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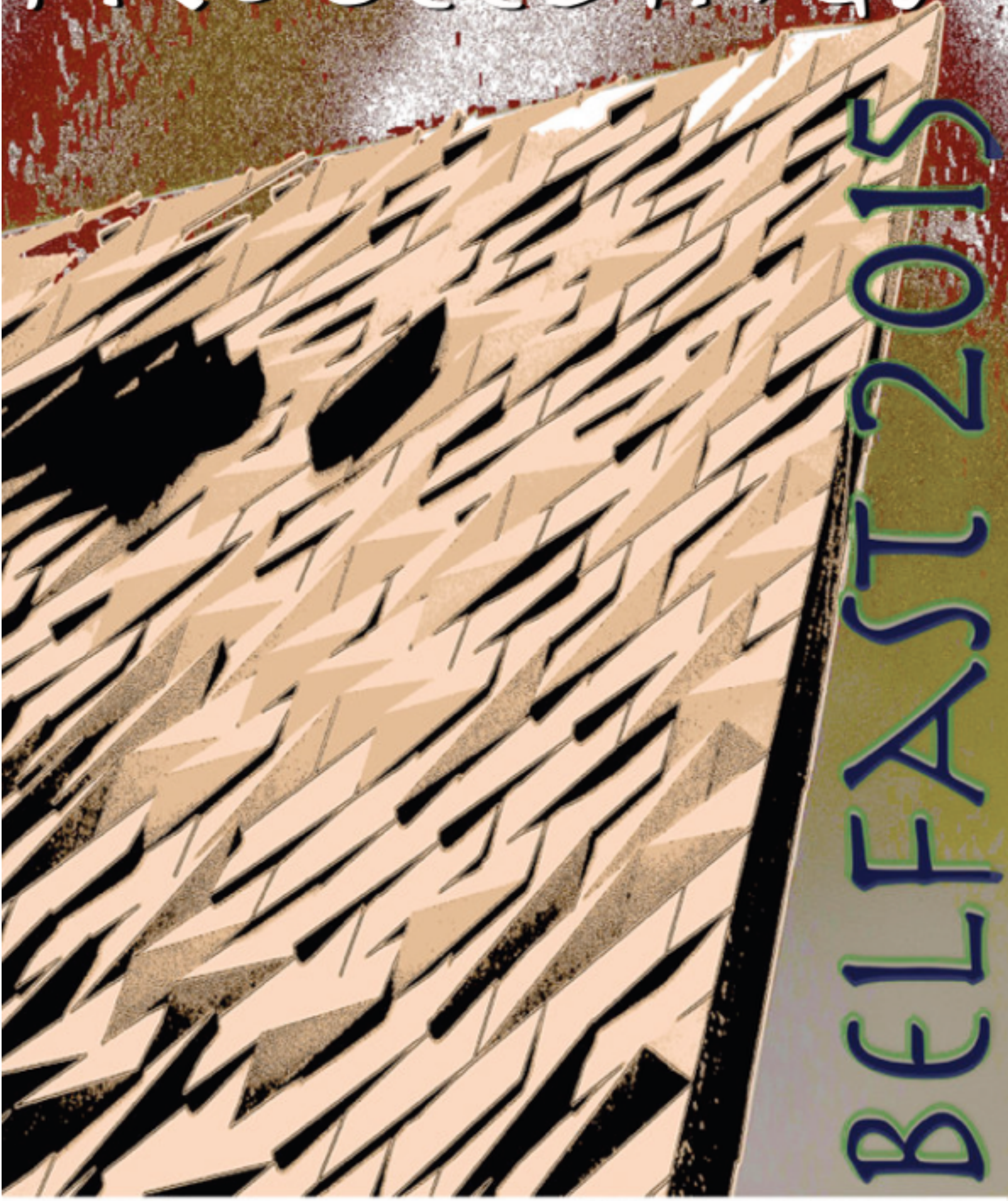

CIB W099 International Health and Safety Conference

Benefitting Workers & Society through Inherently Safe(r) Construction

Ulster University 9th - 11th September 2015

Proceedings CIB W099 Belfast 2015

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This edition published 2015 by EEI Publishing
37 Roughal Park, Downpatrick, BT30 6HB
E-mail: **expertease@confinedspaces.com**

ISBN 978-1-909854-01-7

BIC category: KNXC Industrial Relations, health and safety

© CIB W099
http://www.cibw099.com/home.html

Cover Design: © feidhlimídh macgiollafhínnein

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Table of contents

Organising Committee, Scientific Committees and Session Chairs

This 2015 conference is organised by the CIB Working Commission, W099 Safety and Health in Construction, and hosted at the Ulster University.

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McAleenan, Philip
McAleenan, Ronan
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Oloke, David
Oswald, David
Pestana, Catarina
Pillay, Manikam
Pirzadeh, Payam
Rajendran, Sathy
Sherratt, Fred
Smallwood, John
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Zhao, Dong
Zhou, Zhipeng
Zou, Patrick

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Aulin, Radhlinah
Edirisinghe, Ruwini
Emuze, Fidelis
Goh, Yang Miang
Hare, Billy
Hjort, Bengt
Manu, Patrick
McAleenan, Philip
McAleenan, Ronan
Oloke, David
Sherratt, Fred
Teo, Evelyn

CIB W099 2015 - Conference Paper Review Procedure

Proceedings

These are the Proceedings of the CIB W099 International Conference on "Benefitting Workers and Society through Inherently Safe[r] Construction", held on 9th-11th September 2015 at Ulster University, Belfast, Northern Ireland. The proceedings consists of 51papers across the 12 conference themes.

Review process

All papers in this publication have been through a double blind peer review exercise.

First stage of the review

Initially submitted abstracts were reviewed by two reviewers, with a view to determining whether the one or more of the conference themes and objectives were being met in the proposed submission. Authors whose reviews were accepted were provided with comments for consideration in the production of the full paper.

Second stage of the review

All papers were uploaded to plagiarism software before being submitted for review. The received full papers were then submitted for double blind peer review by a minimum of two reviewers, selected from the scientific and technical committee for their specialist/ expert knowledge of the subject area. The full papers were reviewed for their relevance to the conference themes and objectives, originality, academic rigour, contribution to knowledge and overall quality and suitability for inclusion in the conference proceedings. Authors whose papers were accepted for presentation at conference were provided with comments for consideration in the production of the final camera ready version of the paper.

Final stage of the review

Final modifications of papers by authors to their final version of the paper were subjected to a final review before being accepted for publication and presentation at the CIB W099 conference. To be eligible for inclusion the papers had to receive positive endorsement by all reviewers.

At no stage were members of the scientific and technical committee involved in the review of papers they authored or co-authored. The scientific and technical committee's key function was to ensure that the final papers incorporated the reviewers comments and to arrange the papers into the final sequence of the electronic version of the conference proceedings as captured on the USB data key and listed in the Abstracts book.

Contribution / Importance to the disciplines of the conference

The papers presented in the proceedings for the cIB W099 conference, "Benefiting Workers and Society through Inherently Safe(r) Construction" represent the research outputs from international research practitioners in the field of construction safety and health. The combined contributions collectively offer research with relevance and impact, designed to offer the wider construction community new and innovative approaches to prevention through design and construction safety management.

A PROTOTYPE OF SMART CLOTHING FOR CONSTRUCTION WORK HEALTH AND SAFETY

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Heat related illness is a serious health concern for construction workers in tropical climates or those working under hot and humid environmental conditions. It can cause damage to body organs and the nervous system resulting in permanent disability or even death. Development of systems for construction workers to detect and alert temperature-warning signs early is a timely and strategic need.

The advancement and rapid development of wearable computers and wearable electronics has produced electronic textiles. This paper presents the smart safety vest prototype developed to senses the temperature and alert the wearer and surrounding workers/management about thermal abnormalities. It can be used as an early warning system for construction workers.

The LilyPad Arduino platform was used as the main technology. The LilyPad Arduino board and input output sensors were stitched into a safety vest. The Lilypad Surface temperature readings were continuously measured. The temperature variations were alerted in visual format using coloured LED lights and in audible format using a speaker stitched on to the safety vest.

Early detection of heat stroke conditions can mean the difference between life and death for construction workers. Hence, it is expected that the proposed technology will enable a step change in construction personal protective equipment globally, thereby contributing to the vision of a smart construction site.

Keywords: smart clothing, construction, occupational health and safety, safety vest.

INTRODUCTION

Heat related illness

Heat related illness is a serious health concern for many industries. Heat related illness covers a spectrum of disorders (Lugo-Amador et al, 2004) such as heat stroke, heat exhaustion and heat rash. Heat related illness is caused by exposure to high air temperatures, direct sunlight and other environmental and work-related factors such as work in confined space and radiant heat sources (e.g. arc welders).

Construction workers in tropical climates or those working under hot and humid environmental conditions are often vulnerable to heat related illness. Australian construction workers in tropical climate regions and states (e.g. Queensland); and in other states during the extreme summer temperatures (e.g. Victoria) are exposed to heat stress. Heat stroke occurs when the core body

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temperature rises above 40.5°C. It can cause liver, kidney, heart and muscle damage. Often, the nervous system is affected resulting in delirium, coma, and seizures. Permanent disability, even death, can result. Even though construction workers may be educated on early warning symptoms of heat strokes, it is evident that workers are unable to recognise these symptoms. Construction fatalities from heat stroke have been reported in Australia (Mining Australia, 2013). Development of systems for construction workers to detect heat related illness warning signs early is both timely and important. Such systems can also contribute to improve strategic health and safety objectives.

e-Textiles

The vision of ubiquitous computing to "be connected any-where any-time on any-device" has enabled embedding of a chip on everyday objects beyond the computer. Wearable computers proposed by Mann (1996) became a reality with the exponential advancement of information science. Products currently in the market include smart watches and smart glasses connected to the smart phone, and wearable fitness technologies/wrist bands equipped with sensors such as accelerometers, gyros, and heart sensors. Concurrently, smart fabrics proposed by Post and Orth (1997) became a reality with innovations in electrical engineering, including conductive yarns and fabrics. As a result, smart textiles research and applications are gaining momentum.

