a conception of explicit or implicit characteristics that differentiate individuals based on innate characteristics acquired through various social and psychological experiences (Schwartz, 1992; Kluckhohn, 1951). According to Schwartz (1992; 2009) there are 10 distinctive personal values across four higher-order dimensions as shown in Figure 1. The four higher-order dimensions also form bipolar dimensions: ‘Self-Enhancement’ versus ‘Self-Transcendence’ as well as ‘Openness to Change’ versus ‘Conservation’ (Schwartz, 1992, 2009). The ‘Openness to Change’ versus ‘Conservation’ dimension captures the conflict between values that emphasise independence of thought, action and feelings and readiness for change (self-direction, stimulation) and values that emphasise order, self-restriction, preservation of the past, and resistance to change (security, conformity, tradition) (Schwartz, 1992; 2009). The ‘self enhancement’ and ‘self-transcendence’ dimension represents the bipolar relationship between values that
emphasise concern for the welfare and interests of others (universalism, benevolence) and 
values that emphasise pursuit of an individual’s own interests in relation to success and 
dominance over others (power, achievement) (Schwartz, 1992; 2009). Hedonism shares 
elements of both openness to change and self-enhancement (Schwartz, 1992; 2009).

<table>
<thead>
<tr>
<th>PERSONAL FOCUS</th>
<th>SOCIAL FOCUS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SELF-ENHANCEMENT</strong> - Interests in relation to success and dominance over others.</td>
<td></td>
</tr>
<tr>
<td>Achievement - Wanting to be competent and to be recognised for one's accomplishments.</td>
<td></td>
</tr>
<tr>
<td>Power - Desire to exert control over people and resources.</td>
<td></td>
</tr>
<tr>
<td><strong>OPENNESS TO CHANGE</strong> – Independence of thought, action and feelings.</td>
<td></td>
</tr>
<tr>
<td>Hedonism - Pursuing pleasurable experiences, especially sensual gratification.</td>
<td></td>
</tr>
<tr>
<td>Stimulation - Seeking arousal by participating in exciting, new, and challenging activities.</td>
<td></td>
</tr>
<tr>
<td>Self-direction - The desire to be free from external control or constraints on one's thoughts or actions.</td>
<td></td>
</tr>
</tbody>
</table>

| **CONSERVATION** - Order, self-restriction and preservation. |
| Security - Desire to avoid danger or instability. |
| Conformity - Need to avoid violations of social norms and expectations. |
| **SELF-TRANSCENDENCE** - Welfare and interests of others. |
| Universalism – Desire to promote the welfare of all people (including strangers) and a concern for the protection of nature linked to Maslow’s concept of the self-actualisation. |
| Benevolence - Desire to promote the welfare of people with whom one has frequent personal contact. |

**Figure 1: Definitions of the ten values (Schwartz, 1992, 2009)**

**Occupational Safety and Health Behaviour (OSHB)**

OSHB is commonly used as a measure of OSH performance due to the link between OSHB and the occurrence of accidents, injuries and illnesses (Haslam et al., 2005; Sing et al., 2014). OSHB is often conceived as being two-fold: compliance; and participation (Neal et al., 2000, Neal and Griffin, 2006; Shin et al., 2015). Safety compliance describes following rules in core safety activities to maintain workplace safety (Neal and Griffin, 2006). Safety participation on the other hand refers to behaviours that help to develop an environment to support safety (Neal and Griffin, 2006). This includes helping co-workers, promoting the safety programme within the workplace, demonstrating initiative, and putting effort into improving safety in the workplace (Neal and Griffin, 2006). Various similar scales have been used to measure OSHB (Neal et al., 2000, Neal and Griffin, 2006; Shin et al., 2015).

**CONCEPTUAL MODEL**

Due to the exploratory nature of this study, a loosely joined conceptual model with no specific hypotheses about how human values relate to OSHB was developed and presented in Figure 2.
The conceptual model (shown by Figure 2), builds on the review of literature and brings together the constructs of human values (Schwartz, 2009) and OSHB (Neal and Griffin, 2006) with the broad proposition that workers’ personal values will be related to OSHB. The conceptual model subsequently drove the empirical exploration of linkages between workers’ personal values and OSHB.

**RESEARCH METHODOLOGY**

In view of the cross-cultural relevance of human values, it was deemed important to explore the empirical validity of the conceptual model (i.e. values-OSHB relationship) within different cultural contexts. Consequently, construction workers on project sites in different countries (i.e. UK - European country, and Thailand - Asian country) were surveyed using a questionnaire. The questionnaire adopted Schwartz’s (2009) 21-item portrait values questionnaire (PVQ) for measuring personal values, and Neal and Griffin's (2006) 6-item scale for measuring OSHB (compliance and participation). An example of a compliance item is, “I use the correct health and safety procedures for carrying out my job”, and an example of a participation item is, “I put in extra effort to improve the health and safety of the project site.” Respondents’ background information was also collected. This included role and experience. Two versions of the questionnaire were designed, the first in English for UK respondents and subsequently in Thai language for the study in Thailand. The survey was conducted on 11 construction sites in Thailand and two sites in the UK. The study locations in Thailand were Khon Kaen and Bangkok, and the UK study was in Bristol. The questionnaires were administered to the site workers who showed interest in participating in the survey. 83 useable questionnaires were received from the Thailand survey and 55 from the UK study. Exploratory Factor Analysis (EFA) was adopted to determine the dimensions of personal values and OSHB, and ordinary least square (OLS) multiple linear regression (MLR) was adopted to explore relationships between the dimensions of personal values and OSHB. IBM SPSS 23 was used for the EFA and OLS MLR.

**RESULTS**

The respondents’ details and the EFA and OLS MLR results are presented below.

**Respondents’ background information**

Table 1 shows the respondents' background information.
Table 1: Respondents' background information

<table>
<thead>
<tr>
<th>Respondents Role</th>
<th>Thailand (%)</th>
<th>UK (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bricklayer/Plasterer/Tiler</td>
<td>20.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Roofer</td>
<td>3.6</td>
<td>0</td>
</tr>
<tr>
<td>Cladder</td>
<td>2.4</td>
<td>1.8</td>
</tr>
<tr>
<td>Ground worker</td>
<td>1.2</td>
<td>7.3</td>
</tr>
<tr>
<td>Carpenter</td>
<td>3.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Scaffolder</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td>Machine or Vehicle Operative</td>
<td>1.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Plumber</td>
<td>3.6</td>
<td>29.1</td>
</tr>
<tr>
<td>Steel Erector/Fabricator/Welder</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Labourer</td>
<td>34.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Mechanical &amp; Electrical Operative</td>
<td>16.9</td>
<td>9.1</td>
</tr>
<tr>
<td>Painter and Decorator</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>Steel/Bar fixer</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Other Role</td>
<td>6</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Mean years of experience in role (standard deviation) 7.787 (6.638) 12.50 (9.509)
Mean years of experience in construction (standard deviation) 8.606 (6.634) 14.25 (9.688)

For the UK survey, a majority of the respondents were plumbers, followed by other roles and the mechanical & electrical operatives. The other UK roles comprised: site/construction manager (7), trainee construction manager (1) dry lining operative (1), window installation operative (1), quantity surveyor (1), planner (1), and unspecified role (1). For the Thailand survey, a majority of the respondents' role were labourer, followed by bricklayer/plasterer/tiler and mechanical & electrical operative. The other Thai roles comprised storekeeper (2), fire alarm installation operative (1), foreman (1), and site administration personnel (1).

Personal values and OSHB

In Tables 2 to 5, the results of the EFA based on principal component analysis (PCA) are presented for the UK and Thailand surveys.

The analysis of UK survey data revealed that 12 out of the 21 items for measuring values loaded unto four personal values dimensions: social focus value with self-transcendence being dominant (SFST); another social focus value with conservation being dominant (SFC); and two personal focus values with openness to change being dominant for both (PFOC1 & PFOC2). The total variance explained by the four dimensions is 71.46%. From Table 2, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA) (i.e. 0.729), which is well above the minimum criterion of 0.5 (Field, 2013) confirms the suitability of the sample for factor analysis. All but one of the sub-scales for the four dimensions had a Cronbach’s alpha below the threshold of 0.7 (Field, 2013), which can be attributed to the low number of scale items (i.e. two items) rather than a conceptual ambiguity of the dimension (Tuuli, 2009).
Table 2: EFA Results of Personal Values for UK survey (Adapted from Manu et al. (in press))

<table>
<thead>
<tr>
<th>Scale Items</th>
<th>Communalities</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Personal Focus-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Openness to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change 1</td>
</tr>
<tr>
<td>15_Stimulation</td>
<td>0.772</td>
<td>0.859</td>
</tr>
<tr>
<td>21_Hedonism</td>
<td>0.756</td>
<td>0.784</td>
</tr>
<tr>
<td>10_Hedonism</td>
<td>0.683</td>
<td>0.718</td>
</tr>
<tr>
<td>7_Conformity</td>
<td>0.753</td>
<td>0.84</td>
</tr>
<tr>
<td>14_Security</td>
<td>0.786</td>
<td>0.835</td>
</tr>
<tr>
<td>1_SelfDirection</td>
<td>0.774</td>
<td>0.826</td>
</tr>
<tr>
<td>13_Achievement</td>
<td>0.737</td>
<td>0.71</td>
</tr>
<tr>
<td>3_Universalism</td>
<td>0.737</td>
<td>0.845</td>
</tr>
<tr>
<td>18_Benevolence</td>
<td>0.738</td>
<td>0.75</td>
</tr>
<tr>
<td>16_Conformity</td>
<td>0.644</td>
<td>0.746</td>
</tr>
<tr>
<td>19_Universalism</td>
<td>0.719</td>
<td>0.689</td>
</tr>
<tr>
<td>12_Benevolence</td>
<td>0.475</td>
<td>0.512</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale Items</th>
<th>Communalities</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Compliance</td>
</tr>
<tr>
<td>2_Safety_compliance2</td>
<td>0.953</td>
<td>0.905</td>
</tr>
<tr>
<td>3_Safety_compliance3</td>
<td>0.869</td>
<td>0.85</td>
</tr>
<tr>
<td>1_Safety_compliance1</td>
<td>0.808</td>
<td>0.83</td>
</tr>
<tr>
<td>6_Safety_participation3</td>
<td>0.92</td>
<td>0.909</td>
</tr>
<tr>
<td>5_Safety_participation2</td>
<td>0.864</td>
<td>0.795</td>
</tr>
</tbody>
</table>

Notes: Extraction Method: Principal Component Analysis. Rotation Method: Varimax.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.729. Variance explained by 4 factors: 71.458%.
Bartlett's Test of Sphericity: Chi-Square = 241.362 (df =66), p < 0.001.
Factor loading below 0.5 have been suppressed.

Table 3: EFA Results of OSHB for UK survey

<table>
<thead>
<tr>
<th>Scale Items</th>
<th>Communalities</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Compliance</td>
</tr>
<tr>
<td>2_Safety_compliance2</td>
<td>0.953</td>
<td>0.905</td>
</tr>
<tr>
<td>3_Safety_compliance3</td>
<td>0.869</td>
<td>0.85</td>
</tr>
<tr>
<td>1_Safety_compliance1</td>
<td>0.808</td>
<td>0.83</td>
</tr>
<tr>
<td>6_Safety_participation3</td>
<td>0.92</td>
<td>0.909</td>
</tr>
<tr>
<td>5_Safety_participation2</td>
<td>0.864</td>
<td>0.795</td>
</tr>
</tbody>
</table>

Notes: Extraction Method: Principal Component Analysis. Rotation Method: Varimax.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.777. Variance explained by 2 factors: 88.270%.
Bartlett's Test of Sphericity: Chi-Square = 243.405(df =10), p < 0.001.
Factor loading below 0.5 have been suppressed.

In relation to OSHB, a two-dimension extraction solution (in line with the literature) was specified following an initial extraction of one dimension based on the criterion of Eigen values greater than 1.0. The two dimensions (compliance and participation) are shown in Table 3. The total variance explained by the two dimensions is 88.27%. KMO MSA (i.e. 0.777) confirms the suitability of the sample for factor analysis. The sub-scales for the two dimensions had a Cronbach’s alpha above the threshold of 0.7.
The analysis of the data from the Thailand sample revealed that 14 out of the 21 personal value items loaded unto five dimensions: social focus value with conservation being dominant (SFC); personal focus value with self-enhancement being dominant (PFSE); two personal focus values with openness to change being dominant for both (PFOC1 & PFOC2); and a social focus value with self-transcendence being dominant (SFST) (Table 4). The total variance explained by the five dimensions is 67.71%. The KMO MSA (i.e. 0.706) confirms the suitability of the data for factor analysis. The sub-scales for three of the dimensions had a Cronbach’s alpha below the threshold of 0.7 which can be attributed to the low number of scale items (i.e. two items and three items) (Tuuli, 2009).