The term smart textiles, intelligent clothing and e-textiles are being used interchangeably. Smart clothing is defined as "Textiles that are able to sense stimuli from the environment, to react to them and adapt to them by integration of functionalities in the textile structure" (Langenhove and Hertleer, 2004, p.63). Heart beat sensing garments, light-emitting diode (LED) wedding gowns and electronic music-inspired clothing that pulses in response to background music are already in the market.

Integrating computer science, electrical engineering, textile design, and fashion design, e-textiles cross unusual boundaries; appeal to a broad spectrum of people; and provide novel opportunities for creative experimentation in both engineering and design (Buechley and Eisenberg, 2008, p 12).

Potential applications of this next generation smart clothing are expected to appear in industry sectors including medical monitoring, therapy and rehabilitation (Dunne, 2010), health and wellbeing, sports and fitness, industrial safety (construction and fire fighters) and fashion.

A prototype of a smart safety vest with temperature sensors was developed as a solution to heat related illness in the construction industry. This paper presents the development of this smart vest that can be used as an early warning system for heat related illness.

The CIB programme Committee recently established a new task group TG92 on wearable sensor technology. To address the need for wearable and sensor technology during construction is one objective of the task group. Hence, the research proposed in this paper is timely and fits strategically with the requirements of the research and innovation in the construction industry sector.

BACKGROUND

Despite the presence of basic responsive clothes already in the market, smart clothing is an emerging research area. Among the products researched are motion detecting pants developed by Virginia Tech E-textiles Laboratory, a smart wedding dress (that senses breathing data to illustrate the bride's emotions through LED lights and pulsating flowers in the dress) developed by Simon Fraser University(SFU)'s school of interactive arts and technology (SIAT) in Canada.

Slyper and Hodgins (2008) developed a performance animation system using accelerometers sewn into clothing. They compared the accelerometer readings against simultaneous motion capture systems and found a close match. Similarly, Harms et al. (2008) developed a posture classification system using acceleration sensors.

The expressive t-shirt was developed for sensing air quality by measuring volatile organic compounds (VOCs) (Kim, 2010). They measure the carbon monoxide, ozone, NOx, temperature and humidity levels in the air and indicated the air quality level to both the user and people around using a sequence of LED lights.

In health and fitness domain, Coyle et al. (2009) developed a wearable garment based on physiological signals and body kinematics during exercise. The garment senses the pH value of sweat to determine hydration, breathing pattern and joint strain during exercise. Similarly, The Active T-shirt (Senol et al., 2011) senses body temperature, heart rate, CO2 value of the surrounding environment, motion and the light level. The researchers concluded through experiments that it is vital to filter out undesirable fluctuations of collected sensory data using signal-processing algorithms in order to make reliable decisions.

Other e-textile applications were developed primarily in healthcare for health monitoring and tele-medicine objectives (Cheng et al. 2008; Lee and Chung, 2009; Paradiso et al., 2008; Pandian et al., 2008). Cheng et al. (2008) developed a heart-rate estimating system together with wearable physiological sensors. The sensors include the temperature sensor, ECG electrodes, sweatiness sensor and respiration sensor. They process the sensory data to estimate the maximum likelihood heart rate. Wearable physiological remote monitoring system developed by Pandian et al. (2008) is a washable shirt, which uses an array of sensors connected to a central processing unit with firmware for continuously monitoring physiological signals. Lee and Chung (2009) developed a wireless sensor network based wearable smart shirt for health and activity monitoring. The system transmits ECG and acceleration data via Zigbee wireless communication. Similarly, Paradiso et al. (2008) developed a health monitoring system with a wearable system. ECG, HR, oxygen saturation, impedance pneumography and activity data is transmitted via cellular network for remote access.

However, little research has been done in safety, particularly in the construction domain except for the work of Chan et al. (2012). Chan et al. (2012) developed an anti-heat stress uniform for construction workers. The moisture-management fabric made from nano-materials were used to produce a T-shirt. With higher one-way transferability and liquid moisture management capacity, the technology improves fabric breathability, speeds up sweat evaporation, and helps to reduce heat stress (PolyU, 2014). The clothing was developed based on environmental conditions monitored over few months. However, this anti heat stress uniform is not able to monitor the environment conditions real-time to provide feedback.

Other recent advancements in smart clothing include durable biosensors developed at the University of California San Diego that can be printed directly onto clothing (Yang et al, 2010).

The next section presents wearable technology we developed to monitor the ambient temperature of construction workers real-time.

METHODOLOGY

The LilyPad Arduino

The LilyPad Arduino embedded platform (Buechley et al., 2008) is a microcontroller board designed for wearables and e-textiles. The commercially available LilyPad Arduino USB board (shown in Figure 1) is a microcontroller board based on the ATmega32u4 processor with nine digital input/output pins. The holes in the petals on the board (shown in Figure 1), allow conductive threads to be stitched into fabric.

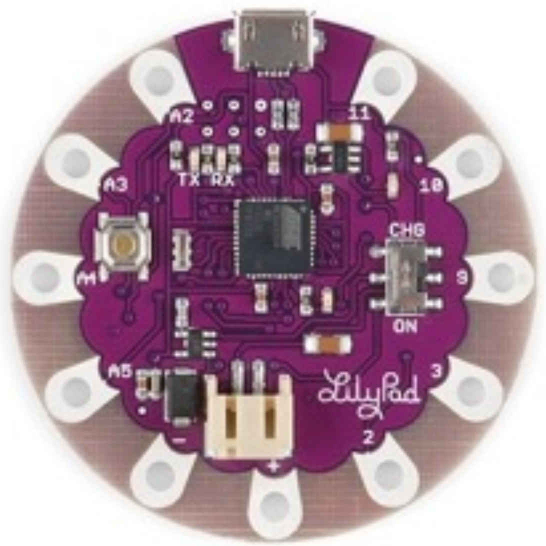


Figure 1. LilyPad Arduino USB board (source:http://arduino.cc/en/Main/ArduinoBoardLilyPadUSB)

Smart Safety Vest

The LilyPad Arduino USB board was used in this study, which is stitched in to a fabric using conductive threads. The board and the sensors stitched in to the fabric is then attached into a safety vest that the construction workers wear. The board was powered with a 3.7V LiPo battery (connected to the JST connector on the board), and was programmed using the Arduino programming environment. The safety vest is shown in Figure 2.

The design choice was not to stitch the hardware directly in to the safety vest. The design motivation to have a separate fabric as an intermediate layer was due to three reasons: (i) for aesthetic appearance (stiches will not be visible from outside) giving a neat finish; (ii) for convenience of wear and user comfort-the hardware directly sewn in to fabric could be uncomfortable for the users; and (iii) the ease of attaching and detaching for demonstration purposes, and to enable washing of the garment.

Figure 2. Smart Safety Vest

Monitoring and Alerting

Monitoring Temperature

The Lilypad Arduino temperature sensor was used to sense the temperature in the safety vest. It is a small thermistor type temperature sensor that can be used to detect physical touch-based on-body heat or ambient temperature. The temperature sensor is stitched into the safety vest using conductive threads and measures the ambient temperature on a continuous basis. An average temperature value of ten readings was taken in order to have a stable value by smoothing out the variations and fluctuations of the readings.

Alerting Mechanism

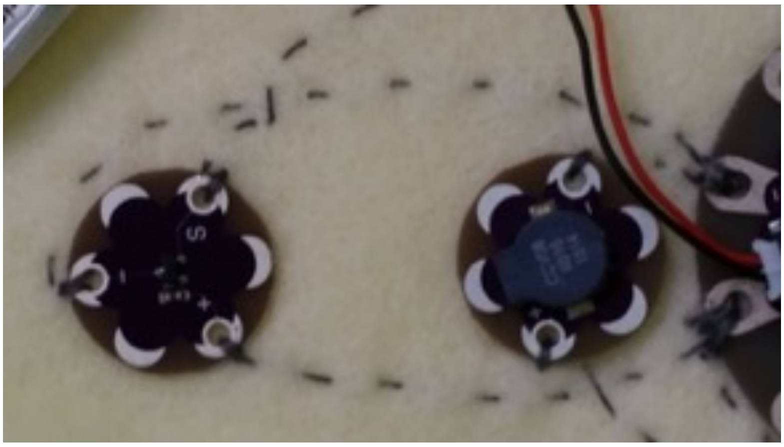
The smart safety vest has an in-built alerting mechanism. The alerting mechanism has two forms, visual and audible. Unacceptable temperature variations generate alerts to the user and surrounding workers and management. This is achieved using a tri colour LED light (Figure 3(b)) and a speaker (Figure 3(a)) that can play sound. These components are shown in Figure 3.

Visual Alerting mechanism

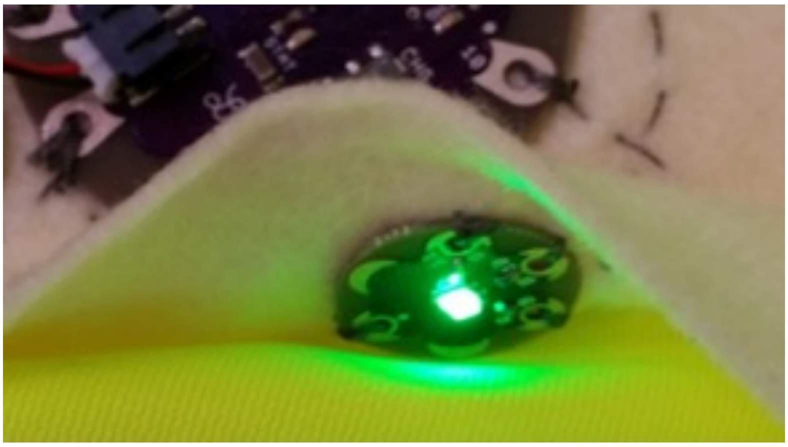
Temperature variations are signalled via a visual indicator at the back of the smart vest, and hence is visible to other people around the wearer. A LilyPad RGB (red, green, blue) LED light is stitched at the back side of the fabric so that it is visible though the vest. The LilyPad RGB is a multi-coloured LED light that can change to any colour of the rainbow. The temperature variations generated based on pre-defined thresholds are indicated through a red, green or blue light at the back of the vest.