Table 5: EFA Results of OSHB for Thailand survey

Similar to the UK data, for the OSHB, a two-dimension extraction solution (in line with the literature) was specified following an initial extraction of one dimension based on the criterion of Eigen values greater than 1.0. The two dimensions (compliance and participation) are shown by Table 5. The total variance explained by the two dimensions is 82.02%. KMO MSA (i.e. 0.701) confirms the suitability of the sample for factor analysis. The sub-scales for one dimension (i.e. participation) had a Cronbach’s alpha
below the threshold of 0.7. This could be due to the low number of scale items (i.e. two items) (Tuuli, 2009).

**Effect of workers’ personal values on OSHB**

The results of the OLS MLR for the UK and Thailand surveys are presented in Figure 3 with UK results shown in blue fonts while the Thailand results are shown in red.

![Figure 3: OLS MLR for Relationship between personal values and OSHB.](image)

The findings from the UK results demonstrate that there is a significant positive relationship between openness to change and OSH participation, and between self-transcendence and OSH compliance. From these results, individuals with greater openness to change values are more likely to engage in OSH participation while individuals with greater self-transcendence values are more likely to demonstrate OSH compliance.

The findings from the analysis of the Thailand data suggests that: individuals with greater conservation values are more likely to demonstrate participation and compliance; and individuals with greater self-transcendence values are more likely to demonstrate compliance.

For both UK and Thailand survey, self-transcendence showed significant positive relationship with compliance.

**DISCUSSION**

There was no prior formulation of hypotheses given the exploratory nature of the research. The results of the EFA were generally consistent with the extant literature, in particular the work of Schwartz (2009). Whilst the extracted dimensions of personal values did not exactly reflect Schwartz’s (2009) 10-values profile, the dimensions from both studies largely align with Schwartz’s (2009) four high-order values profile: self-enhancement; openness to change; conservation; and universalism. In terms of OSHB, the loading of the sub-scales concurs with the two dimensions of OSHB (Neal and Griffin, 2006), although a two-factor extraction solution had to be specified, resulting in mediocre Eigen values for compliance (in the Thailand survey) and participation (in the UK
These signal that the OSHB scales would need some adjustment either in terms of the number of items and/or the response options. Nevertheless, the pilot and exploratory nature of the inquiry means that such adjustments could be accommodated in a subsequent larger survey.

The dearth of research on the relationship between personal values and OSHB makes contextualisation of the research outcomes within the extant OSH literature a challenging task. However, some of the relationships that emerged from the OLS MLR analysis lend themselves to some rational explanation. The explanation offered here only focusses on the OSHB dimensions with an acceptable Eigen value (i.e. greater than 1 (Field, 2013)). These are shown by the bold and underlined fonts in Figure 3.

A worker complying with OSH rules might not only increase the likelihood keeping them safe, but also could result in a safe environment for others in the workplace. A worker with strong self-transcendence values will therefore have the tendency to engage in OSH compliance as that worker would seek the welfare of others and therefore see compliance of workplace OSH rules to be important to the safety of others in the workplace. This line of reasoning could clarify the observed relationship between self-transcendence and OSH compliance in the UK survey. Whilst it would have been more reasonable for conservation to be associated with compliance, it was rather associated with participation in the Thailand survey. Individuals with strong conservation values avoid violation of social norms and family or religious customs (Schwartz, 1992; 2009). Where these customs encourage goodness and kindness to others, individuals with strong conservation values (seeking to preserve custom) would tend to have an interest in the welfare of others. In Thailand, there is strong affirmation of conservation (including following religious customs - predominantly the practice of Buddhism) which encourages seeking the welfare of others (Redding et al., 2014). This may explain the observed positive relationship between conservation and OSH participation which entails undertaking voluntary safety activities.

The major implication arising from this research is the need for OSH managers and implementers of BBS programmes to take into account that, workers (like ordinary individuals) have a range of personal values that could influence different OSHB. It would thus be inappropriate to pigeonhole workers by insisting on a one-size fit all intervention/measure in the implementation of BBS programmes, particularly across different national cultures. Additionally, insight into the association between personal values and OSHB could be useful in flagging early, workers who might be inclined to just compliance. Whilst it may not be desirable for contractors to recruit workers on this basis, such insight could be put to better use by providing the appropriate induction, training programmes, and supervision to workers who by virtue of their personal values may be inclined towards just compliance.

CONCLUSIONS

Construction accounts for the greater proportion of work-related injuries, deaths and illnesses in several countries and unsafe worker behaviour/act is amongst the contributory factors to these occurrences. BBS programmes are intended to improve workers OSHB, and an understanding of whether workers’ personal values affect OSHB could be vital in implementing effective BBS programmes. Through two separate surveys in different
cultural contexts, this research has provided some evidence of the potency of personal values in predicting OSHB. For instance, self-transcendence was positively associated with OSH compliance in the UK inquiry, while conservation was positively associated with occupational safety and health (OSH) participation. On the other hand, the study revealed positive association between conservation values in Thailand and OSH participation. Whilst the research outcomes could have far-reaching implications for the implementation of BBS programme in construction and other industrial work environments, the limited sample size and coverage of the survey also warrants that a larger survey be undertaken to enable the establishment of firmer conclusions.

ACKNOWLEDGEMENT

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REFERENCES


THE CONTENT AND PEDAGOGY OF PROJECT SAFETY MANAGEMENT IN THE CONSTRUCTION MANAGEMENT CURRICULUM: DOES DESIGN MATTER?

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¹School of Built Environment, Curtin University, Australia
²KAEFER Integrated Services Pty Ltd. Australia

The Bachelor programme in Construction Management in Australia offers a standalone safety management unit in recognition of the importance of safety issues on construction site. A central issue that motivates our research inquiry into the content and pedagogy of a safety management unit in a construction management programme is the fact that the overwhelming majority of students are not on a career path of professional safety engineers but will be filling in the construction professional roles in different stakeholder’s organisations that have influence on construction safety. Thus, instead of focusing on the technical skills of identifying hazards or documentation of risks and incidents, the curriculum design was guided by a systems thinking framework, aimed to sensitise the future construction professionals on the safety implication of management and designers’ decisions and to raise awareness on how the production side and the supply chain of construction projects impact on and interact with on-site safety and the personal lives of construction workers through the creation of authentic learning experiences. This paper presents results of an action research on a Project Safety Management unit in the BAppSc Construction Management programme, drawing from data of a reflective curriculum development of the unit over two years, with industry involvement, triangulated with document analysis and interviews with students, industry partners and education administrators. Results of the study are compared with similar curricular in the USA and UK with a focus on the absence of the content of safety-in-design and its connection with the curriculum in the design disciplines.

Key Words: construction project safety management, systems thinking, curriculum, stakeholders, safety-in-design

INTRODUCTION

Safety management in university curriculums is predominantly structured by the typology of workplace hazards. A consequence of the hazard-structured curriculum is that the content is repeating that of on-site training provided to workers or safety advisors. The standard content of safety management course also includes the Australian site safety management systems of filling in risk assessment forms, e.g. Job Hazard Analysis and Safe Work Method Statements. These documents are designed and used on site to collect information on workplace hazard, which, joined by incident reports by safety managers, are supposed to feed back into the project management system for organisational learning. However, the information from hazard identification, risk assessment and incident reports

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form the forms filled by workers, supervisors or safety advisors is limited to the immediate circumstances of the workplace. The issue that with a safety management unit in a construction management undergraduate programme is that the overwhelming majority of students are not on a career path of these roles but will be filling in the construction professional roles in various stakeholder’s organisations. Their future jobs will not be filling these forms or reporting incidents, but will have influence at higher levels of the system that impact on construction safety. In this paper we discuss a Project Safety Management study unit designed on the base of system thinking in a Bachelor of Applied Science (Construction Management) programme in Australia.

SYSTEM THINKING FOR SAFETY MANAGEMENT

“It is systems thinking: going up and out, trying to understand how influences from many things relate to and impact on many other things; how the system in question is configured in networks of other systems – social, political and postcolonial, humanitarian, ecological”. (Dekker 2011: 133)

Systems thinking takes our attention from individual mistakes to the underlying structure, from discrete components to their interconnections, and from static snapshots to the changing process (Senge 2006). Through this perspective, the systemic models on construction accident causality are developed more as a guide to identify inadequacies in site management, organisation, market and societal systems rather than prescribing deterministic cause-and-effect paths. Project organization works together with the society level systems such as legislation to define the acceptable safety margins (Haslam et al. 2005, Dekker 2011, Rowlinson and Jia 2015), through which many rational and nominal constraints and motives outside of the safety domain come into play to shape individual behaviours (Jia et al. 2017).

Under the current forms of construction project organizations, except for the roles of safety manager/officer/advisor, few of the stakeholders are primarily accountable for safety in their formal job commitment. Therefore, constant prioritization or reconciliation of production and safety goals constitutes their daily decision-making activities. From a process perspective, Goh et al (2012) operationalize Reason’s (1997) organizational accident concept to identify the safety impact of production pressure. Dekker (2011: 154) further describes two important processes of how a complex system is influenced by external factors: (1) External factors impact on a complex system through shaping the collective decision-making preferences of local players, without the need of central coordination. (2) External environment (or, upper-level systems) influence the system through resource restriction, goal confliction and internalization of social norms.

THE SYSTEMS OF CONSTRUCTION SAFETY

So what is the ‘system’ in regard to safety management in construction? The Loughborough model framed construction accident causal factors into immediate circumstances, shaping factors and originating influences (Haslam et al. 2003, Haslam et al. 2005, Gibb et al. 2006). Its underlined assumption is that an accident is caused by many factors in the whole systemic context, rather than a single error in the immediate circumstance. Its applications in Australia and USA (Cooke and Lingard 2011, Behm and Schneller 2013) further
validated its cross-national context. Rowlinson and Jia (2015) build on this model to identify institutional factors of construction accident causality at eight levels of systems (eco-system, society, industry, organisation, project, team, job unit and individual) for identifying what can be done in relation to safety by stakeholders at the upper stream of the supply chain.

Continuous efforts have been made to integrate OHS concerns as an integral part of project goal (HSMO 1994, Hare et al. 2006, Hare and Cameron 2012, HSE 2015). Following an initiation by the ILO Code of Practice (ILO 1985), there is a shift of attention in safety research from site management to designers (Hinze and Wiegand 1992, Gambatese and Hinze 1999, Behm 2005, Lingard et al. 2014a). The solutions included to provide designers with detailed knowledge on site safety impacts of their work and to engage constructors at design stage (Lingard et al. 2014b) and investigation of OHS experiences in the design decision making process (Lingard et al. 2012). Recently there has been an increasing volume of literature tracing the responsibility of actors over the supply chain on workers’ safety on site (Saunders et al. 2015). The UK government issued Construction Design and Management (CDM) regulation to require the integration of health and safety concern into the whole construction project lifecycle, particularly at the design stage. The Model Client Framework in Australia (Office of the Federal Safety Commissioner 2008) was developed as a guide for government agencies to make influence on a construction project when they act as client. The model client is suggested to treat safety as an integral part of project management, which is to be achieved through collaboration of all stakeholders of a project. The client is suggested to influence the suppliers and designers by making them aware of the safety implications of their services and goods, and through effective monitoring and measuring the safety outcomes across the project lifecycle. More importantly, the model client framework suggests senior management demonstrate their commitment to safety by “allocation of safety responsibilities throughout the project organization from senior management down to the various teams members” (Lingard et al. 2009: 134). Lingard et al (2010) studied safety climate at multiple levels and found that principal and subcontractors’ organisational safety responses did not have a direct influence on injury rate, rather, the influences were mediated by the safety responses at supervisory level. Zhang et al (2016) measure workers’ perceptions of stakeholders’ safety commitment at multiple levels in the supply chain of a construction project. Love and Teo (Love and Teo 2017) found 47% of injury incidents could be attributed to rework, evidencing a significant link between safety and project quality as a whole (see also Love et al. 2015). The aim of the unit design was to guide students to understand safety in its construction project delivery system context and be aware of the responsibilities of different stakeholders on site safety performance.

RESULT

With this objective in mind, a Project Safety Management study unit under the Bachelor of Applied Science (Construction Management) programme was developed with an objective of changing the areas of for different stakeholders of construction projects to take for the improvement of construction safety. The Bachelor programme accredited by Australian Institute of Building (AIB) and Royal Institute of Chartered Surveyors (RICS) offers a standalone safety management unit in recognition of the importance of safety issues on construction site. The content of the unit is therefore designed for students to understand
the responsibilities of different stakeholders in the construction industry, including ten modules:

Table 1. Contents of the Project Safety Management study unit

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic/Content</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stakeholders in construction project safety management</td>
<td>The roles of government, client, project manager, design consultant, principal contractor, subcontractor, worker, union; the power structure in a project organisation</td>
</tr>
<tr>
<td>2</td>
<td>Systems thinking in safety and health management</td>
<td>The concept of safety risk management; necessary elements of HS management system; hierarchy of control; systems thinking; Swiss Cheese Model; HAFCS; Loughborough ConAC Model; organisational learning and resilience</td>
</tr>
<tr>
<td>3</td>
<td>HSES Management practice (by industry guest speaker)</td>
<td>Everyday safety and health management practice of a subcontractor’s organisation on a megaproject site</td>
</tr>
<tr>
<td>4</td>
<td>Case study: a heat stress management system</td>
<td>Factors and consequences of heat stress on construction site</td>
</tr>
<tr>
<td>5</td>
<td>Online quiz</td>
<td>Facilitating student groups to develop their organisational structure, develop personal leadership</td>
</tr>
<tr>
<td>6</td>
<td>HASES Management (by industry guest speaker)</td>
<td>Building trust with client, influencing management, dealing with unions</td>
</tr>
<tr>
<td>7</td>
<td>Reading week</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Safety in design</td>
<td>Who are the designers; Designers’ duties in safety; relevant legislations; institutional constraints of achieving it; BIM</td>
</tr>
<tr>
<td>9</td>
<td>Work-life balance: managing fatigue and burnout</td>
<td>How individual physical and psychological wellbeing is influenced by human resource management practice and its consequence on site safety</td>
</tr>
<tr>
<td>10</td>
<td>Safety in project delivery systems (industry guest speaker)</td>
<td>The risk transference culture in construction project subcontracting system; disputes and conflict resolutions; how these translated down to cause fatalities</td>
</tr>
<tr>
<td>11</td>
<td>Student Debate</td>
<td>Debates are video recorded for marking and analysis for feedback</td>
</tr>
<tr>
<td>12</td>
<td>Prizes / Feedback</td>
<td>Awarding a Best Debate Prize and a Best Organization Prize to two student groups; giving feedback to student debates; reflection on learning</td>
</tr>
</tbody>
</table>

A class of 120 undergraduates were grouped into six ‘organisations’. They were given options to select among six stakeholder’s roles including government, client, design consultant, contractor, project manager and worker. Interestingly, none of the student groups was willing to assume the role of design consultant. Two groups wanted to assume the role of contractor. They were thus designated into the roles of a principal contractor (a large organisation) and a sub-contractor (small business). Each ‘organisation’ was required to elect a leader, who was responsible to set up an organisational structure, assigning roles and responsibilities to the team members. The essential task for each ‘organisation’ was to deliver a debate between two contrasting approaches to improving safety management system based on the specific stakeholder’s role. Most student organisations developed a structure of three speakers on each side, each speaker supported by three researchers, coordinated by a chairperson. They were encouraged to discuss and debate within the group and with the lecturer and industry-based guest lecturers.

The task of developing an organisational structure to deliver a debate was assigned in the first lecture and organised in a studio-based setting. Students were thus challenged with a
‘wicked problem’, to which they need to try to define it before proceeding to solve it (Coyne 2005). The ‘wicked problem’ was both personal and topical: first of all, students in an incredibly large group of 20 started from scratch: to elect a group leader, divide into affirmative and negative teams, set up an organisational hierarchy and assign roles. This was set up to develop students’ personal leadership and management skills through experience. The process of developing an effective organisational structure was parallel to the process of defining the topical problem in safety. Students need to first identify the core interest of the stakeholder their group represented in a construction project – not surprisingly, none of the stakeholders’ primary interest in a construction project was safety. The groups then progressed to define two contradictory views, one on a safety-centred approach, the other sought to understand safety in a systemic context. The groups then further developed the two broad topics into two or three statements to articulate a debate. As typically in a studio-based learning environment, the lectures were given as background knowledge, while students were expected to be able to understand and apply the lecture contents as needed in their own problem framing and solving in constructing a resilient organisation while developing the debate. Here the central message, organisational learning and resilience as the ultimate systemic solution to safety is not only in the topics of debate, but also in students’ personal experience of running their own ‘organisations’ to deliver the assignment.

The following debate topics are delivered by the student organisations (see Table 2).

**Table 2. Topics of student debates**

<table>
<thead>
<tr>
<th>Represented stakeholder</th>
<th>Debate topic</th>
<th>Brief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Legislation or education?</td>
<td>Whether regulators should provide more prescriptive legislation to ensure compliance or more performance-based legislation facilitated by education</td>
</tr>
<tr>
<td>Client</td>
<td>Pay for safety or pay for safety programmes?</td>
<td>Whether client should pay for more safety programmes and campaigns when such programmes are not necessarily improving workers’ safety</td>
</tr>
<tr>
<td>Principal contractor</td>
<td>Safety culture or organisational culture?</td>
<td>Whether principle contractor should focus on building safety culture or a learning organisational culture as a whole</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Safety leadership or project leadership?</td>
<td>Whether project manager should focus on visible safety leadership or a project leadership that commit project resource to safety</td>
</tr>
<tr>
<td>Sub-contractor</td>
<td>Safety training or team practice?</td>
<td>Whether sub-contractor should commit more resource for safety training or aim for improving practice as a whole</td>
</tr>
<tr>
<td>Workers</td>
<td>Safety behaviour or the right knowledge of work?</td>
<td>Whether safety is about workers’ safety behaviour or holistically the right knowledge of work</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The curriculum development integrated content and pedagogy to develop systems thinking about safety among the construction management students. The assignment of delivering a debate requested students to determine their own point of view and argue it against an opposite view; the process stretched students to think through what they believed and respond to challenges. Meanwhile the group work process stressed the students to develop
a resilient organisational structure, to understand the importance of roles and responsibilities of delivering through an effective organisation and responding to internal conflicts, dysfunctional team members or external pressures. The integration of personal experiences of organising and topical debates of ideas ensured construction management students authentic learning in the systems thinking on construction safety management.

A major shortage for the student debate outcome in this unit was a lack of interest in the safety-in-design issues among the construction management students. This reflects the disciplinary segregation of the built environment curricula and the fragmentation in the construction industry. There is currently no inter-disciplinary exposure between design and construction management disciplines. In the light of systems thinking, the knowledge segregation resulted in the lack of awareness of the interrelatedness among project stakeholders’ respective scopes of work in construction practice. When a construction work package was under time pressure of delivery, the design of the temporary work are often skipped, which significantly reduced the opportunity of examining the work against the safety regulations before constructing it, thus leading to rework or accidents. Ghosh et al (2017) compared educators’ knowledge of prevention through design (PtD) in architecture, engineering and construction management disciplines in the USA, and found that most of the design programs had little content in occupational safety and health, while construction management educators are lack of knowledge of the latest safety practice. While in the UK the civil engineering discipline has a relatively long history of incorporating construction safety in the undergraduate curriculum (Al-Mufti 1999) as corresponding to the CDM regulation in practice. While the build environment discipline curricula have a similar situation to that of the USA, this unit was developed to educate the future construction management professionals with a greater safety awareness by involving practitioners in the teaching and motivating students on critical reflection on the current practice.

CONCLUSIONS

This paper discusses the content and pedagogy of a safety management unit in a construction management programme to address the issue that an overwhelming majority of students are not on a career path of professional safety engineers but will be filling in the construction professional roles in different stakeholder’s organisations that have influence on construction safety. Instead of focusing on the technical skills of identifying hazards or documentation of risks and incidents, the curriculum design was guided by a systems thinking framework, aimed to sensitise the future construction professionals on the safety implication of management and designers’ decisions and to raise awareness on how the production side and the supply chain of construction projects impact on and interact with on-site safety and the personal lives of construction workers through the creation of authentic learning experiences. A lack of interest in design issues was observed among the students. The study suggests inter-disciplinary education between design and construction management in university curriculum and holistic improvement of project management system for effective improvement in construction safety.

REFERENCES


Developing Collaborative Capacities in Industrialized Building: Roadmap for Knowledge Transfer

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Industrialized building (IB) has been linked to a number of benefits such as improved worker safety, shortened construction times and less material waste. In Australia’s housing construction industry, however, uptake of industrialised building has been low and a number of key barriers have been identified. Industrialised building requires a fundamental transformative effort in the housing sector. Local experience and international research suggest that barriers can be addressed by large-scale collaboration, but collaboration has not been systematically explored in the industrialised building domain. Our aim in this study is to examine collaborative practice in five innovative supply chains to enrich theoretical conceptualizations of collaboration through a processual framework that uses the stages of actor-network theory as a scaffold (ANT). Each of our five industrialised building case studies had motivations in varying degrees related to safety, health, well-being, and social and environmental sustainability. Qualitative data was gathered from 29 semi-structured interviews. Based on our analysis, we proposed a framework that examines how collaboration develops and evolves across supply chains. We then took this analysis further into a stage of interpretation. We presented a systematic, narrative-centred process of knowledge translation that transforms research findings into actionable knowledge, thus proposing a method for addressing the persistent evidence-to-practice gap in construction. This knowledge translation process allowed us to identify specific competencies that are critical to building collaborative capacity, thus contributing to practice by developing a roadmap towards a comprehensive behavioural framework for collaboration in industrialized building.

Keywords: actor-network theory, collaboration, competency building, industrialized building, knowledge transfer

Introduction

Australia has historically has exhibited robust housing indicators (Kitson, Thompson & Chaplin 2015), but recent reports have shown a number of alarming trends. Australian house prices, for example, are now the second least affordable in the world (Demographia 2016) and construction times have increased by 40% in less than two decades (Gharai, Wakefield & Blismas 2010). Such issues have been linked to the housing sector being highly fragmented and craft-based (Loosemore, Dainty & Lingard 2003). In recent times the promise of an industrialised manufacturing production approach to housing construction known as “industrialized building” (IB) has been suggested to address this myriad of challenges, as international research has linked IB methodologies to benefits in
efficiency, cost, innovation, and environmental and social responsiveness (Blismas & Wakefield 2009, Pan & Goodier 2012). Still, the number of IB champions in Australia has been limited, and uptake remains low. Local case studies have pointed to numerous hurdles to IB, including inconsistencies in regulations across the country and resistance from unionized labour (Blismas & Wakefield 2009). However, these case studies, while insightful, tend to overlook an important consideration: that many of these barriers are underpinned by the fundamental problem of fragmentation. Housing supply through industrialised building is a complex “problematique”, an issue that can only be addressed through the creation of intricate interdependencies among diverse stakeholders. In such complex situations, collaboration has been identified as the only viable response (Gray 1985).

In this paper, we contribute to research that seeks to enrich theoretical understandings of collaboration in industrialized building by presenting the results of our analysis of exemplar case studies where there was adoption of industrialised building. Specifically, our aim is to enrich existing conceptualizations of collaboration by proposing a processual framework to analyse how collaboration emerges and stabilizes in industrialized building networks, building on nine elements of collaboration and using concepts from an analytical approach known as actor-network theory. One important impact of this conceptualization as far as practitioners are concerned is that each element can be explored more deeply through the development of narratives. We argue that narratives provide a robust, richly-textured foundation that can be translated into knowledge forms readily applicable for practice. We explicate the steps of this knowledge translation process and in doing so we propose one approach for bridging the persistent gap between evidence and practice (Chapman 2013). This knowledge translation process allows us in this case to identify skills that are required to develop collaborative capacity in industrialized building.