Figure 4 illustrates the colour changes of the light according to the temperature variations. For example, the vest is programmed to indicate the lights as follows.

- normal temperature in green (Figure 4(b))
- too cold in blue (Figure 4(a))
- too hot in red (Figure 4(c)).



(a) temperature sensor and the speaker

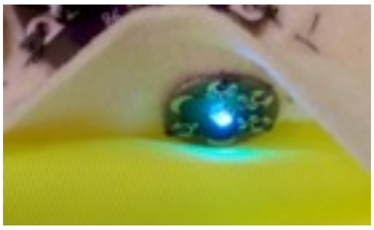


(b) LilyPad RGB LED

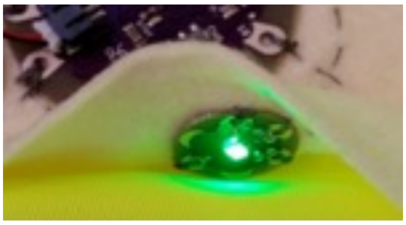
Figure 3. Smart safety vest sensory components

Audible Alerting mechanism

The audio alert is implemented by stitching the LilyPad Buzzer / LilyPad Speaker into the safety vest. The alert is loud enough to be clearly heard by the person wearing the safety vest. If the temperature is in the normal range, the buzzer is not activated; however, if the temperature is too cold the buzzer is activated to emit a "beep" every 500ms. If the temperature is too hot, the buzzer is activated to play warning music.



(a) cold temperature



(b) normal temperature

(c) hot temperature

Figure 4. Temperature changes indicated by the light colour

Alerting Algorithm Flow Chart

The flow chart shown in Figure 5 outlines the alerting algorithm.

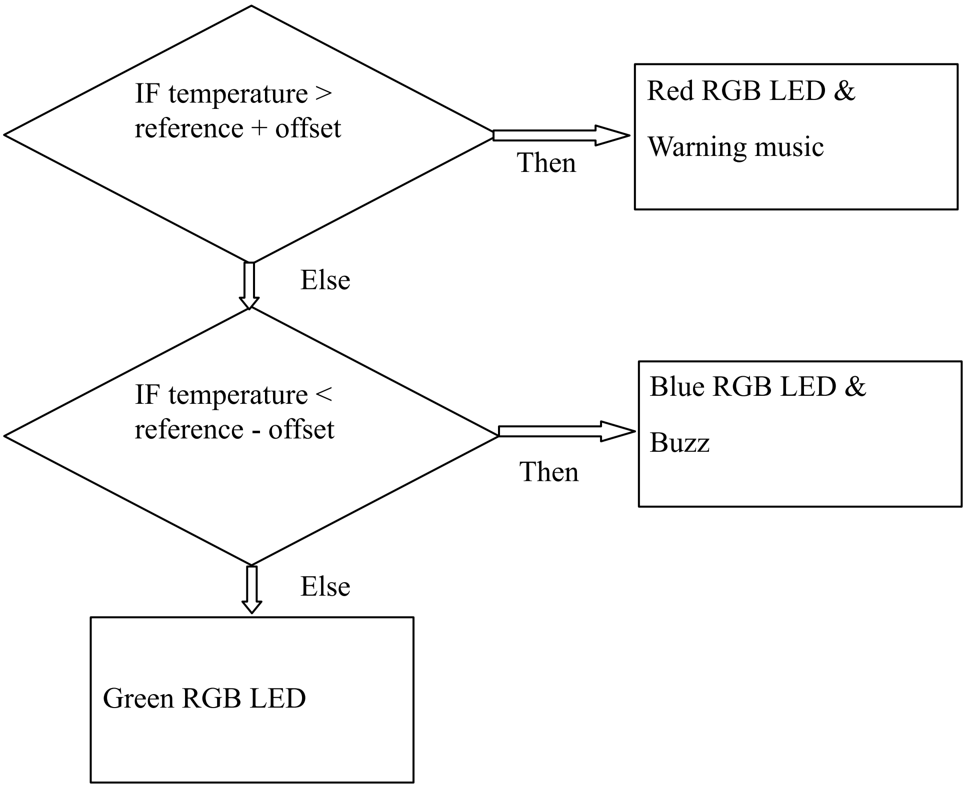


Figure 5. Flow chart of alerting mechanism

A reference temperature is used to indicate the acceptable temperature value. In order to have an acceptable temperature range an offset value is introduced. If the temperature is in the normal range, the green light of the RGB LED is activated and the buzzer continues to be inactive. If the temperature reading is lower than the reference temperature plus offset temperature, the blue RGB LED light is activated and the speaker is buzzed at a certain frequency. If the temperature reading is higher than the reference temperature plus offset temperature value, the red RGB LED light is activated and the buzzer plays music as a warning sign.

DISCUSSION AND CONCLUSIONS

Open challenges

Open challenges exist for the use of wearable technologies to its full potential (Cherenack and van Pieterson, 2012; Dunne, 2010). Technical challenges include: the mechanical issues relating to e-fibre that are related to the design issues and strain and stress levels; power supply issues needing energy harvesting rather than a battery powered textile; and accuracy of sensor inputs and outputs for reliable sensory data. Practical implications include washability (to introduce water proof packaging for sensitive electronics) and the ability to ensure user comfort of e-textiles.

Despite these challenges, e- textile research projects, such as photovoltaic fibres (Lee at al, 2009), energy harvesting (Jia and Liu, 2009), elastic batteries (Kaltenbrunner, 2013) are gaining momentum to resolve these open issues near future.

Conclusions and future work

This paper discussed the smart safety vest developed for construction heat related illness. The prototype smart safety vest verifies the technical feasibility of wearables in the construction industry, which is relatively low in technology adoption compared to other industries.

Several areas of future work present themselves.

- Real-time data capture

The LilyPad Arduino board will be extended with a blue tooth transmitter in order to transmit the data to a smartphone. This enables real-time continuous monitoring and real-time further analysis of sensory data. This enables reliability testing of the sensory data too.

- User testing

The prototype needs to be tested in a live construction site situation to study the usability. The issues related to user comfort and calibrating the sensors to various climate and seasonal needs are to be addressed through real site testing. In addition, the site testing enables extending the prototype with other sensors to measure parameters such as UV exposure and/or hydration where applicable. For example in Australia these parameters are critical for the construction industry.

It is expected that the proposed technology will contribute significantly to the use of wearable sensory technology in construction to achieve the future vision of a smart construction site.

REFERENCES

Buechley, L., & Eisenberg, M. (2008). The LilyPad Arduino: Toward wearable engineering for everyone. Pervasive Computing, IEEE, 7(2), 12-15.

Buechley, L., Eisenberg, M., Catchen, J., & Crockett, A. (2008, April). The LilyPad Arduino: using computational textiles to investigate engagement, aesthetics, and diversity in computer science education. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 423-432). ACM.

Chan, A. P., Yi, W., Wong, F. K., Yam, M. C., Chan, D. W. M., Li, Y., ... & Wong, D. P. (2012). Designing anti heat stress clothing for construction workers. In Proceedings of CIB W099 International Conference on “Modelling and Building Health and Safety”, Singapore (pp. 332-339).

Cheng, M.-H., Chen, L.-C., Hung, Y.-C. and Yang, C. M. (2008) “A real-time maximum-likelihood heart-rate estimator for wearable textile sensors,” in EMBS 2008: Proceedings of 30th Annual IEEE EMBS conference, 20–25 August 2008, pp. 254–257.

Cherenack, K., & van Pieterson, L. (2012). Smart textiles: challenges and opportunities. Journal of Applied Physics, 112(9), 091301.

Coyle, S., Morris, D., Lau, K. T., Diamond, D., & Moyna, N. (2009, June). Textile-based wearable sensors for assisting sports performance. In Wearable and Implantable Body Sensor Networks, 2009. BSN 2009. Sixth International Workshop on (pp. 307-311). IEEE.

Dunne, L. (2010). Smart clothing in practice: key design barriers to commercialization. Fashion Practice: The Journal of Design, Creative Process & the Fashion Industry, 2(1), 41-66.

Harms, H., Amft, O., Roggen, D. and Tröster, G. “SMASH: A distributed sensing and processing garment for the classification of upper body postures,” in Proceedings of the third International Conference on Body Area Networks (Bodynets 2008), 17 March 2008, pp. 1–8.

Jia, D., & Liu, J. (2009). Human power-based energy harvesting strategies for mobile electronic devices. Frontiers of Energy and Power Engineering in China, 3(1), 27-46.

Kettlgruber, G., Kaltenbrunner, M., Siket, C. M., Moser, R., Graz, I. M., Schwödiauer, R., & Bauer, S. (2013). Intrinsically stretchable and rechargeable batteries for self-powered stretchable electronics. Journal of Materials Chemistry A, 1(18), 5505-5508.Kim, S., Paulos, E., & Gross, M. D. (2010, January). WearAir: expressive t-shirts for air quality sensing. In Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction (pp. 295-296). ACM.

Lee, M. R., Eckert, R. D., Forberich, K., Dennler, G., Brabec, C. J., & Gaudiana, R. A. (2009). Solar power wires based on organic photovoltaic materials. Science, 324(5924), 232-235.

Lee, Y. D., & Chung, W. Y. (2009). Wireless sensor network based wearable smart shirt for ubiquitous health and activity monitoring. Sensors and Actuators B: Chemical, 140(2), 390-395.

Lugo-Amador, Nannette M; Rothenhaus, Todd; Moyer, Peter (2004). "Heat-related illness". Emergency Medicine Clinics of North America 22 (2): 315–27.

Mann, S. (1996). Smart clothing: The shift to wearable computing. Communications of the ACM, 39(8), 23-24.

Mining Australian (2013). "Santos sub-contractor dies of suspected heatstroke" http://www.miningaustralia.com.au/news/santos-sub-contractor-dies-of-suspected-heat-strok, Accessed January 2015.

Pandian, P. S., Mohanavelu, K., Safeer, K. P., Kotresh, T. M., Shakunthala, D. T., Gopal, P., & Padaki, V. C. (2008). Smart Vest: Wearable multi-parameter remote physiological monitoring system. Medical engineering & physics, 30(4), 466-477.