COLLABORATION IN INDUSTRIALIZED BUILDING

There are numerous challenges to conducting theoretical research in collaboration in industrialized building and, more broadly, in construction settings. Two are mentioned here. First, there is currently very limited systematic work that seeks to develop a theoretical definition of collaboration in these areas. A number of studies have identified collaboration as a facilitator of IB processes (Tezel & Nielsen 2013), as a condition that could aid behavioural change within a sector seen to be problem-ridden (Sunding & Ekholm 2015), and as a driver of industrial renewal (Håkansson & Ingemansson 2013). These studies acknowledged the importance of collaboration as a driver for change. Nevertheless, there is limited work that seeks to address the more fundamental question of what collaboration actually means in IB settings. A literature review on collaboration in the broader field of construction supply chain management shows there is an emerging body of work that has begun to address this (see for example Walker & Walker 2015), but overall theoretical development has remained limited. A second challenge to conducting theoretical work on collaboration is the lack of clear processes for translating research findings into a form of knowledge that is useful in real-world settings, for example policy-making or actual business practice. At present there is limited research that explores how to translate research to practice in construction (Chapman 2013).
These gaps persist in construction research in part because construction settings have unique characteristics that make it challenging to examine collaboration phenomena in a nuanced way. Construction contexts are deeply conflict-ridden, permeated by human as well as non-human actors, and comprised of supply chains, some temporary, others more persistent (Pablo & London 2016a). These could very well lead to forms of collaboration that differ in subtle ways from those that emerge in more homogenous settings. We argue here that while these unique features of construction can make collaboration be difficult to capture, there are certain research approaches with methodological toolkits that lend themselves to discerning these features in fine-grained ways. One such approach is actor-network theory.

**ACTOR-NETWORK THEORY**

Actor-network theory (ANT) is an analytical approach built on the premise that much of what we see in the world is the outcome of human and non-human actors interacting in heterogeneous networks (Callon 1999, Law 1992). Networks are created mainly (not entirely) by a key actor called a prime mover, who lays the groundwork for a network by defining a problem and formulating a solution (*problematization*). The prime mover then seeks humans and non-humans that can address the problem and implement the solution. An important task here is defining roles for possible actors then implementing strategies to convince potential actors to take on these roles, which may at times be narrowed and simplified to facilitate actors fitting together in a coherent manner (*interdefinition of actors*). The prime mover may succeed (*enrolment*) if actors are convinced to break away from other competing roles and identities (“interessement”), but it is also possible that they resist (Callon 1999). When actors are enrolled, the network can become increasingly converged to the point that what was once a multi-actor entity begins to look like a single actor (*convergence*). A network that runs according to the same programs and goals over time is described as stable, and through the use of devices (*immutable mobiles*) can expand their programs across time and space. This state of stability may persist but can be interrogated at any time (Law 1992). This process of enrolment, convergence, stabilization and expansion is called translation (Callon 1999).

We argue here that ANT is a robust analytical device with a methodological toolkit that can capture dimensions of collaboration in construction that could otherwise be overlooked by other approaches. ANT’s assumption that actors can be human and non-human carves out space for exploring the role of objects like equipment, buildings, and building products in construction collaboration. ANT’s premise of networks as units of analysis supports the examination of supply chains, in contrast to more limiting approaches that examine collaboration as a phenomenon between autonomous firms. Finally, its notion of networks developing through stages allows researchers to consider that collaboration is a processual phenomenon that evolves as a network of actors evolves (Pablo & London 2016a).

**METHODOLOGY**

To address the aim of this paper, we used qualitative case study techniques to examine five networks of actors that had successfully completed innovative industrialized housing construction projects supported by large-scale collaboration. These five case networks were selected for the purpose of achieving maximum variation (Flyvbjerg 2006). For
example, our mix of cases showed the focal organizations of each network as being at
different life stages (two start-ups, two in growth stage, one mature), producing different
housing types (detached, low-rise, and medium rise), and mobilizing IB at different levels
(manufacturing components, systems, and modular housing). Data was gathered through
semi-structured interviews. Questions were framed around four main topics: drivers and
barriers to industrialized building, and drivers and barriers to collaboration. The 29
interviews lasted an average of one hour each, were fully transcribed, and were then
analysed thematically. The first round of analysis yielded 100 initial codes, with 60 of
these codes being linked to collaboration. These 60 collaboration-related codes were
clustered into key categories, which we then initially identified as nine key elements of
collaboration:

<table>
<thead>
<tr>
<th>Element</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>“Convener” or IB champion provides vision, drives chain through key organizational citizenship behaviours, and ensures roles and tasks of actors fit together</td>
</tr>
<tr>
<td>Goals and norms</td>
<td>Commitment to a clear set of commercial as well as non-commercial goals (worker safety, environmental sustainability, etc.) and values is widespread</td>
</tr>
<tr>
<td>Expertise</td>
<td>Expectations on the knowledge, skills and attitudes of the team as a whole are explicated and upheld, and the right combination is achieved</td>
</tr>
<tr>
<td>Change</td>
<td>Actors are open to change, and are willing to shed traditional mindsets to take on new roles and skills associated with IB</td>
</tr>
<tr>
<td>Problem solving</td>
<td>Parties interact directly to solve problems in ways that generate mutually acceptable solutions</td>
</tr>
<tr>
<td>Investment in relationship</td>
<td>Relationships are prioritized and maintained over the long term</td>
</tr>
<tr>
<td>Shared physical/virtual space</td>
<td>Co-location and frequent face-to-face meetings are prioritized, and at times supported by IT</td>
</tr>
<tr>
<td>Organizing mechanisms</td>
<td>Decisions on team size, member roles, boundary spanners are formalized, or at least made explicit</td>
</tr>
<tr>
<td>Technical standards</td>
<td>Procedures related to project tasks and output specifications are documented and parties commit to adhering to these procedures</td>
</tr>
</tbody>
</table>

Table 1: List of elements of collaboration and their definitions

We now develop, in two stages, a deeper analysis and an interpretation, the latter
specifically aimed towards material relevant for practitioners. In the Findings section, we
present our enriched analysis, demonstrating how we can move from a static list of
elements to a processual framework, that is, one that proposes logical relationships
between elements based primarily on sequentiality. This addresses the paper’s aim of
enriching theoretical conceptualizations of collaboration, which among other things tend
to be predominantly static (Gray 1985). In the Discussion section, we move to the process
of interpretation. We use narratives to develop the definition of each key element more
richly. The narratives then provide a platform for identifying critical skills foundational to

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1 In earlier work (Pablo & London 2016b), we originally identified eight elements and proposed definitions; with further analysis we have refined the terms and added a ninth one.
building collaborative capacity in the housing construction sector, an important impact for industry.

**FINDINGS**

We now propose a framework for defining meaningful inter-relationships between the nine elements. In this case, we suggest these elements are linked processually, in that each element can be primarily (not exclusively) situated in a particular stage of network development as defined by ANT (Figure 1, next page). There are four important points to note about Figure 1. First, it suggests that the nine collaborative elements we have identified (Table 1) are linked to the four stages of actor-network theory (problematization, convergence, stabilization, expansion). Specifically, four elements are conditions that lead to collaboration in the problematization stage, three are linked to the convergence stage and two are linked to the stabilization stage. Expansion is shown in the diagram but we clarify that it is a new cycle of problematization, convergence, and stabilization related to a new network. We discuss these stages and conditions in detail shortly. A second point about Figure 1 is that it suggests the focus of collaborative activity shifts, starting from a focus on individual actors, then moving to relationships between actors, and finally to mechanisms of work that render collaborative activity durable. This suggests that collaboration is dynamic (Gray 1985); that is, the nature of collaboration changes depending on a network’s stage. Third, the two arrows in the centre of the figure suggest that progression through the stages ideally proceeds in a clockwise manner. However, networks in later stages can at times fall back into early stages (for example when a stable network is disrupted and has to be recreated anew). This suggests that collaboration can also evolve in a non-linear manner. Fourth, the conditions for collaboration laid at early stages must persist in later stages for collaboration to be enduring. Elements 1-4 emerge in the first stage, but they must persist all the way to the last stage for collaboration to be robust. In this sense, collaborative conditions are multi-layered. An exception may be in cases where a new network spins off through expansion and becomes independent of dynamics in the original network. This remains an empirical matter to be explored.
Collaboration in the problematization stage. Figure 1 shows that collaboration in industrialized building begins at the problematization stage, and rests on the fulfilment of four conditions. First, it collaboration begins with one or more leader(s) with enough credibility to challenge the status quo in the housing construction industry. A recurring theme across our case studies was the presence of one or two individuals who made a strong case for shifting, either radically or incrementally, from traditional to industrialized building. In our findings, the leader(s) “problematic” or framed IB goals in ways that transcended commercial motives. We have seen how champions, or prime movers in ANT, have successfully laid the groundwork for collaboration in IB by pointing out how IB addressed commercial goals as well as non-commercial goals like worker safety, design complexity, and environmental sustainability. Leaders were thus highly skilled at formulating a compelling vision or goal for industrialized building (Element 2).

Leaders also strategized on the different roles and functions needed to fulfil this vision, articulating the collective pool of skills and expertise (Element 3) needed to achieve the vision. This is a process consistent with ANT’s interdefinition of actors (Callon 1999). One leader recounted,

> So we went out to the largest frame and truss manufacturers who had the best detailers in their…pool of employees. We went to a flooring company who [sic] had the ability and cashed up to be able to do all the independent testings that we wanted to be done. And we had the best engineers on board.

This process of enrolment was not always straightforward and unproblematic, as some target actors refused to detach from the mindsets of traditional construction. Key actors like carpenters exhibited significant levels of resistance when confronted with the need to take on manufacturing-based skill sets. One conclusion then is that collaboration in a new network also requires an attitude of openness to change generally, and to radical initiatives like IB specifically (Element 4). An architect noted that key actors had to be “completely on board with prefab, otherwise we couldn’t have done it.” This openness to change facilitates the translation activity interessement, as it makes it easier to cut away actors from the entrenched mindsets, tasks and roles of traditional, craft-based construction. Those actors who were not open to change were not enrolled in the network.

Collaboration in the convergence stage. We have noted that once actors have been enrolled into a network, the shape of collaboration tended to shift, moving from focusing on a loose amalgamation of actors to the interactions giving rise to a seemingly seamless entity that appears to function as one. ANT researchers refer to this state as punctualization (Law 1992). At this stage, relationships become focal. Our research suggests that for collaboration to be characterized by such significant levels of convergence, three additional conditions were needed. One is that actors had to clearly signify their commitment to invest in sustained, long-term partnerships (Element 5). Our findings suggest these could be achieved in several ways. For example, actors showed willingness to go “beyond” contractual agreements by making sacrifices when necessary to assist partners in difficulty. Others accepted the inefficiencies and costliness of relationship building by being present at multiple, time-consuming meetings even if they were “a waste of time”, just to build trust.
An important supporting mechanism for building these close relationships was shared space (Element 6). While this shared space presumably could have been achieved through virtual, computer-based connections, our findings repeatedly show that IB actors preferred traditional arrangements involving physical co-location. One team member we interviewed recalled that when they first used IB methodologies, they had an intense six-month period where actors met every week in a single room where critical decisions were made on the spot:

We wanted questions, answers right there and then... By us having everyone there at the table once we hit an issue we can ask that discipline, how do we get around it, what are my options, bang. Decision is made right there and then, you move on.

The quote also highlights that central to interactions in this shared environment was a process of participative problem-solving (Element 7). One team member claimed that a considerable amount of time in these meetings was spent brainstorming freely but systematically on anticipated problems. In the process, team members began to draw expert knowledge from one another, leading to people becoming increasingly “like-minded”. Engineers and non-engineers, for example, began to think alike.

Collaboration in the stabilization/expansion stages. Following convergence, a network reaches a point where it can begin to operate in a steady and predictable manner (stabilization), such that the prime mover can then seek to extend this ordering over time, and over space to more locations (expansion). These two processes are facilitated by inscribing network programs into texts, oral messages, technological artifacts like machines, or social artifacts like institutions. These devices are often referred to as immutable mobiles (Law 1992). In this case, collaborative interactions became persistent and durable because they were inscribed into two main kinds of immutable mobiles. One involved formalized technical process and output standards (Element 8). Plans, standards, software, contracts and even simple drawings exercised a powerful disciplinary force over disparate actors, in effect “forcing” players to act in a highly coordinated manner because a shared physical artefact with precise specifications had become central to interactions. Drawings compelled actors to collaborate, at times confining actors to deviations of not more than five millimetres. A second immutable mobile involved formalized organizational arrangements, for example clear team structures, rules on optimal team size, member roles, and clearly-identified boundary spanners who could straddle interfaces between specialized teams (Element 9). When these arrangements became documented, they in effect sustained and reified previously fleeting and adhoc patterns of collaboration.