Paradiso, R., Alonso, A., Cianflone, D., Milsis, A., Vavouras, T., & Malliopoulos, C. (2008, August). Remote health monitoring with wearable non-invasive mobile system: the healthwear project. In Engineering in Medicine and Biology Society, 2008. EMBS 2008. 30th Annual International Conference of the IEEE (pp. 1699-1702). IEEE.

Post, E. R., & Orth, M. (1997, October). Smart Fabric, or" Wearable Clothing". In 2012 16th International Symposium on Wearable Computers (pp. 167-167). IEEE Computer Society.

PolyU (2014), "Anti-heat stress uniform for construction workers" in PolyU Milestones.url: http://www.polyu.edu.hk/cpa/polyumilestones/14Jun/pdf/201412_PolyU_Milestones.pdf

Senol, Y., Akkan, T., Yazgan Bulgun, E., & Kayacan, O. (2011). Active T-shirt.International Journal of Clothing Science and Technology, 23(4), 249-257.

Slyper, R., & Hodgins, J. K. (2008, July). Action capture with accelerometers. InProceedings of the 2008 ACM SIGGRAPH/Eurographics Symposium on Computer Animation (pp. 193-199). Eurographics Association.

Van Langenhove, L. and Hertleer, C. (2004) “Smart clothing: A new life,” Int. J. Clothing Sci. Technol.16, 63–72.

Yang, Y.-L., Chuang, M.-C., Lou, S.-L. and Wang, J. (2010) “Thick-film textile based amperometric sensors and biosensors,” Analyst 135, 1230–1234.

BUILDING INFORMATION MODELLING (BIM) FOR SAFETY IMPROVEMENT IN SINGAPORE CONSTRUCTION

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Despite the decades-long efforts to improve safety in the construction industry in Singapore, the safety performance of the industry is still poor. The use of Building Information Modelling (BIM) has been a compulsory requirement for all building designs being submitted for regulatory approval; it was implemented in stages since 2013. A series of interviews was carried out in 2014 to investigate the views of practitioners on the current state of safety performance and BIM application in Singapore's construction industry, and explore the potential of BIM in contributing towards efforts aimed at improving safety on construction projects. The interviewees comprised a representative cross-section of relevant parties in the industry including policy makers, contracting companies, architectural firms, a cost consultancy firm, a professional institution and a trade association. The findings suggest that although the interviewees acknowledge the potential of BIM for safety improvement, the companies are currently not using it in a significant manner for that purpose. The industry is currently at a transition stage with a steep learning curve; in general, its application of BIM is still at a relatively elementary stage. Other than meeting the compulsory requirement of BIM submission, the firms use BIM mainly for visualisation. In the future, the industry should be able to make use of the potentials of BIM so that safety could be improved in the industry. To realise this, much will need to be done by government and industry to put in place the enabling framework, infrastructure and resources, as well as the motivation, commitment and appropriate mindset from the parties concerned.

Keywords: BIM, construction, industry view, safety performance, Singapore.

INTRODUCTION

Overview

The Ministry of Manpower (MOM) of Singapore outlined the national Workplace Safety and Health (WSH) 2018 vision, which is "A safe and healthy workplace for everyone and a country renowned for best practices in WSH". As part of the vision, the MOM aims to reduce the national fatality rate from work-related accidents to less than 1.8 per 100,000 workers by 2018. Another related aim is that Singapore, as a country, would hold one of the best safety records in the world. However, despite a programme for enhancing the safety performance of the construction industry in Singapore which has lasted over many decades, among the sectors of the country's economy, the construction industry has remained the largest contributor to the number of fatalities. Considering the government's big programme and series of initiatives in support of the implementation of Building Information Modelling (BIM), the aim of this study is to investigate the potential of utilising BIM as part of the effort to improve the safety performance of the construction industry.

The paper reports on part of a larger research project on productivity, safety and BIM in the construction industry in Singapore. The larger study examines the relationship between productivity and safety in Singapore construction; studies how BIM can be applied to improve performance in

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both parameters; and develops a system to guide decision making concerning both productivity and safety throughout the project. This paper presents the findings on safety and BIM. The objectives of this aspect of the larger project are to:

(a) assess the current WSH situation in the construction industry in Singapore and the factors which contribute to it;
(b) ascertain the level of implementation of BIM in the industry and the drivers and facilitators as well as the challenges and concerns of both administrators and practitioners;
(c) determine the potential of BIM in contributing to the efforts to enhance the safety performance of the construction industry; and
(d) propose further action that can be taken to accelerate the implementation of BIM in the construction industry, and particularly for the purpose of improving the industry's safety performance.

Current situation of construction safety performance in Singapore

Ofori et al. (2011) discuss the recent developments in the efforts to improve the safety performance of the construction industry in Singapore. They outline the development of the WSH regime for the industry, starting from the introduction of the new Occupational Safety and Health (OSH) framework on in 2005. It was followed by the Workplace Safety and Health Act (WSHA), which came into effect on 1 March 2006. Thereafter, the strategy, "Implementing WSH2015 for Construction Industry" was launched in 2007 to guide the efforts of the industry. The construction safety guide was then updated with the launch of "Implementing WSH 2018 for Construction Sector in Singapore" (WSH Council 2010). The new WSH framework (MOM et al. 2014) emphasises the importance of predicting, identifying, eliminating or mitigating risks before they manifest themselves. In line with this principle of the framework, the parties which create risks have the responsibility to eliminate or reduce those risks.

Despite the various efforts which have been made by both the government and the construction companies to enhance the safety performance of the industry, not much improvement has been realised owing to the large number of inter-related factors which influence safety performance in construction, including the structure of the industry, the nature of the construction process and the features of the items which are built and the components used to build them. Other reasons include the influence of factors outside the control of the participants in projects in the industry (Teo et al. 2014). Since the launch of the new WSH framework in 2005, all sectors of the economy in Singapore industries, except construction, have made good progress in their safety performance, and this has led to a decrease in the overall workplace fatality rate. It dropped from 3.1 per 100,000 workers in 2006 to 2.3 per 100,000 workers in 2013 (WSHI 2015). In 2014, Singapore's workplace fatality rate dropped to the lowest ever figure of 1.8 fatalities per 100,000 employed persons, which meant that Singapore had been able to meet the WSH 2018 target several years early (Khor 2015). Despite achieving the overall national target, there remains a persistent concern with reducing the number of fatalities in the construction industry.

Between 2009 and 2011, there was a decline in the fatality rates in the construction industry; the figure fell from 8.1 to 5.5 fatalities per 100,000 workers. However, the rates increased again to 5.9 and 7.2 per 100,000 workers in 2012 and 2013 respectively, whereas the overall Singapore fatality rates were 2.3 and 2.1 per 100,000 workers in 2012 and 2013 respectively. Although the fatality rate in the construction industry fell to 5.5 per 100,000 workers in 2014, the industry continues to report the highest number of workplace fatalities, compared to other industries including the marine and manufacturing industries, which can also be considered to entail high WSH risks (WSHI 2015).

BIM and its implementation in Singapore

The use of BIM in the construction industry has received considerable attention in Singapore over the past few years. The government-led effort is spearheaded by the Building and Construction Authority

(BCA). A target set by BCA in 2011 was that by 2015, at least 80 percent of the construction industry would be using BIM widely.

The Singapore government has identified BIM as "the key technology to improve productivity and level of integration across various disciplines across the entire construction value chain" (BCA 2013a). BIM is one of the recent key components of the programme put in place by the government of Singapore, through the BCA. The BCA has put in place a series of programmes for enhancing productivity in the construction industry (Ofori et al. 2011). The main objectives of the productivity drive have been to: upgrade the industry in terms of the application of technology and management systems; wean the industry away from labour intensive techniques; and reduce the reliance on foreign site workers. At the broad economy level, higher productivity would enhance levels of efficiency in construction in order to reduce lead times on investment projects; and ensure that the construction industry plays its part in the long-standing national effort to enhance productivity throughout the economy.

Whereas the push from the Singapore government for the construction industry to utilise BIM in Singapore is mainly for the purpose of improving the industry's productivity performance, it is appropriate for the industry to explore the broader potential that BIM can offer, including its possible contribution to the safety improvement drive. BIM, which involves a transformation of the traditional presentation of production information for building projects into computer-generated three-dimensional models, provides a platform for various building professionals to simulate, develop, analyse, test and review the results of the concepts, solutions or features of buildings. Smith (2007) considers the concept of BIM as being able to build a building virtually, prior to building it physically, in order to work out problems, and simulate and analyze potential impacts.

BIM offers a wide range of benefits to the participants in various stages of the construction process (BCA 2013a). It is suggested that it helps to save costs and time, improve quality. For example, BIM helps contractors to plan the entire construction process and material delivery through the computer simulation and determine, review and optimise the sequence of the building's construction (BCA 2011). From the perspective of safety, BIM helps designers and contractors to anticipate possible problems during the design stages of the project, and hence reduce the risks during construction. BIM has the potential to facilitate efforts to improve the overall safety performance on the construction project due to the elimination of potential risks and uncertainty (Smith 2007).

A number of authors have shown how BIM can be used to improve safety. Benjaoran and Bhokha (2010) developed a rule-based system that is able to detect any work-at-height related hazards and propose necessary safety measures. Zhang et al. (2013) developed an automated safety checking platform to prevent fall-related accidents. Choi et al. (2014) developed a BIM-based evacuation regulation checking system for high-rise and complex buildings.

There are many problems and challenges in applying BIM. These include the technical issues involved in developing the components of the models; interfacing among the participants, the direct cost of implementation, the need for new roles, skills and human resources. There is the need for a change in practices, procedures and mindset. The sheer inertia and resistance to change are key constraints to the adoption of BIM. Some of these challenges were outlined by Rajendran and Clarke (2011).