DISCUSSION

A key question we ask at this point is how to translate the elements, their definitions, and the framework of collaboration into a form of actionable knowledge. Literature suggests the use of narratives as a robust mechanism for bridging this evidence-to-practice gap (Schreyogg & Koch 2006). Narratives have been described as a valuable source of expert knowledge, as devices for understanding of complex situations, and as tools for conveying detailed descriptions in compelling ways. They serve as a potent vehicle for transforming complex, perhaps even uncodified expert knowledge into explicit
knowledge forms that can be systematically disseminated. Narratives can “set up a basis for actionable knowing” (Schreyogg and Koch 2006, p. 1). Actionable knowledge can take many forms; Torrell (2006, p. 248), for example, has argued that “a storied report of past events is the frequent first step in training design.” We thus propose a six-step methodology centred on the development of narratives for every key element in the definition of collaboration (see Figure 2).

Narrative development involves a process of data interpretation as defined by Wolcott (1994). It is helpful to contrast interpretation to the earlier process of analysis. Steps 1-3, carried out in previous studies (Pablo & London 2016b), involved a methodical, deductive process of moving from data to codes to themes to nine key elements, a process that is disciplined in that it intentionally stays “tightly bound” to the original data (Wolcott 1994, p. 37).

Figure 2: Proposed knowledge translation process based on narratives

Step 4, discussed earlier in this paper, is an extension of this methodical process as well. The outcome of this type of analysis was a complex mosaic of codes and themes. While detailed, this system of codes, rooted in a methodological commitment to stay close to the data, has limitations in terms of interpretative flexibility (Czarniawska 1998, in Schreyogg & Koch 2006).

As we move to Step 5, however, we now proceed to a process of interpretation through narrative. Interpretation is a different approach to data transformation, as it seeks to present findings in ways that are “unbounded”, “inductive” and “generative” (Wolcott 1994, p. 23). The outcome is not a strict and confining system of codes, but a rich story, still linked to data, but with coherence, vividness and texture. Narratives are thus endowed with a level of malleability that lends itself to the process of translation into actionable forms of knowledge. Revisiting the data and bearing in mind the broad story line encapsulated in the process-based framework, we thus generated narratives for each of the nine elements on collaboration. Due to space constraints we limit ourselves to discussing one example (Element 8). Like any process of interpretation, there is considerable flexibility; other researchers could use our data as a starting point and develop narratives of their own. We present ours as one possibility. Our goal is to point out how the interpretative flexibility of such narratives allowed us to then parse it into specific skills (see Table 2). When this process is carried out for each of the nine elements, the outcome is a robust framework capturing not just skills but also knowledge and attitudes, all observable through concrete behaviours. The framework can serve as a systematic guide for building collaborative capacity in IB settings in different
ways. It can be further translated into checklists that can guide the recruitment and assessment of human resources in IB projects. In our current research, we are using the framework as a basis for developing detailed training scenarios for collaboration, and are exploring the possibility of transforming it into a multi-dimensional collaborative “index”.

Table 2: Sample translation from narrative to detailed behaviours and skills

<table>
<thead>
<tr>
<th>NARRATIVE: ELEMENT 8</th>
<th>SAMPLE SKILLS FOR PROJECT LEADER</th>
</tr>
</thead>
</table>
| Process and output standards can take diverse forms in IB settings, and can include contracts, work programs, plans, drawings, technical standards, ad formal documentation of processes and procedures. Standards in this case should reflect a number of characteristics: (a) precision, which in IB refers to standards being exact, unambiguous, and accurate, hence their interpretation by different team members is straightforward and unproblematic; (b) efficiently deployed, which in IB settings suggests that they can easily created, recreated, and made readily available in a timely manner for all team members; (c) collectively upheld, which means shared standards are followed by all while specialized ones across disciplines are significantly coherent; and (d) formalized into repeatable systems so that informal, tacit knowledge of value is captured and can be redeployed in other settings. | • Establishes a culture that supports developing and committing to clear and precise process and output standards, particularly those related to manufacture, material flow, transportation and installation  
• Leads the team in creating transparent process and output standards when there are none  
• Manages information systems in a reflective manner, balancing timeliness and detail with issues like information overload and too much transparency  
• Readily identifies points of convergence and divergence between sets of standards (for example can identify if seemingly “new” IB engineering standards are actually equivalent to existing ones)  
• Identifies best practices currently existing in tacit form, then selects the most effective way to capture in the form of explicit knowledge (written document, software, specialized tool)  
• Translates best practices and simplifies products into repeatable systems  
• Commits to agreed-upon team standards, including tight tolerances that characterize IB processes and outputs, particularly those related to manufacture, material flow, transportation and installation  
• Documents, formalizes, and disseminates standards at optimal levels of detail required by team (balancing tradeoffs between level of detail and simplicity that supports dissemination) |

CONCLUSIONS

Defining and implementing collaboration in IB settings has been problematic, yet it is necessary given that the housing construction sector is fundamentally fragmented. In this study, our aim was to enrich existing understandings of collaboration through a processual framework. Building on earlier work that argues collaboration comprises nine elements, we have deepened our analysis by proposing relationships of sequentiality between these elements, using the stages of actor-network theory as an organizing device. This enriched conceptualization highlights how collaboration evolves as a network of actor evolves. It carves out space for exploring how collaborative conditions, practices, and outcomes can be different at various stages of a network’s development. We have also proposed a narrative-based approach for translating theoretical concepts on collaboration into actionable forms of knowledge, and presented the beginnings of a behavioural framework for building collaborative capacity in the IB sector.

ACKNOWLEDGEMENTS
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AN EVALUATION OF COLLABORATIVE PRACTICES IN CONSTRUCTION CONTRACTING IN SOUTH AFRICA

Zanele Matsane¹ and Clinton Aigbavboa

The purpose of this paper is to advance ways of promoting collaborative cooperation between contractors and their supply chain (SC) in South Africa. The research approach is qualitative and the design is based on multiple case studies. It was found that collaboration in South African construction sites has taken a different form from the international construction community, that of a rudimentary existence. The nature of collaboration in South African construction is one of mutual dependency as well as antagonistic relations within teams on site. Industry professionals apply collaboration by means of incentive programmes and standard contracts. This paper reinforces the idea that SCM collaborative practice can be identified within the existing structures of site practices, thus showing that collaborative practices are an integrative management approach. There is a need to develop and implement alternative forms of contracts such as negotiated, and strategic alliancing contracts that are tailored to South African construction. Collaboration enablers such as regular communication, frequent meetings, incentives and reward programmes can improve the morale of the construction team. Opportunities thus exist for eliminating non-collaborative tailored practices between contractors and their supply chain in South Africa.

Keywords: collaborative practice, contracting, supply chain management, subcontracting, South Africa.

INTRODUCTION

The nature of supply chain management (SCM) is that of coordinated decisions and activities used to efficiently assimilate supplier, manufacturers, transporters, retailers and customers in order to ensure that the correct product or services is distributed in the correct quantities, to the appropriate location and at the right time with the objective of reducing system-wide costs in the process of satisfying end-user or customer level requirement (Singh et al., 2013). SCM is considered to be a process-orientated or cross-functional model which comprises of planning, sourcing, production and distribution that is not exclusively focused in one of these areas (Brandenburg et al., 2014). Thus, SCM focuses on understanding and subsequently improving the multiple systems and networks within a supply chain (Balwani et al., 2015). It is considered a broad spectrum that embodies a variety of characteristics, which require understanding of the entire spectrum to enable managers to implement the SCM concept in business. In the construction context, SCM encompasses a network of organizations that are involved in varying processes and activities, which produce the material, components and services that are integrated into procurement in order to deliver a building. According to Mamter et al. (2014), SCM in construction is engrossed in the coordination of isolated quantities of

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materials and associated with specialized engineering services and installation which are delivered to specific construction projects.

Construction supply chain (CSC) is a SC according to the make-to-order system. Chunyu (2013) links this element to the structure and function of CSC, which is characterised by irreconcilable facets such as it being concentrated, temporary and complex. Ahmed et al. (2002) create a mental visualisation of CSC by providing a practical application of SCM on a construction project: in a construction project, the SC can be conceived with the owner at the top, followed by the designer, contractor and specialist contractors/subcontractors/suppliers etc. The fragmentation of construction projects makes it difficult to adapt, not only for SCM, but also to develop lean supply (LS) even with the constant exhortation to learn from the manufacturing industry (Davis et al., 2010). Pryke (2012) adds that issues such as an increase in transaction volumes at lower average values and higher levels of opportunism, in the context of low barriers to entry, has resulted in the industry having various interfaces (SC contributors) which hinder the application of construction SCM (CSCM). Pryke (2012) thus summarises critical features of SCM for successful adaptation in construction. SCM in construction should focus on: (i) the impact of the SC on construction site activities and aiming to reduce the cost and duration of those activities. The primary concern, therefore, is to establish a reliable flow of material and labour on site (ii) the SC itself and aiming to reduce costs, especially those related to logistics, lead time and inventory (iii) on transferring activities from the site to earlier stages of the SC and, (iv) on the integrated management and improvement of the SC and site production, that is, site production that is subsumed by SCM (Pryke, 2012).

As brought out by Egbu et al. (2004 cited by Emuze, 2009) the implementation of CSC depends on the ability to create, manage and restructure relationships between individuals, firms and networks within the supply chain. Cognisant of the effort required in the application of SCM in construction, Pryke (2012) suggests the development of vertical integration in the design and production process and operations to link the process into a chain focusing on maximising opportunities to add value while minimising total cost. Moreover, this application requires a significant shift in the mind-set of the SC participants towards collaboration, team work and mutual benefits (ibid).

Additionally, Chunyu (2013) defines a stricter model CSC structure as one which provides the concept of SCM in construction from the angle of the participants of the building process. The CSC model promotes the need for collaboration among the participant of SC to establish a high-trust environment; constraint mechanism and information sharing mechanism and for participants to share common objectives. Benton and McHenry (2010) agree with this notion that collaboration is critical to the implementation of CSC techniques such as strategic alliances. Thus, SCM in the construction context is an innovative tool utilized in organizing and managing resources. According to Myerson (2012), it is a performance enhancement tool that is primarily a financial control initiative due to the fact that supply chains in construction are a major cost centre in a project.

This description of SCM suggests that it is not an emergent concept as the construction industry has relied on the knowledge of the manufacturing industry to implement it adequately (Chunyu, 2013). Azambuja and O’Brien (2009) state that construction has
transferred key concepts of SCM from manufacturing to construction projects in an effort to improve productivity and alleviate project costs. In the tradition of SCM, the ensuing key approaches have characterised construction supply chain (CSC) modelling (ibid) which comprise of structure, information flow, collaboration, product demand, production variability, buffering and capacity planning. In modern construction projects, these characteristics can either be reflected collectively or independently. This paper addresses collaboration as one of the key elements of CSC as it possesses special characteristics encompassed in the diversity of the end product as well as team formation (Bouchlagen & Shelbourn, 2012). Collaborative practice (CP), as a feature of SCM in construction along with concurrent engineering and lean production, is becoming a core part of management paradigms in order for the industry to remain in the global market and fulfil the growing demand for better performance from clients (Bouchlagen & Shelbourn, 2012). Despite its advocated benefit, there is little knowledge of the nature, viability and limitations of CP when adopted in a construction project (ibid), particularly in South African construction.

Collaboration in a supply chain relates to the capability of two or more independent firms working together, planning and implementing SC operations with common goals in mind (Scholten and Schilder, 2015). Lavikka et al. (2015) portrays collaborative practice as a process that requires planning and synchronisation which could potentially lead to the spontaneous development of relationships between the parties involved in the course of working together. Collaboration as a core principle has pluralistic advantages including the potential to encourage real-time information exchange required to prepare for, respond to and recover from supply chain disruptions while reducing their impacts (Scholten & Schilder, 2015).

The purpose of this paper is to identify ways of promoting collaborative working arrangements between contractors and their SC in South Africa. This is significant because the traditional procurement method that predominates in South Africa has contributed in no small way to the pervasiveness of antagonistic relationships and its consequent problems in construction (Emuze, 2012). This paper begins with an explanation of collaborative practices and how leading international construction communities has shaped its application thereof. It further sets the premise for evaluating South African construction contracting. This is steered on by three objectives, namely: to determine the nature of CP in construction; to determine how contractors could apply CP in a supply chain and to determine the key drivers of CP in a supply chain. This paper thus endeavours to put forth advantages of collaboration and the nature of CP as applied in construction, particularly in South Africa.

COLLABORATIVE PRACTICE IN CONSTRUCTION

Emuze and Smallwood (2014) describe collaborative practice in construction as the ability of firms or entities, project teams, and individuals to agree upon mutual goals, decision-making processes and troubleshooting systems while focusing on specific improvement to their normal performance objectives in a project undertaking. The key dimensions of collaborative practice include information sharing, incentive alignment and decision coordination (Eyaa et al., 2010). Collaborative practice has generated more attention to contracting firms as a result of a shift in responsibilities among contracting partners. Bemelmans et al. (2012: 343) explain the increased focus on collaborative practice by pointing out the fact that the coordinating role previously held by the client
has, in recent years, fallen upon the main contractor. This recent development has brought about benefits and challenges that require careful examination.

**Categories of collaborative practices**

According to Anumba et al. (2002, cited by Shelbourn et al., 2012), there are four different modes of collaboration which relate to types of interactions found among participants and the pattern of communication adopted in the project, namely:

1. Face-to-face collaboration – normally involves physical meetings in real time.

2. Asynchronous collaboration – conducted in a shared location but not necessarily in real time (e.g. electronic media such as notice board/memos).

3. Synchronous distributed collaboration – real time interactions among participants from various locations (e.g. video conferencing).

4. Asynchronous distributed collaboration – participant interaction from dispersed locations but not in real time (e.g. electronic mail systems).

It is common for SC contributors to assume one mode of collaboration as outlined above, construction projects as a whole are expected to consist of numerous subcontractors. According to Xue et al. (2010), collaboration has advantages that appeal to organisations, namely, increased probability of winning bids; faster, better or cheaper development or deliver of products or services or markets; in-depth learning; meeting an external requirement; and saving costs. Collaboration is said to have a substantial positive impact on project performance, not only with regard to time, cost, and quality objectives, but also for more general outcomes such as greater innovation and client satisfaction (Akintoye & Main, 2007).

Douma et al. (2000, cited by Akintoye & Main, 2007) are of the opinion that the need to collaborate is determined by a number of factors, namely, market opportunities; time pressures and the number of alternative options available and they thus list the following key drivers for strategic fit in collaboration: (i) collaboration is only advisable when participants have a shared vision of future developments and of the impact that these developments will have on their individual positions; (ii) that precondition for strategic fit is compatibility of strategies; (iii) alliance partners will only be prepared to make concessions when the alliance is of strategic importance to them; (iv) a successful union requires mutual dependency; (v) any alliance should have added value for the partners and/or their customers and; (vi) partners must carefully consider whether the market will accept the alliance.

Over and above having a shared vision, there are five more critical factors that contribute to effective collaboration, which include (Shelbourn et al., 2012):

1. Stakeholder engagement – collaboration leaders need to ensure that all key participants are consulted on the practices to be employed during the collaboration;

2. Trust – time and resources are needed to enable all participants to build trusting relationships;

3. Communication – a common means of communication should be established and agreed upon by all participants in the collaboration;
4. Process – the outworking of the collaboration in relation to both business and project, should be known by all key participants, and
5. Technologies – an agreement on those technologies to be used is required to ensure the collaboration is easily implemented and managed.

Collaboration therefore requires trust between partners, clearly defined processes and efficient communication infrastructures supported by appropriate technologies (Shelbourn et al., 2012). Trust between collaborators can never be overemphasised, reasons Ochieng et al. (2013) who believes that, without an appropriate level of trust, true collaboration would simply not take place regardless of the previously mentioned factors.

**Enablers and barriers to collaborative practice in construction**

Collaborative practices provide a unique cultural environment which is not limited by boundaries while other forms of relationships between entities are limited to synchronisation of decisions and processes (Kumar and Banerjee, 2014). Ideally, the relationships forged by collaborative practice are long-term partnerships, however, owing to the character of construction projects, one-time alliances are much more common (Lonngren et al., 2010). Love et al. (2004 cited by Lonngren et al., 2010) cautions organisations that enter into one-time partnerships to be cognisant of possible percussions and effects relating to: self-governance (understanding their own capabilities relative to demand); responsiveness (the ability to recognise the changes in demands that will have an adverse effect on its operation immediately), and flexibility (the ability to respond to changes in client needs and demands).

Further benefits of collaboration include added value to a project; increased revenues and profits; improved business efficiency; improved productivity of individuals as a result of being part of a team; improved customer/end user satisfaction, and enhanced collective image of the groups within the collaboration partnership (Shelbourn et al., 2012). Scholten and Schilder (2015) argue that while collaborative practice brings about benefits such as higher visibility, flexibility and reduced lead times, they are mindful of the fact that this practice might not always be possible or wanted by SC contributors. Shelbourn et al. (2012) summarise the following possible barriers to collaborative practice:

It is imperative to strike a balance between the enablers and barriers of collaboration and to further explore ways in which this can achieved. As brought out by Akintoye and Main (2007), for any collaboration to be successful, relationships between participants need to be exceptional and should consider teambuilding (coordination and integration of project organisations to increase productivity, efficiency, motivation, goal attainment, group dynamics and dispute minimisation) within contracting firms.

**RESEARCH METHODOLOGY**

The methodology adopted for this study is the inductive approach of conducting research. The rationale for selecting this design stems from the fact that an explorative undertaking of research topic favours a case study strategy, especially in the case of conducting preliminary studies as is the context of this study. Fellow and Liu (2015) attest to this accentuation by alluding to the fact that research in construction is relatively ‘nascent’ and intermediate in maturity and in matching to the field work context. An evaluative
study using the inductive approach is appropriate to nurture development of construction knowledge (ibid).

The research study was carried out in five provinces of South Africa, namely Free State, Gauteng, North West, Limpopo and Mpumalanga. Eight construction projects were investigated out of which three construction sites (case studies) were explored more extensively. The provinces were selected for the study because of the willingness of the respondents to participate in the study. The data collection instrument used for the study comprised of an interview protocol. The interviews, individual interview professionals and case study interviews consisted of 18 and 14 questions respectively. The data collection process produced two streams of respondent. Although a chief interview template was developed, a second interview template which was loosely based on the main template was used for the case study respondents. As brought by Hair (2015), respondents are chosen because they have specialised insight on the subject under investigation. Due to the varying involvement of the respondents, partly based on: job title and role; scope and capacity of the respondent’s activity on the project; duration on the project and affiliating with main collaborators (client and main contractor); the interview had to be structured cognisant of the aforesaid circumstances.

The analysis of the interviews followed an abbreviated guideline of analysing textual data developed by Taylor-Powell and Renner (2003). The analysis process followed a five-step plan to describe the basic elements of the narrative data analysis and interpretation. The analysis process followed five steps, namely: (i) Get to know your data by reading and re-reading the recorded texts (ii) Focus the analysis by questions or topic, time period or event (iii) Categorise information by identifying themes and patterns and organising them into coherent categories (iv) Identify patterns and connections within and between categories (v) interpretation by bringing it all together. The themes are colour coded to allow ease of allocating similar themes across every participant response.

RESEARCH FINDINGS AND DISCUSSION

The participants were unanimous in attributing the nature of their relationship as one of mutual dependency and adversarial when challenges arose. The majority of the participants perceive that the environment they worked in afforded them a measure of transparency and gave them the freedom to express themselves. Main contractor representatives complied with an open door policy that encouraged subcontractors to propose innovative solutions for problems they encountered on site. However, one project manager cautioned against being too transparent and preferred sharing information on a need-to-know basis. Some supply and install subcontractors were given a measure of independence. This however did not reassure them of trust on the main contractor’s part but was perceived as nonchalant attitude towards their presence on site. Numerous factors impacted the type of relationship between project participants, which centred on communication and frequency of project collaborations.

The most preferred mode of communication was face-to-face; asynchronous collaboration and synchronous distributed collaboration. The frequency of communication however, was determined by two factors, namely familiarity of the team leaders (foremen and subcontractor relationship) and duration of participant in the current project collaboration. A main contractor representative stated that subcontractors and suppliers whom they had
worked with before on other projects were trusted and therefore did not require constant communication or supervision as both sides were familiar with the required standards of quality and efficiency. This proved successful as some of the subcontractors were given added tasks to complete on behalf of the main contractor. Subcontractors who had occupied the construction site the longest seem to have developed an understanding of the work ethics and cultures that persisted on site. While participants who had joined the construction site on a later period struggled to establish a working system. This was true on both sides of the collaboration (main contractor representatives and subcontractors). For example, one main contractor representative had only been on the current project for a week (20 months into a 36-month project). He displayed an authoritative presence, which most of the subcontractors did not approve which led to a troubled relationship plagued by constant communication characterised by hostile and unforgiving nature. On one project, subcontractors perceived that they are side-lined by the main contractor and their representatives. The modes of communication did not seem to yield the desired outcomes thus making both sides less trusting and respectful to each other. A commonality raised among all participants was the fact that the main contractor’s decision to act in “good faith” was welcomed by all parties involved as it allowed integrity to develop among the construction team. Information sharing by the main contractor representatives encouraged a relaxed, conducive environment as participants were assured that work assigned was completed in the manner in which it was instructed.

The application of collaboration in an SC is guarded by standard forms of contract, which includes the JBCC series 2000 and NEC 3 family contract. Both these forms of contract include provisions for subcontracting work. The main contractor would organise their relationship with the subcontractor (domestic or nominated) as if they had not subcontracted. Thus main contractor representatives maintained managerial roles while the subcontractors were in charge of production.

The manner in which subcontractors/suppliers were appointed influenced how subcontractors were assigned to tasks and whether they could occupy and maintain leadership structures. Two of the construction projects investigated had additional clauses imposed upon the main contractor, with an addition of 3 individual professionals who operated sites under the same clause. This client-imposed clause required the main contractor to allocate 30% of the contract sum to the appointment of local SMMEs (subcontractors and suppliers). A much needed intervention to improve the community, this however meant that new-entrants were included in the collaboration tasking the main contractor with added responsibilities. To alleviate these responsibilities, designated roles and project-tailored responsibilities were assigned to members of the SC. Subcontractors who had a long-standing relationship with the main contractor were allocated added relationships of managing new subcontractors who had little or no experience in the trade.

The simple nature of material and equipment suppliers meant no formal agreement was required to govern the partnership. As such, main contractors appointed suppliers on a negotiated quotation system. This relationship was easy to maintain as suppliers engaged with a specific buying department from the main contractor.

The majority of subcontracted work included wet trades (labour only) and supply and installation subcontractors. For this reasons, main contractor representatives served on supervisory capacities enabling subcontractors to coordinate their employees free of
interruptions from the main contractor. Subcontractors who lacked adequate understanding of basic site practices were allocated to work on tasks that would later be finished by subcontractors with more experience. Therefore, one trade comprised of a number of subcontractors undertaking the same work. This reassured the main contractor of quality in work executed. This also allowed subcontractors to work as a team in a conducive environment.

Noteworthy is one contracts manager who opted to use a custom-made contract form which incorporated some of the conventional contracts but omitted some clauses he deemed unnecessary for the project undertaken. The contracts manager justified this approach by alluding to the unrealistic nature of standard forms of contracts which bound the main contractor in a partnership he was not satisfied with. Moreover, the participant preferred the use of other regulatory body guidelines as binding obligation between them and the subcontractor as this council was tasked with signing off on subcontracted work on behalf of the client.

Client representatives were also incorporated into the SC, especially on specialist trades to ensure accuracy in installing and operating of equipment. Subcontractors were then provided with first-hand instruction and advice from stakeholders who represented the client enabling a successful execution of work and trust among SC contributors.

The key drivers for collaborative practice in a SC concern beneficial outcomes for the project and the participants. Subcontractors ranked job security as a motivating factor to collaboration with main contractors. The prospect of performing on the current project ensured that subcontractors of a continued working relationships in other future projects. Risk allocation and sharing was the driving force behind main contractor representative participation in the partnership. As pointed out by one professional, subcontracted work ensures minimum waste, theft of materials and other resources as they are the sole responsibility of the subcontractor. The majority of main contractors specialised in one trade or another, thus housing employees for all trades would mean financial ruin to their businesses. Therefore, having subcontractors removed the burden of constantly paying people even when no work was allocated. Subcontractors indicated that association with a reputable contractor enhanced their qualifications and moved their business ranking in the CIDB database. Job satisfaction and successful project execution was also the key driver among SC contributors. The majority of participants stated that they love their job and they enjoy the satisfaction of being a part of and witnessing a large group of individuals come together and produce a structure/building the client and community at large could be proud of.