The implementation of BIM in Singapore has involved: (a) the development of a national roadmap and a series of technical guides; (b) appointment of a broad-based national steering committee; (c) a series of training programmes for practitioners playing different roles in the industry; (d) incentive schemes, mainly under the BIM Fund. The fund, which is part of the Construction Productivity and Capability Fund (CPCF) for BIM adoption, covers the costs for training, consultancy services and purchase of hardware and software for businesses and projects. Arguably the most important strand of the national BIM implementation strategy of Singapore is the regulatory one. Singapore is one of the first countries to make BIM utilisation compulsory for building control purposes (BCA 2011; 2013b). From 1 July 2013, the architectural plans for all new building projects with gross floor area (GFA) of

20,000 square metres and above being submitted for building plan approval must be in BIM format. This regulation was soon followed by another requiring BIM e-submissions for all engineering plans for new building projects with GFA of 20,000 square metres and above. Finally, from 1 July 2015, all plans for new building projects with GFA of 5,000 square metres and above have to be submitted to the approving authorities in BIM format.

The BIM strategy in Singapore appears to be successful. In 2013, a BCA survey found that 65 percent of the industry had adopted BIM, compared to 20 percent two years earlier (Quek 2013). Despite the promising development, there is still a lack of integration between BIM and other tools for hazard identification, risk assessment and other design processes (Ku 2014). Hence, this study investigates the industry's views towards the current state of safety and BIM application in the Singapore construction industry, and explores the potential of BIM in improving safety in the industry.

FIELD STUDY APPROACH

The information for the part of the field study reported in this paper was obtained in a series of interviews which were intended to establish the baseline in terms of the Singapore construction industry's practice of safety, the level of awareness of BIM and the status of its implementation.

The interview questions sought to find out the interviewees' current concerns about safety in construction in general and their companies' or institutions' policies on safety. The interviewees were also asked about their awareness of various government policies and incentives on safety and BIM, the extent to which they have taken up the various incentives and their experiences with the utilisation of the support initiatives. On BIM, the interviewees were also asked for their companies' and institutions' current practices and procedures, as well as their views on the benefits and enablers of, and obstacles to, the implementation of the technique. They were asked about the level of BIM utilisation in their companies; and their opinions on the potential of BIM generally, and its impact on safety performance in particular.

Eighteen in-depth, face-to-face interviews were conducted with representatives of twelve firms and institutions in the construction industry in Singapore from January to December 2014. The first group of firms and institutions which were interviewed were identified from reports indicating that they had played a key role in implementing BIM on their projects; or had exceptional safety performance records. The names of the subsequent interviewees were identified in a snowballing approach.

There were 30 interviewees altogether, and they included the key relevant people from six contractors, two architectural firms, one cost consultancy firm, as well as representatives from the government (including the BCA), and the leaders of a professional institution and a trade association in the construction industry in Singapore (Table 1). All the interviewees were holding senior management positions (they were of the rank of director and above).

Table 1: Profile of interviewees

No	Interviewee	Number of interviewees	Organisation type
1	1A, 1B, 1C, 1D, 1E, 1F	6	Contractor
2	2A, 2B, 2C	3	Contractor
3	3	1	Architectural firm
4	4A, 4B, 4C, 4D, 4E	5	Trade association
5	5	1	Professional body
6	6	1	Consultancy firm
7	7	1	Architectural firm
8	8	1	Contractor
9	9A, 9B	2	Contractor

10	10A, 10B, 10C, 10D	4	Government
11	11	1	Contractor
12	12A, 12B, 12C, 12D	4	Contractor

FIELD STUDY FINDINGS

Current concerns about safety in general

In general, the interviewees were of the view that safety is very important. As Interviewee 1A remarked, "There is no point in being productive but not safe." Many of the interviewees stressed that the top management's commitment to safety is of paramount importance. As Interviewee 1A remarked, "Safety is a long journey. The mindset must change from the top." His subordinate added, "What makes the difference is that my bosses go to the sites daily. When they go to the site, they are able to foresee the safety hazards, and identify what is the safest method and so on. This makes a lot of difference." As another interviewee remarked, when the decision maker has a poor attitude towards safety, he could make decisions that lead to unsafe conditions on site.

Teo and Phang (2005) had found that contractors understand the importance of having a safety culture but do not have the right mindset or attitude towards implementing it. Ofori et al. (2011) also found that it is the mindset of the developers, project managers, and contractors that should change. All the also interviewees acknowledged that safety culture is very important. They gave accounts of ways in which their firms promote safety culture. Some of the companies provide incentives such as safety bonuses. For example, the company of Interviewee 11 offers every worker S$50 (about 10 to 30 per cent of one-month's salary) for every three months of zero incidents on the project's site. and awards for workers with exceptional performance or attitudes with respect to safety. On many sites, the profile of the "Safe Worker of the Month" is prominently featured in the various languages of the site workers. Interviewee 8 mentioned that his company gives special Personal Protective Equipment (PPE) that will help the workers to work, such as a good helmet and leather gloves. Such gifts motivate the workers as they enhance the overall appearance and prestige of the winners wearing them, as compared to other workers with the normal PPE.

The interviewees mentioned a number of challenges that faced with regard to safety on site. While new workers may lack the necessary knowledge and working experience, managing experienced workers is not without challenges. Some experienced workers are complacent. Interviewee 1E recalled what one skilled worker with over 30 years of experience in the industry once said: "We have been working in this industry for a very long time and nothing has ever happened to us". This sentiment is shared by many of the older workers.

One challenge that many interviewees mentioned is that contractors need to work faster because of more demanding schedules in a relatively busy real estate market but at the same time, they have had to reduce the number of workers due to the prevailing implementation of the government's decision to reduce the number of foreign workers that a company is allowed to employ based on the nature, value and duration of the project (the Man-Year Entitlement) with the view to encouraging the construction industry to focus on improving productivity. As a result, safety may be compromised.

When asked about the causes of the recent spate of fatal accidents, the interviewees cited a number of reasons such as the reduction of the number of workers, fatigue among the workers, as well as lack of supervisors and safety officers. The interviewees were concerned with accidents on site, particularly owing to the consequences for the project as a whole. The key concern appears to be with the impact on the schedule. As Interviewee 8 mentioned, "There is nothing worse than if your site is being stopped". It is pertinent to note that, in Singapore, the MOM would order work on any site where a significant incident occurs to stop, while investigations are being undertaken.

BIM implementation

The interviews revealed that companies were operating at different levels with respect to BIM utilization. While some companies are at relatively advanced levels, and use the tool for sophisticated tasks, some use BIM merely to meet the requirements of the compulsory submission, and others apply it to simple tasks such as visualization. Thus, in some cases, the model which has been prepared at an earlier stage is subsequently used in a sub-optimal manner. Indeed, some companies have not even started using BIM. As Interviewee 2C remarked, "We don't use BIM because we need to work quickly".

In general, most of the interviewees whose companies have used BIM reported that their firms had benefited from it (a summary of their views is presented in Table 2). Among the benefits highlighted were improved communication and co-ordination among the members of the design team, as well as between contractors and the architects and other consultants. During the tendering stage, BIM helps to avoid the possibility of overlooking issues. BIM can also be used for co-ordination. The most frequently mentioned applications were: visualization and clash detection (especially in electrical and mechanical engineering works). One highly significant benefit of BIM which was highlighted by Interviewee 3 concerned dispute avoidance; this would be possible because of greater clarity, collaboration and sharing of information.

Table 2: Interview results - perceived benefits of BIM

Benefits of BIM	Interview results
(a) Communication	BIM facilitates communication among the project participants, especially among the design team, and between design team, and contractors and clients.
(b) Coordination	BIM allows project participants to work simultaneously. For example, BIM allows adjustment to information on the spot.
(c) Visualisation	Almost all interviewees mentioned that visualisation was a benefit from BIM. BIM helps project participants to visualise the construction process beforehand. This helps to minimise changes during construction. BIM is useful for the simulation of construction methods to be used in the project. For example, it can be used to determine the type of crane necessary for works at a certain height.
(d) Training	BIM could be used for training purposes.
(e) Safety measures	BIM helps in implementation of safety measures, for example, it can provide advice on where and how to install barricades and so on. BIM also helps in forecasting safety budgets. BIM helps in its ability to foresee hazards before the project starts.
(f) Clash detection	BIM helps in clash detection by checking the positions of objects and identifying interfering objects. It can also help to resolve accessibility issues.

While many of the interviewees reported that their companies have realised benefits from BIM implementation, a few of them had not seen such benefits, and remained skeptical about the technology. Table 3 outlines the challenges that the firms of the interviewees face in implementing BIM. The key issues mentioned were lack of standardisation in practice in BIM preparation; technical issues relating to the tool itself and interface problems; the low level of development of the necessary library for BIM; the shortage of trained human resources; and the legal issues which have not yet been resolved.

A challenge that the company of Interviewee 1A had to face as a contractor was that it had to take the initiative to train personnel. From the interviews, it was evident that most construction project participants in Singapore are still not conversant with BIM and the details its implementation requires, such as code checking and, distance measurement. All these require a significant amount of investment in terms of equipment and training by the companies in the industry.

Table 3: Interview results - perceived challenges of BIM

Challenges of BIM	Interview results

(a) Standardisation	There is a lack of standardisation of various aspects of modelling such as the size of columns and staircases. As many parties have their own preferred ways, a significant amount of time was spent on re-modelling and checking. In addition, BIM models submitted for building control approval purposes are often not up to the standard required in the subsequent stages.
(b) Change of mindset	Contractors sometimes encounter reluctance from site personnel due to lack of awareness of the benefits of BIM. They also mention additional time and commitment required for updating the models throughout the duration of a project. There should be a change of mindset from the subcontractors as well, as they are used to 2D drawings instead of 3D models.
(c) Technical issues	All interviewees encounter technical issues including interface issues, the loss of information when transferring the models from one software to another, license, bandwidth and security issues.
(d) Library	The construction industry is still building up a comprehensive library for modelling purposes.
(e) Resources	There is still a shortage of people who are competent in BIM. It is even more difficult to find the people with the necessary experience in the construction industry. Hence, such people are in high demand and companies face disruptions to their work as there is high turnover among such persons.
(f) Lead time	The companies in the industry are not ready for a full BIM implementation; sufficient time must be given to them to develop the necessary infrastructure and resources to implement BIM.
g) Legal framework	There are still uncertainties of who is legally responsible for the models which are developed on projects. There is also an issue of the maintenance costs of the BIM server. The contract for the project has to consider these elements.

The interviews revealed that the most common obstacles to the implementation of BIM are interface issues, legal issues, and considerations of cost (investment in equipment and training) and time (for building the model). Government incentives have been a great help for the companies. Many of the companies have used the funding provided under the government's incentive schemes to the maximum possible extent. More support is needed. In particular, subcontractors are in great need of assistance. In the administration of the support schemes, procedures such as the requirement to submit quarterly reports and the process for reimbursing beneficiaries for approved expenditure could be simplified to reduce the amount of work needed.

BIM and safety

The interviewees were asked specifically to give their views on the potential of BIM to enhance safety in construction. As shown in the summary in Table 2, many of the interviewees perceived that BIM could play a role in the safety effort. The biggest advantage of BIM in this connection would be its ability to give warnings about hazards before the project starts. It also helps in the visualization of workflow. Among other things, this enables proper scheduling of the works. Some of the interviewees were most keen on how BIM enabled the Project Manager (concerned with schedule performance) and Safety Manager to reduce the possible conflict between speed at work and the need for caution to avoid accidents on site. This conflict was mentioned by a number of the interviewees.

Other possible contributions lay in the opportunity BIM provides for complex parts of buildings to be modelled, and precautions to ensure safe working to be taken. By enabling conflicts to be resolved, and proper sequencing of work to be done, it facilitates the development and application of good work practices.

It should be noted that not all the interviewees were convinced of the potential for a beneficial relationship between BIM application and safety performance. For example, Interviewee 1A, a contractor, did not believe that BIM is beneficial when one considers safety on site. He cautioned, "BIM is a useful tool but safety depends so much on the people on site." However, Interviewee 1A did note that BIM could help by enabling the workers and supervisors to visualise the sequence of work. While there are many efforts that could be made to prevent accidents, the interviewees are of the view that safety on site depends on the workers, the day-to-day activities and the conditions on the site. Hence, despite the availability of BIM as a tool that can help to address safety concerns, the safety team on site still needs to brainstorm and discuss the conditions on site and identify best approaches to particular tasks on a daily basis.

CONCLUDING REMARKS

The findings from the study suggest that although construction practitioners in Singapore acknowledge the potential of BIM to contribute to safety improvement efforts, the companies are not taking full advantage of the tool. The industry is currently at a transition stage with a steep learning curve. Firms prepare BIM models simply to comply with the compulsory requirement of BIM submission. The models are not yet being used to enhance the performance of the construction industry on all the relevant parameters, including safety where performance remains particularly poor. For example, BIM could be used as a rule-checking platform which is integrated with safety tools and assessments.

Before that, the industry must be able to overcome the challenges and address the issues and concerns regarding BIM implementation and effective application. The issues that the industry is facing include the shortage of BIM-competent personnel, development of the comprehensive library, technical issues, as well as funds for the necessary investment in equipment and resources. As yet, there has also not been full participation in the implementation and application of BIM on projects by the various parties. This limits the potential benefits from the tool.

Regulation has helped to push the implementation of BIM in the industry in the right direction. However, in the long term, for an effective and successful implementation of BIM in the firms, there needs to be the vision and commitment from the top management. There should also be buy-in by all employees including the site personnel, and the subcontractors.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the funding received from the Workplace Safety and Health Institute (WSH Institute) of the Ministry of Manpower (MOM). They are also grateful to the collaborating organisations, the Building and Construction Authority (BCA) and Samwoh Corporation Pte Ltd, for their support. The authors would also like to thank the interviewees for their time and insights.

REFERENCES

Benjaoran, V and Bhokha, S (2010) An integrated safety management with construction management using 4D CAD model. "Safety Science", 48(3), 395-403.

Building and Construction Authority (BCA) (2011) "Media Release: Construction Productivity Roadmap to chart transformation of the construction sector". Singapore: BCA. Retrieved from http://www.bca.gov.sg/newsroom/others/pr03032011_CPA.pdf.

Building and Construction Authority (BCA) (2013a) "Building Information Modelling". Singapore: BCA. Retrieved from http://www.bca.gov.sg/bim/bimlinks.html.

Building and Construction Authority (BCA) (2013b) "Singapore BIM Guide Version 2". Singapore: BCA. Retrieved from https://bimsg.files.wordpress.com/2012/04/singapore-bim-guide_v2.pdf

Choi, J, Choi, J and Kim, I (2014) Development of BIM-based evacuation regulation checking system for high-rise and complex buildings. "Automation in Construction", 46, 38-49.

Khor, A (2015) "Speech for WSH Institute Forum on 11 March 2015". Singapore.

Ku, K (2014) Design risk management practices and assessment tools for safety in construction: opportunities for BIM. In Aulin, R and Ek, Å (Eds.), "CIB W099 International Health and Safety Conference: Achieving Sustainable Construction Health and Safety", 2-3 June 2014, Lund University, 180-191.

Ministry of Manpower (MOM), Workplace Safety and Health Council (WSH Council) and Workplace Safety and Health Institute (WSH Institute) (2014) "Workplace Safety and Health Profile 2014". Singapore.

Ofori, G, Teo, E A L and Tjandra, I K (2011) Safety in Construction in Singapore: Policies, Assessment and Further Development. In "Proceedings of the CIB W099 Conference 2011: Prevention - Means to the End of Safety and Health Injuries, Illnesses, and Fatalities". Washington, D.C.: CIB.

Ofori, G, Teo, E A L and Tjandra, I K (2011) "A decade of change and Improvement? Construction industry development programmes in Hong Kong, Singapore and United Kingdom". Unpublished Research Project Report, National University of Singapore.

Quek, S T (2013) "Welcome Speech at the Built Smart Conference (Innovate, Integrate and Transform with BIM)", 1 August. Singapore: BCA. Retrieved from http://www.bca.gov.sg/newsroom/others/CMsp01082013_BIM.pdf.

Rajendran, S and Clarke, B (2011) Building Information Modeling: Safety Benefits and Opportunities. "Professional Safety", October, 44-51.

Smith, D (2007) An introduction to building information modeling. "Journal of Building Information Modeling", Fall, 12-14.

Teo, A L and Phang, T W (2005) Singapore's contractors' attitudes towards safety culture. "Journal of Construction Research", 6(1), 157-178.

Teo, E A L, Ofori, G, Tjandra, I K and Kim, H (2014) The Potential of BIM for Safety and Productivity. In Aulin, R and Ek, Å (Eds.), "CIB W099 International Health and Safety Conference: Achieving Sustainable Construction Health and Safety", 2-3 June 2014, Lund University, 618-627.

Workplace Safety and Health Institute (WSH Institute) (2015) "Workplace Safety and Health Report, 2014 National Statistics". Singapore: WSH Institute.

Workplace Safety and Health Council (WSH Council) (2010) "Implementing WSH 2018 for Construction Sector in Singapore: Towards a Progressive and Pervasive Safety and Health Culture". Singapore: WSH Council.

Zhang, S, Teizer, J, Lee, J, Eastman, C and Venugopal, M (2013) Building Information Modeling (BIM) and Safety: Automatic Safety Checking of Construction Models and Schedules. "Automation in Construction", 29, 183-195.

A REAL-TIME MONITORING SYSTEM FOR IMPROVING CONSTRUCTION WORKERS' HEALTH AND SAFETY

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While previous research have been undertaken to improve construction site safety, from manual handlings, management systems, to human skills, behaviors and culture, it is believed that the next step must focus on application of information technology (IT) on construction sites. The aim of this research is to design and develop a real-time system for monitoring construction sites workers' health and safety conditions. Through the university-industry collaborative effort, a real-time monitoring system is designed and developed and it is currently being pilot applied in a construction site. This system has the following functions: (1) Real-time monitoring of workers' physiological conditions (such as heart beat rates, and body temperatures); (2) Real-time tracking of worker's physical working positions and conditions (such as heights and locations); (3) Real-time communication between managerial staff and site workers. This paper also explains various information technologies adapted for developing the system, together with discussions of the advantages of this system. In addition the paper discusses the costs, training and ethical issues in relation to the development and application of the system. Furthermore, it highlights the lessons learned from the development process, and discusses potential future research. This research contributes to advanced information technology development for improving workers' health and safety on construction sites.

Keywords: information technology (IT); real-time; tracking; monitoring.

INTRODUCTION AND RESEARCH AIM

Construction projects are characterized by its unique, dynamic, and complex nature, including large amounts of investments, multiple stakeholders' involvements, long construction period, application of new materials and new construction technologies, unknown site conditions, and many different trades and workers working on the site concurrently. These characters are likely to increase workers'

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exposure to hazardous working environment. Construction safety management involves cares and planning throughout the entire project life cycle from the design to the construction execution (Zhang et al., 2013). Traditionally, on-site observations, on the basis of weekly, bi-weekly or monthly, are typically conducted for safety managements, and inspectors make inspection notes depending on the one to two hours on-site observations at a randomly scheduled time (Seo et al., 2015). However, the manual inspection notes suffer from the limitations of missing, inaccurate records, different understandings of observed issues and non-uniform writing styles (Taneja et al., 2010); in addition, the inspection reports are rarely used for further analysis of safety issues (Lin et al., 2014). Furthermore, on-site environment continuously change over time and skilled supervisory manpower is not always present at sites (Laitinen et al., 1999). Thus, a major challenge is formed for the traditional construction safety management, and the implementation of manual observations and recording processes in construction safety practice could not serve as an effective method in monitoring the health and safety of on-site workers.

Information technology (IT) is emerging as a potential solution in making construction sites safer and preventing injuries. IT is being used to improve construction safety through advanced design technology, on-site real-time communication and real-time monitor. Emerging information technologies have different impacts in different situations on construction sites. Designing for safety is one area where IT is becoming more widely used and accepted (Naticchia et al., 2013). On-site communication and monitoring is another area where IT can be used for safety management. Introducing tracking and technologies on sites is one way to improve communications in safety management. Implementation of IT in monitoring individual health and safety is also being introduced onto construction sites. In particular, several ITs, such as automated and robust means of on-site observations, have been applied for construction safety management in recent years, such as: RFID (radio frequency identification system), RTLS (real-time locating system), GIS (geographic positioning system) and BIM (building information modelling). Previous research has investigated the development and application of such IT for tracking, detecting and recognizing objects on construction sites. These technologies are discussed in the following sections.