Social responsibility affected the attitudes of project participants. The mere thought of enriching a community trumped any problems experienced by main contractor representatives when dealing with local SMMEs as part of the client requirement. The main contractor’s willingness to subsidise financial and material resources on behalf of the subcontractors enabled the subcontractors to thrive and improve their performance on the project.

Contractor-led incentives programme and innovation platform developed an appreciative attitude in the subcontractors. One such project was the awarding of trophies to best performing subcontractors as a means to motivate them to continually improve their
skills. Delegated responsibilities to more than one subcontractor encouraged an environment devoid of any pressure to complete a task in unrealistic time-frames thus equipping subcontractors with confidence need to complete the job.

Innovative forms of communication contributed to a successful relationship. In one project, besides the use of radios, notice boards and site meetings, main contractors introduced the use of social media as a communication platform. The use of WhatsApp groups to communicate with various members of the construction team ensured information sharing and technical support units when issues arose.

The establishment of business forums afforded the local SMMEs with a platform to express and discuss issues they encounter on site. These forums provided the subcontractor the opportunity to engage with the main contractor thus building confidence in participants that the project could yield better business outcomes.

**CONCLUSIONS**

This paper started by identifying three objectives that were explored in the reported study. The objectives include to determine the nature of CP in construction, to determine how contractors could apply CP in a supply chain and to determine the key drivers of CP in a supply chain. The findings from the triangulated data sources showed that collaboration between partners was of a mutual nature. Partners of the collaboration shared the same responsibility with labour only subcontractors, but enjoyed exclusivity in responsibilities with supply and install subcontractors who were assigned different tasks but occasionally interacted with each other in order to coordinate tasks. Face-to-face and asynchronous collaboration characterised the nature of main contractor and subcontractor relationship. Collaboration could exist at least under three collaboration arrangements as the majority of collaboration studied were mainly classified as separate organisations that maintain their independence; large national organisation working with a small local group and a group structure where a parent organisation governs a group of subsidiary organisations.

All members of the SC were under legal obligations as standard forms of contracts (JBCC and NEC3) were signed prior to commencement of work. In the three classification of collaboration, the main contractor maintained a managerial role while the subcontractor undertook the role of supervisor of works. Moreover, primary findings suggested job security, successful work execution and client satisfaction as the key driver for members of the construction team. The sharing of risks and having specialists complete various facets of the project encouraged main contractors to continue pursuing a collaborative relationship with their subcontractors. Incentive programmes, training and induction programmes enabled smooth running of processes, trust and open communication.

Given the fragmentation of this project based industry, SCM principles such as CP provide practical lee ways to address some of the challenges faced by the industry as it strives to improve productivity and competitiveness of the industry. This requires the early participation of every member of the SC network, which includes subcontractors and supplier on the project. It is necessary to redefine the roles of the multi-disciplinary project team and allocate responsibilities according to each member’s impact in the supply chain model adopted in the project. While the principle of collaboration is a
predominate feature of SCM, other features need to be studied alongside this principle to ensure successful application of SCM in South African construction. Future studies should therefore seek to establish core principles of SCM within construction projects and ultimately move to developing a model for implementing various aspects of SCM seamlessly in South African construction.

REFERENCES


DEVELOPING WORKER ENGAGEMENT MATURITY MODEL FOR IMPROVING OCCUPATIONAL SAFETY AND HEALTH (OSH) IN CONSTRUCTION

Kenneth Lawani¹ Billy Hare and Iain Cameron

Research on Worker Engagement (WE) has identified the increased importance of meaningful discussion, communication, knowledge sharing, and shared decision-making regarding Occupational Safety and Health (OSH) practices within the construction industry. This paper reports on initial findings on the development of a meaningful discussion framework for improving OSH and engagement of the construction workforce. The main purpose of the framework is to rank levels of discussions amongst construction operatives and supervisors relevant to positive performance at work and enhancement of OSH. This reflects the legal and ethical requirements for management to collaborate with the construction workforce for the improvement of OSH. For effective WE in OSH to become the norm, the effectiveness of corporate OSH engagement programmes needs to be assessed using a valid and reliable tool. Also, there is a need for a practice-driven and validated Worker Engagement Maturity Model (Meaningful Discussion Framework) that not only identifies and aligns with existent organisational capabilities, as shown in the HSE Leadership and Worker Involvement research, but addresses a set of dimensions specifically targeted at the construction workers. The methods used to develop the framework discussed here involved qualitative interviews to gain accounts of episodes of worker engagement, which were categorised using Nvivo, and ranked based on feedback from expert focus groups. The ‘Meaningful Discussion’ Framework highlights the links that higher levels of worker and organisational maturity can have in relation to higher levels of construction OSH performance. This is based on a number of logically progressive worker maturity levels where higher levels build on the requirements of already existing levels; from discussing issues affecting individual worker to issues that affect other workers and eventually to those ‘beyond the site gate’ such as design processes. Final validation testing of the model will be reported at a later date.

Keywords: Worker engagement, meaningful discussion, operatives, supervisors

INTRODUCTION & BACKGROUND

The construction industry is one of UK’s most important economic sectors with 2.1 million jobs or 6.2% of the UK population employed in construction jobs, (Rhodes 2015). The industry has realised that managing people and their behaviours is a core success for better work-related performance and higher output. Managers have realised that employees are key factors that constitute the base of their accomplishments. Thus, engaging employees at work is an important element for the success of the industry and

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improving all the outcomes that leads to this success (Bakker & Demerouti 2008; MacLeod & Clarke 2009).

The concept of worker engagement was originally defined by Cameron et al. (2006) as a process where every worker on a construction site actively participates in improving health and safety by influencing others. More specifically, workers are keen to share their experiences and knowledge with other workers and managers; managers positively encourage worker participation to identify and resolve health and safety problems, and everybody on site benefits from safer working conditions. HSG263 guidance (HSE 2015) identified worker engagement as a consultation process where management give information to the workforce (inclusive of supply chain and sub-contractors) or employees and they in turn acquire feedback from them before making decisions.

The definition developed for the research reported in this paper builds on these existing ones, but includes factors identified in literature search, which includes meaningful discussion, motivation, empowerment, commitment and trust. The current definition therefore considers worker engagement as:

"A process where every worker on a construction site is motivated and empowered to participate in improving health and safety through meaningful discussions with workers in advance of decisions being taken, influencing others, and is committed to sharing their experiences and knowledge; and managers positively encourage workers to identify and resolve health and safety problems in a culture of trust, leading to every worker on site benefiting from safe and healthy working conditions."

This also includes aspects such as the recognition of the positive influence that trained trade union safety representatives have through the exercise of their workplace rights and functions through effective consultative structures and the duty of the employer to consult with them (section 3(6) of the Health and Safety at Work etc. Act 1974).

There is little research on worker engagement specific to construction workers (operatives and working supervisors) and that is where the significance of this paper on meaningful discussion relevant to engagement lays its emphasis. Previous research has identified informal lines of communication, hazard reporting and informal disciplinary roles see (Cameron et al. 2006). Following on to the work of Cameron et al. (2006), research have identified that direct worker engagement in construction has been studied in relation to workers identifying hazards and reporting injuries and that training is paramount for meaningful discussion.

However, for meaningful discussion to take place there should be some degree of trust in management’s commitment to safety and any unsettling of this trust relationship by management will potentially disrupt meaningful discussions. The views of workers related to trust in management and emotional commitment to the organisation could be assessed to measure progress in the meaningful discussion process; see (DeJoy 2005). Maloney & Cameron (2003) suggested that meaningful discussions can only take place when workers possess some elements of capability, i.e. training, experience and knowledge. Therefore, the provision of requisite training for workers and management,
especially ‘soft skills’ that are fundamental for informal communication and relevant to meaningful discussions can help in the identification of hazards, reporting unsafe conditions or near misses. This creates an opportunity for a two-way communication mechanism that is required for imparting information to workers and eliciting their own views in a structured manner (Cameron et al. 2006).

Jensen (2002) and Cameron et al. (2006) both reflected on five dimensions to workplace assessment which can serve as a guide to assessing the level of meaningful discussions:

1. The area of the issues that are covered e.g. if they are related to physical hazards or if they extend to organisational management (safety culture, i.e. how safety is managed within an organisation);

2. The objectives in developing the solutions and where they rank in the UK hierarchy of risk controls; e.g. Eliminate, Prevent, Control

3. The depth of understanding with applicability to accident causation;

4. The range of solutions presented in relation to proactive and reactive decisions;

5. The capability to transfer issues out-with the immediate chain of command e.g. workers involving senior management, plant managers, or directors.

Research has continued to highlight the advantages of developing a highly engaged workforce, and therefore, many organisations are turning to enhancing levels of engagement within their influence (Wollard & Shuck 2011). Workers that are highly engaged are involved and immersed in their jobs that they enjoy the challenge (Staples et al. 1999), lose track of time while working (Gonzalez-Roma et al. 2006), have stronger organisation commitment (Hakanen et al. 2006), expend more effort on the job and are intrinsically motivated.

The importance of meaningful discussions within the construction industry lies in the perception of its importance in predicting positive performance at work and improvement of construction Occupational Safety and Health (OSH). Most construction workers will support formal organisational goals if they understand how these goals benefit themselves, the business, their fellow workers, its customers, and society as a whole. Therefore, meaningful discussions within the construction industry can be considered as a precondition for sustainable competitive advantage and it can make the real difference for the survival of an organisation, see (Macey & Schneider 2008; Song Hoon et al. 2012).

There is also an important element of reciprocity in trust (Scholefield 2000). For workers to be engaged and to reinforce their commitment within an organisation, an employer should invest in worker’s well-being, and the workers in return would feel valued and reciprocate directly with renewed employer loyalty and by working harder and more efficiently. There are also legal and ethical requirements for management to collaborate with the construction workforce for the improvement of OSH. This study therefore considers approaches to the development of a meaningful discussions maturity framework for the construction industry. Workers that are involved in the workplace should be engaged and given the opportunity to share their own views and opinions in matters related to improvement of the workplace and performance (Hummerdal 2015). Baicus et al. (2008) identified that worker’s creativity resident in them are mostly suppressed as a result of lack of support from the management and bureaucracy.
When discussions (face-to-face) are mediated by response or feedback and have direct impact on the capabilities of workers, such discussions can be considered as meaningful. Experience shows that within the construction industry, effective meaningful discussions are wholly dependent on individuals, teams and organisations. Also, because of the transient and inter-trade nature of most construction projects, the industry is often characterised by groups of workers that are peripatetic, unacquainted, working together over a limited period of time before disbanding to work on other projects, (Dainty et al. 2006).

The notion of meaningful discussions therefore is to ensure that the flow of information is effectively managed, messages are appropriately conveyed and the worker is able to interpret and act on such information in a way that is consistent with the expected intents. Meaningful discussions is considered as a fundamentally social activity which includes engaging in conversations, listening to co-workers, networking, collecting information, and directing subordinates. Meaningful discussions will thrive better in a workplace where there are some predictive elements of co-worker knowledge, team tenure, co-worker and supervisory support, group orientation and group cohesion, see (Burt et al. 2008). A discussion that directly influences a worker’s intellectual growth, learning, curiosity and engages them in productive instructional activities can be regarded as a meaningful discussion, see (Hirumi 2002).

It is also suggested that meaningful discussions nurture faster information acquisition and facilitate organisational socialisation. The work of Burt et al. (2008) shows that acquisition of information via socialisation such as induction training helps in getting to know the personal life of co-workers, their attitudes, families and interests and these are relevant in developing positive safety related attitudes, co-worker knowledge and social relationships.

**OBJECTIVE**

The study reported in this paper has been developing a framework against which to assess ‘meaningful discussion’ in relation to OSH engagement. This is only part of a wider framework being developed to encapsulate levels of worker motivation, commitment, empowerment and trust. This section of the framework will serve as a guidance tool that will be useful to workers and managers on construction sites in order to improve meaningful discussion on OSH.