Communication and Positioning Technology for Improving Safety

Radio-Frequency Identification (RFID) positioning system, based on real-time locating system (RTLS), using a wireless sensor technology consisting of RFID tags and readers that uses electromagnetic signal detection to communicate with each other via radio frequency (RF) signals within a reasonable range. RFID as a form of tracking information technology has been introduced to construction sites for advanced communication. An RFID system typically consists of RFID tags and readers that communicate with each other via radio frequency (RF) signals within a reasonable range (Cai et al., 2014). Andoh et al. (2012) stated that application of RFID technology on construction sites is very diverse and is being applied in different areas and on different resources. Chae and Yoshida (2010) concluded that an RFID location system is effective in preventing certain dangerous situations including collisions with heavy equipment. Wu et al. (2010) proposed a similar RFID system which can be used on construction sites to prevent struck-by-falling-object accidents. Peinado et al. (2009) reported the successfulness that the RFID technology had in the use of underground mining, in which the technology could track workers who had entered or left the tunnel and allow managers to know where people were at all times. Guo et al. (2014) also developed a conceptual system in which RFID was used to improving construction site safety.

Another technology, namely Ultra Wide-Band (UWB) which is considered to be a form of RFID system is also having an impact on site safety. The UWB is said to be able to transmit more information than the RFID with less interferences and have a greater range of coverages (Mulloy, 2004). Hwang (2012) stated that the UWB technology can effectively track tower cranes to prevent collisions and it has the potential to be extended past simple tracking and locating tasks. The real-time tracking that RFID and UWB provide allows the speed and trajectories of site resources to be measured. After these data is analyzed, safer site travel patterns can be identified to improve work practices (Carbonari et al., 2011).

Wireless sensor network (WSN) is another form of communication technology that is being used on construction sites. WSN is a system, in which large sensor nodes are spatially distributed on a construction site and are able to interact with the physical world (Li and Liu, 2007). (Wu et al., 2010) also revealed that similar to RFID and UWB technologies, wireless sensor networks are able to track and monitor chosen site assets and resources.

Geographic Positioning System (GPS) as a positioning technology is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. It can be used for construction site location identification.

Physiological Monitoring Technology for Improving Health

Physiological status monitors (PSMs) are wireless, non-invasive monitors that are worn to determine physiological constraints in the human body. Gatti et al. (2014) researched the effect that certain PSMs can have on construction sites in identifying workers who were being over-worked. They concluded that the heart rate and breathing rate monitors that were worn by participating workers are effective when measuring the physiological demands on construction sites in an unobtrusive manner. Although this technology can be seen as a communication technology, it focuses on individual's wellbeing and safety; this separates it from the general communication technology such as RFID (Gatti et al., 2014). Cheng et al. (2012) also recognized physiological monitoring can help identify and eliminate risks which derived from overexertion. However, Cheng et al. (2012) pointed out that a problem with PSMs was that the system did not record the locations on where the unsafe activity was taking place. To counter this problem, participants in a study wore tracking technologies (UWB) as well as a PSM; results showed the fused technologies enabled monitor the locations and physiological status of construction workers successfully.

Summary of Current Literature

In summary, research about IT application in construction safety can be categorized into three groups:

- Development of specific technologies. For example, improve the accuracy and reliability of RFID location systems (Cai et al., 2014); maintain enough signal availability by overcoming the effect from obstacles in worksites (Lee et al., 2011); integrate multi IT functions to make full use of them (Cheng et al., 2012, and Guo et al. 2014).
- Application of IT for specific safety scenario. For example, warning systems building for hazards prevention (Guo et al., 2014); safety management for specific construction tasks, such as: enhancing safety of scaffolding safety enhancement (Zhu et al., 2013), crane operation plans (AlBahnassi and Hammad, 2011), prevent collision accidents of workers with heavy equipment (Chae and Yoshida, 2010).
- Application of real-time IT monitoring systems, such as moving and static obstacles (Teizer et al., 2007); tracking 4- dimensions of construction site dynamics (Andoh et al., 2012).

The existing research of IT application in construction safety management, to some extent, has overcome the limitations of manual safety observations by real-time on-site monitoring and information communication. However, detail analysis reveals that several challenges still exist. First, the vision device, such as video camera, usually is installed in fixed positions, which resulted in limited vision ranges, and likely be affected by the dynamic nature of construction site environment. Second, previous research mainly focus on material detections and worker's locations, ignored the workers' physical and physiological status (heart rates, body accelerations, postures), which are of great importance for healthy and safe operations. Third, most of previous studies used IT only for on-site management, lack of making full use of the information for assessing individual worker's performances and develop early warning systems by analyzing safety risk scenarios. Fourth, most of the frameworks proposed by previous research remained at the design and experimental stage, seldom of them made into real product. These limitations need to be overcome in order to achieve better effectiveness and practicality of IT applications in construction health and safety.

Research Aim

The aim of this university-industry collaborative research project is to design and develop a state-of the-art real time monitoring system which can address the above mentioned problems by integrating various ITs (RFID, sensors, video camera and communication device) to collect more information and facilitate on-site communications and monitoring of workers. This research distinguish itself from the existing research for two main reasons: First, it is a university-industry collaborative research project, and second a real system has been developed and currently being pilot applied on a construction site, while previous research only developed conceptual systems (e.g. Guo et al. 2014). The paper reviewed the current research on commination technologies and onsite monitoring systems. This innovative system is introduced and developed to specify the concepts and functions to improve workers' health and safety. Potential application issues are discussed to draw researchers' attention to further develop the effectiveness and practicality of the system in construction site management.

DESIGN AND DEVELOPMENT OF THE SYSTEM

In order to address the current limitations and achieve the research aim, the following sections present a case example which is a real-time monitoring system, and discuss its development process and the main functions. The system has been already developed by the construction technology company, in collaboration with the university. Specifically, the case study starts from introduction of the system's components; then it moves on to discuss the system's operational principles. Afterwards, the specific system functions are introduced. Subsequently, how this system can be used for better on-site construction health and safety management is discussed.

System Components

The whole system can be contained in a brief case, as showed in Figures 1. The system container features some quarantine spaces for well-placement of different devices, and in order to make good adaption of the complex construction environment, the case is made by engineering plastic to make it waterproof, dustproof, anti-collision. Table 1 provides details on the functions of each device.

Smart watch

The smart watch (as shown in Figure 1), is one of the most important functional devices in the system, and it features with workers' physical conditions and physiological status information collection and precise positioning. The compositions and functions of the smart watch are shown in Figure 2. The bracelet of the smart watch is made of rubber, the watch band and watch clasp can make it detachable. The display screen is used for data display and the switch is used for controlling data collection and transmission. The embedded PCB (printed circuit board), which links the battery and other sensors, is used for data analysis.

Figure 1 The system including the smart watch (shown on the right hand side)

Figure 2 The compositions of the smart watch

Table1 Functions and devices of the system components

Functional classification	Devices
	Smart watch, iPad
Data collection	Intelligent helmet (with video camera)
	Safety belt
	Data cable
Data transmission	WIFI
	Keyboard and Mouse
	Tablet
Data analysis	iPad
	Portable Power
Other component	Torch light
System Container	The Case

System Operation Principles

Figure 3 shows the operational principles of the system, which includes (1) data and information collection, (2) internet/WIFI-based data and information transmission, and (3) information processing and analysis as well as displaying.

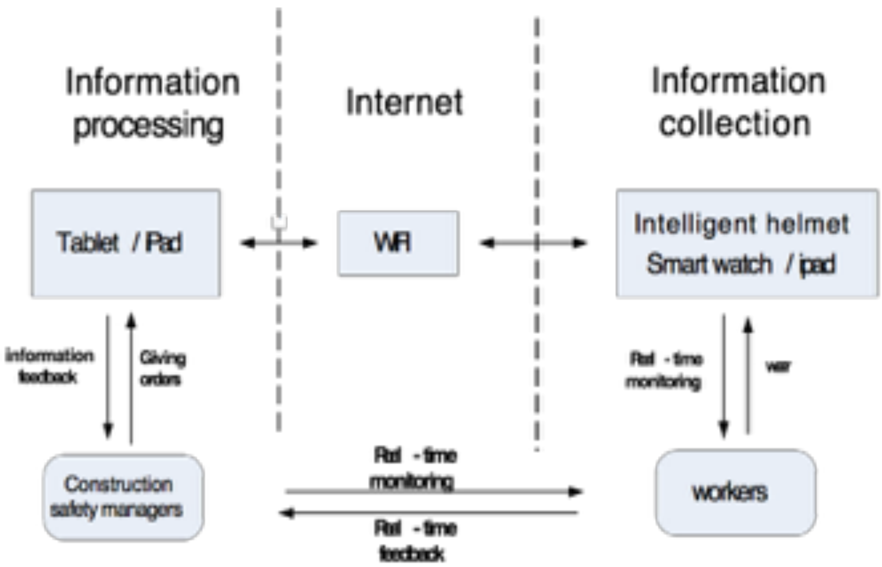

Figure 3 Operation principles of the System

Based on the internet WIFI which covers the whole construction site, a real-time monitoring and communication can be built between the managers' tablet (or iPad) and the workers' intelligent helmet (with video camera) and the smart watch (or iPad). The information about workers' physical conditions, physiological status, onsite locations and the construction progresses, which are collected through the intelligent helmet (with video camera) and the smart watch or iPad, can be transmitted to technical/managerial staff (such as safety managers), then, real time monitoring and management are achieved.

The intelligent helmet is not only used for protecting, but also for monitoring and data capturing by the miniature high definition video camera and communication devices that are embedded in it. Furthermore, the video camera can help managerial staff to check construction progresses and monitor the workers physical positions and the potential on-site blind spots; the communication devices allow managerial staff in real-time give safety instructions and suggestions. The operational principles of the smart watch can be explained by introducing the sensors embedded in it.