**METHODS, DESIGN & INTERVIEWS**

The research objective dictated a qualitative approach to obtain rich data giving accounts of 'worker engagement' episodes which could also describe circumstances and context. The specific type of qualitative design implemented was the phenomenological research inquiry which describes the lived experiences of construction operatives and supervisors about the phenomenon of worker engagement as described by workers; see (Creswell 2014). This was considered most suitable for this study because the type of description articulates the experiences for several operatives and supervisors who have all experienced different types of worker engagement. Phenomenological research design is based on strong philosophical underpinnings and it involves conducting interviews, see (Giorgi 2012).
Getting access to construction operatives and supervisors was facilitated by the research Steering Group, made up of construction industry OSH experts. A purposeful sampling strategy was utilised for selecting construction sites (from house building to large scale civil engineering projects) and workers from a pool of site options available across the UK. The participants sought for the interviews were “engaged” workers and supervisors i.e. a worker described as engaged will be operatives who shows interest in health and safety issues, contributes to H&S and/or regularly attends H&S meetings; whilst a supervisor will be someone who encourages engagement and regularly discusses H&S issues with their workers.

Phenomenological studies typically involve three to 10 participants (Creswell 2014); however, this study conducted a semi-structured; face-to-face and open-ended, non-leading interviews with 29 operatives and supervisors until saturation, (Charmaz 2014). Each interview lasted an average of 40 minutes. The interview process was audio recorded with note taking on site and later transcribed. The development of the meaningful discussion framework involved using inductive and deductive logic. The inductive process involved working back and forth between the themes emerging from interviews conducted and the information from literature until a comprehensive set of themes were established (Creswell 2013). This involved collaborating and interacting with industry experts (Steering Group) via presentations and workshops in order to shape the emerging themes of meaningful discussion from the interviews. The validation of the framework and categorisations was done through workshops with members of the Steering Group iteratively. The visual representation of meaningful discussions framework was developed deductively with members of the Steering Group from the categories of information acquired from interviewing the research participants to reach a logically certain conclusion. This was considered ideal working from the more general to the more specific context of meaningful discussions based on examples.

ANALYSIS & DISCUSSION

The framework for meaningful discussions was conceived and developed by the researchers in collaboration with the industry experts. This resulted in a visual representation of factors radiating out from the individual worker, to their immediate surroundings and eventually to factors 'beyond the site gate', illustrated by a conceptual dartboard; see Table 1 & Figure 1. The significance of involving industry experts was to address complex issues of diverse views regarding assigning and categorising the levels of the different issues discussed by the workers (Fontana & Frey 1994). It was identified that meaningful discussion between workers, co-workers, supervisors and managers was dependent on the fundamental principles of trust, motivation, empowerment and commitment of the workers which are some of the key features identified in the work of Cameron et al. (2006). Table 1 outlines the development of meaningful discussion criteria that was adopted in assigning levels of issues that were frequently discussed, raised or flagged up by the workers. The criticality of the issues identified; the impact on workers; and the relative meaning of such issues such as welfare, housekeeping, hazard spotting etc. are summarised in Table 1.
Table 1: Areas of issues discussed by the workers with their levels, criticality and meaning

<table>
<thead>
<tr>
<th>Level</th>
<th>Criticality</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Personal work area; housekeeping; and work environment</td>
<td>Hazards that directly affect/related to the worker</td>
</tr>
<tr>
<td>2</td>
<td>Welfare</td>
<td>Issues related to site welfare</td>
</tr>
<tr>
<td>3</td>
<td>Hazard spotting; site hazards; and hazard causes/procedures</td>
<td>Hazards that are associated to other workers</td>
</tr>
<tr>
<td>4</td>
<td>Proactive site solutions</td>
<td>Proactive discussions or proactive actions taken to resolve issues</td>
</tr>
<tr>
<td>5</td>
<td>Beyond the site gate: boardroom/other sites; designs; and mental health</td>
<td>Issues that are beyond the site gate needing some management interventions</td>
</tr>
</tbody>
</table>

Figure 1 shows the output from the workshop with industry experts. The core of the subjects discussed by the workers was central to issues of personal work area and welfare which is considered significantly important to the workers. It is only when issues related to personal work area and welfare have been addressed and there is that element of trust (Scholefield 2000) in the management to act on problems, that a worker will have the confidence to raise other immediate issues that either impact them personally or their work environment. Engaging with workers in resolving immediate issues like housekeeping, personal work area and work environment issues will reinforce some sense of empowerment, meaning, competence, impact and belief that they are being listened to (Conger & Kanungo 1988). This is when workers feel empowered and emotionally committed (DeJoy 2005; Hakanen et al. 2006; Schaufeli 2013) to identify and raise other issues that pose as hazards to others. These involve issues like hazard spotting; identifying site or work related hazards; risk assessment; accident investigation; equipment design and selecting PPE and equipment. These are more effective if involvement is on a voluntary basis as this ensures ownership (Lancaster et al. 2001). The depth of engagement and meaningful discussion depends upon a range of factors as highlighted by Jensen (2002) and Cameron et al. (2006).

The Construction Design and Management Regulations (2015) (CDM) in the UK explicitly state the requirements of those who indirectly influence site health and safety during the pre-construction, or planning stages, see (Hare et al. 2006). This requires designers to manage health and safety risks. Regulation 14 of CDM 2015 places duties on the principal contractor to consult and engage with workers in construction work to cooperate effectively in developing, promoting and checking the effectiveness of measures to ensure the health, safety and welfare of the workers. However, the issues discussed by the workers clearly identify that inherent issues related to design were not reflected in their meaningful discussions. Other issues beyond the site gate, like mental health, and boardroom level issues were not captured in the discussions that workers had. But this is hardly surprising as these are the most advanced levels of meaningful discussion and therefore will be rare until full maturity is gained.
Table 2 shows the issues that were either discussed by workers or established by the expert group, actions that were taken to resolve or mitigate the issues and the ranking of such issues. Nine of the issues discussed by the workers involved welfare (Level 1) which is considered significant to every worker on site. Two issues were related to personal work area or housekeeping (Level 2) while hazard spotting or site hazards (Level 3) accounted for fifteen of the thirty issues discussed by the workers. Three of the issues were on proactive site solutions (Level 4) and none on design, boardroom or other sites issues, family/personal issue or mental health.

CONCLUSIONS

Based on the results from this study, the level of mutual understanding between workers on construction sites as well as the close coordination and communication of design issues were lacking (beyond site gate issues). Although there seemed not be significant
barriers to communication between workers; issues that were relevant to design professionals, construction phase plan and contractors were not discussed. This gives a sense of the level of reach of the workers in terms of identifying such problems and cascading to the relevant level. From the interviews conducted, site inductions, toolbox talks and pre-start meetings were considered by the workers as a critical point for the communication of health and safety information between management and the workforce. However, the opportunities for two-way communication that relates to the mechanisms that are required to impart information to workers and elicit their views in a systematic, but not necessarily formal manner is considered still lacking. It is worthy to say that meaningful discussions are taking place but, the level of reach of such discussions need to go wider and farther than the examples shown in Table 2. For the operatives and supervisors to meaningfully discuss issues up to Level-5 of the framework, they will need to have the requisite skills, experience, competence and training. The expert group recommended further data collection from a sample of female workers and trade union Safety Representatives to ascertain if Level 5 discussions (beyond the gate) are identified.

REFERENCES


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<table>
<thead>
<tr>
<th>Level</th>
<th>Issues &amp; Description</th>
<th>Action Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Battery charging points e.g. batteries are being charged in the canteen</td>
<td>Extension cables ordered and extensions delivered and now in use</td>
</tr>
<tr>
<td>2</td>
<td>Ear plug dispenser</td>
<td>Ear plug dispenser fitted to the board on the lower ground and ready for use</td>
</tr>
<tr>
<td>1</td>
<td>Temporary lighting</td>
<td>Contractor supplied task lighting but subcontractors are to supply their own if there is not enough on site</td>
</tr>
<tr>
<td>1</td>
<td>Housekeeping</td>
<td>With lots of new faces on site, people are not tidying up last 10 minutes at night. All foremen should ensure that work personnel tidy up before leaving site.</td>
</tr>
<tr>
<td>3</td>
<td>PPE</td>
<td>Everyone is not adhering to the five-point PPE rule. If the same people persistently fail to adhere to the rules, their boss will be informed to take relative actions</td>
</tr>
<tr>
<td>4</td>
<td>Relevant tickets for Scissor lifts</td>
<td>Spot checks will be carried out; charge hands are to make sure that only personnel with tickets use machines</td>
</tr>
<tr>
<td>2</td>
<td>No running water in joiners canteen</td>
<td>Supervisor to talk to subcontractor to resolve issue</td>
</tr>
<tr>
<td>4</td>
<td>Work plan - Plant, machinery &amp; equipment</td>
<td>Everyone to be aware that the crane operator will be working closer to the building</td>
</tr>
<tr>
<td>2</td>
<td>Someone squatting over the toilet, broke seat and made a mess</td>
<td>All personnel spoken to; if for any reason you need to do this speak to management to see if alternative arrangement can be made</td>
</tr>
<tr>
<td>3</td>
<td>Car park mud e.g. sparks complained that the car park was very muddy and no walkway</td>
<td>New tar car park now in operation with walkway through the canteen</td>
</tr>
<tr>
<td>3</td>
<td>Mixed wastes e.g. plasterboards, timbers, and metals all mixed in the bins</td>
<td>Everyone told to separate waste bins provided to allow forklift driver to put waste in relative skips</td>
</tr>
<tr>
<td>3</td>
<td>Bottom of plant room stair has open area you need to jump over</td>
<td>Area was boarded over to make suitable platform</td>
</tr>
<tr>
<td>3</td>
<td>Stairs blocked off for pour and no dry routes to wing B</td>
<td>New routes with barriers and no mud designed</td>
</tr>
<tr>
<td>3</td>
<td>Machinery movement/awareness e.g. lots of MEWPS moving on site</td>
<td>Safety advisor suggested signs be made and erected for MEWP working area</td>
</tr>
<tr>
<td>2</td>
<td>People smoking outside building and canteen</td>
<td>All personnel spoken to and told to use designated smoking areas. The designated smoking area to be made larger</td>
</tr>
<tr>
<td>2</td>
<td>Canteen left untidy and microwave not cleaned after use</td>
<td>Foremen to speak to men and more bins and signs to be put up</td>
</tr>
<tr>
<td>3</td>
<td>PAT testing equipment</td>
<td>All equipment on site tested</td>
</tr>
<tr>
<td>3</td>
<td>Uncovered risers</td>
<td>Barriers erected to protect it</td>
</tr>
<tr>
<td>3</td>
<td>Water bottle not used during cuttings</td>
<td>Brickies given water bottles and they are under observation</td>
</tr>
<tr>
<td>3</td>
<td>COSHH bins not being used</td>
<td>Signs were made up and put up on site</td>
</tr>
<tr>
<td>2</td>
<td>No microwave in the canteen</td>
<td>New one was purchased and put in place</td>
</tr>
<tr>
<td>4</td>
<td>Commendation</td>
<td>Scaffolders commended for prompt action taken at east elevation scaffold</td>
</tr>
<tr>
<td>3</td>
<td>Fire alarm</td>
<td>Fire alarm did not go off with others during fire drill. Supervisor to silent test the alarm</td>
</tr>
<tr>
<td>2</td>
<td>Toilet water running out frequently</td>
<td>Signs to be put up to “pull up taps” after use; plumber to look at taps</td>
</tr>
<tr>
<td>2</td>
<td>Water not fit for drinking</td>
<td>Signs to be made to warn personnel that water from canteen sink is not suitable for drinking</td>
</tr>
<tr>
<td>2</td>
<td>No closer on canteen door</td>
<td>Supervisor will look into fitting new ones</td>
</tr>
<tr>
<td>1</td>
<td>Cables on ground at west wing</td>
<td>Cables to use nearest drop points and hung up off the floor</td>
</tr>
<tr>
<td>3</td>
<td>Metal cutting with jigsaw very noisy</td>
<td>When cutting metal (trays or ducting) with jigsaw, do it outside if possible or warn people in area before cutting. Ear plug dispenser to be put up on site for easy access</td>
</tr>
<tr>
<td>3</td>
<td>Using other workers platforms without charging after use</td>
<td>All team members to speak to other co-workers and to ask them to charge machines at night. Tool box talk</td>
</tr>
<tr>
<td>3</td>
<td>Signing in book to be used everyday</td>
<td>Supervisor to talk to all operatives to ensure they</td>
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*Table 2: Meaningful discussion with actions taken to resolve issues and their ranking*
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