- **Heart rate sensor**--- helps managers and the workers monitor the physiological status of workers. It also provides self-checking and warning to the workers.
- **Pressure sensor**--- helps managers and workers know the altitude of the workers.
- **Temperature sensor**--- helps managers and workers themselves monitor the workers' body temperature and working environment temperature, prevent heat stroke from occurring.
- **Acceleration sensor**--- could collect movement data of individual workers.
- **GPS and RFID reader**---RFID reader help to locate workers by reading the information of RFID label which set in different part of the construction site. When a worker walk passes one RFID label, the smart watch will display the current location, and check this information with GPS, to get correct location information and to eliminate the positioning errors.
- **Module tab**—the tab set in the smart watch, is used to store workers' code and work type. When the other information of workers are sent to managers' Tablet/iPad, they will be matched with the work type and personal code, then the managerial staff can have a clear understanding about the information of specific workers, which is a useful way for arrangement of onsite personnel.

System Functions

The main functions of this system included:

1. **Real-time monitoring of workers' physiological information**: In the smart watch, temperature sensor and heart rate sensor are embedded, and they can monitor and send the workers' physiological conditions to managerial staff through the system. Should there be a limit reached, (for example too high heart rate or too high temperature of the working environment) the system will send a warning signal to the managerial staff, so that they can communicate with the worker and make suggestions to the worker to change the situation.

2. **Real-time monitoring of worker's physical working location and position**: In the smart watch, the embedded pressure sensor, GPS and RFID locating system, can be used to analyze position of workers on a construction site. The high definition video camera, which is embedded in the intelligent helmet, can take photos and videos at anytime and anyplace where workers arrive or work; thus, real-time information regarding workers physical positions, body pressure, etc. can be provided to managerial staff. As a result, the effectiveness of daily management and risk prevention are developed.

3. **Auxiliary lighting**: In the system, detachable LED torch light can be held or attached to any facilities; this is helpful, especially for night lighting and local illumination.

DISCUSSIONS

Advantages of the System

In the design process of the system, the research team have reviewed the current IT development and application in relation to construction safety (as discussed in the previous sections), to ensure the system's effectiveness and practicality. Basically, the advantages of this system can be summarized as below:

1. **Real-time monitoring of workers condition and construction site**: In many other IT applications, the cameras, which are applied to capture images and videos of construction sites, have been installed in fixed positions, resulting in limitations of vision range and ignorance of blind spot. In this curent system, the high definition video camera is installed in the helmet and therefore largely overcomes these limitations by the moving nature with the workers' movement around the site; besides, the managerial staff can request workers to observe the construction site specific areas where they want.
2. **Focusing on physical and physiological conditions**: the system pays particular attention to collecting and analyzing data related to workers physical and physiological conditions. For example, the system can track workers working location and height by using the GPS, RFID, pressure sensor and acceleration sensor so that to analyze the level of 'working at height' risk. Besides, workers' physiological status can be obtained by analyzing their body temperature and their heart beat rates. Apart from being equipment for data collection, the intelligent helmet is also a safety helmet and together with the safety belt function as a set of PPE (personal protective equipment) for site worker to improve their safety.
3. **Optimizing worker safety management system:** Real-time collecting, analyzing and sharing the information about the physical condition, location and work type of particular workers, help to improve worker's safety behavior, and establish worker' archives. The system can help to build the archives of workers, assess their work performance, which is of great importance for targeted safety training.
4. **Developing effective real-time communication:** By using the communication devices in the system, the timely information communication and sharing can not only achieve among managerial staffs, but also between the managerial staff and workers. As a result, different information and instructions can be transmitted and shared with high efficiency.

Cost, Training and Application of the System and Ethics

- **System Cost:** The costs can be divided into three components, human resource costs, equipment/device costs and operation/maintenance costs. The human resource costs include those who were involved in the research and development process. Apart from the research undertaken by the university team, the collaborative company also have a team of 4 people undertaking trial and error process in developing the system, this is in addition to the programming that was subcontracted to professional programming firms. The estimated sum of human costs is around $200,000 Chinese Renminbi (RMB). The cost for purchasing the various devices and equipment are around $70,000- 80,000 RMB, these two items added up to be around $300,000 RMB, which is about US$50,000. The system maintenance costs is yet to be known, but would not be high as nowadays electronic devices' and equipment's prices are dropping while the quality and functions are improving.
- **System Training:** The system is designed to be user friendly by using most current IT. Only 3 to 4 hours of training would need to be provided to the workers so that they know what functions are available and how to operate the smart watch, the intelligent helmet or the iPad.
- **System Application:** The system is currently being applied in a construction site. Ten workers have been provided this system, which include intelligent helmet, smart watch, safety

belt and iPad. The construction manager and safety manager are using this system (i.e., the tablet or iPad) to communicate with these 10 workers onsite. Lessons will be drawn from this pilot application, fine tune and improvement of the system may be needed before full scale application implemented.

- **Ethics:** One may raise ethical issue as such system could be abused and over used for monitoring workers every movement and behaviour onsite, which may indirectly cause psychological pressure to the workers. However we would argue that the aim of developing and applying this system is to protect and improve workers' occupational health and safety, by letting them and the management team know about their on-site health statutes and physical working conditions. The system can also be used for checking on-site 'blind-spots', monitoring 'worker's safe behaviour', identifying 'no-entry zone'. The data and information can be used to analysis so that to improve the construction site conditions. In a word, we argue that one should view the system from a positive angle. As such the workers should have a feeling of 'being cared by the management' instead of feeling of 'being watched by the big brother'. Nevertheless, relevant ethical policies and guidelines need to be developed and implemented for using such real-time monitoring system, to ensure that the system will not be over used or abused.

CONCLUDING REMARKS AND FUTURE RESEARCH

This paper has reviewed the current literature in the areas of IT-enabled on-site monitoring systems, with specific focus on workers' health and safety conditions. Following this, a real-time health and safety monitoring system is presented: First, the high definition video camera is installed in the helmet and therefore overcomes the vision range limitations. Second, worker's physical and physiological information, which have been regarded as one of the most important causes of accidents, are obtained from the helmet, smart watch and iPad, and transmitted to managerial staff's iPad/Tablet. Third, managerial staff can communicate with the workers about occupational health and safety in real time. Fourth, the information collected by the system can be analyzed for optimizing worker resources management and safety performances assessments. Last but not the least, the system has already been developed as a real product, and currently being trial applied in a construction site.

Based on the development of the system, it is found that there is great potential to improve construction site safety by utilizing IT. Meanwhile, the current IT application is mainly focused on the real-time information collection, which is just one part of the entire safety management; how to make more use of IT for a comprehensive and systemic safety management needs more efforts. Besides, how to make wearable IT devices more suitable for construction workers is of great importance. These two issues, as future research, are discussed as below:

Developing comprehensive on-site safety management system: It includes two parts: (1) develop early warning systems at the workers end. Based on relevant arithmetic, the system should be able to automatically identify risk scenarios, and then workers should be alerted to stop or watch out. This is important in construction practice, especially on large construction sites with hundreds, even thousands of workers on sites at peak operations. An automotive warning system can be used as a supplementary or prior-control method, to help worker avoid safety risks themselves and reduce the workload of managerial staff. (2) Make full use of the collected information for better construction management. The information collected from work sites can be transmitted, analyzed and stored in standard format and structure; it can be applied not only for employees' working capability assessment, but also for project implementation. This means a database, which includes all on-site information, can be built for future safety risk analysis.

Wearable technology: Nowadays, it has been applied in many aspects of our lives and work places, such as the smart watch to monitor health conditions, the smart helmet for construction workers (Carter C, 2015). However, these wearable devices are not in common use yet. In the construction context, the wearable devices play a vital role in safety risk alerting, real-time monitoring and information collecting. How to make the wearable device more comfortable, cheaper and more functional, is a key for successful construction site safety management.

Further application and improvement of the system: This system will be continuously refined, improved and applied to construction sites. The future improvement of the system will take into consideration of the issues discussed above. The university and the company will continue collaborate and undertake sociotechnical research parallel with the system application and feed the research findings back to the system refinement and improvement, by adapting the research-practice nexus framework developed by Zou and Sunindijo (2015).

REFERENCES

ALBAHNASSI, H. & HAMMAD, A. 2011. Near real-time motion planning and simulation of cranes in construction: Framework and system architecture. Journal of Computing in Civil Engineering, 26, 54-63.

ANDOH, A. R., SU, X. & CAI, H. A framework of RFID and GPS for tracking construction site dynamics. Proceedings of the ASCE Construction Research Congress (CRC), 2012.

CAI, H., ANDOH, A. R., SU, X. & LI, S. 2014. A boundary condition based algorithm for locating construction site objects using RFID and GPS. Advanced Engineering Informatics, 28, 455-468.

CARBONARI, A., GIRETTI, A. & NATICCHIA, B. 2011. A proactive system for real-time safety management in construction sites. Automation in Construction, 20, 686-698.

CHAE, S. & YOSHIDA, T. 2010. Application of RFID technology to prevention of collision accident with heavy equipment. Automation in Construction, 19, 368-374.

CHENG, T., MIGLIACCIO, G. C., TEIZER, J. & GATTI, U. C. 2012. Data fusion of real-time location sensing and physiological status monitoring for ergonomics analysis of construction workers. Journal of Computing in Civil Engineering, 27, 320-335.

GATTI, U. C., SCHNEIDER, S. & MIGLIACCIO, G. C. 2014. Physiological condition monitoring of construction workers. Automation in Construction, 44, 227-233.

GUO, H., LIU, W., ZHANG, W. & SKITMOR, M. 2014. A BIM-RFID Unsafe On-Site Behavior Warning System. Bridges, 10, 9780784413777.040.

HWANG, S. 2012. Ultra-wide band technology experiments for real-time prevention of tower crane collisions. Automation in Construction, 22, 545-553.

LEE, H.-S., LEE, K.-P., PARK, M., BAEK, Y. & LEE, S. 2011. RFID-based real-time locating system for construction safety management. Journal of Computing in Civil Engineering, 26, 366-377.

LI, M. & LIU, Y. Underground structure monitoring with wireless sensor networks. Proceedings of the 6th international conference on Information processing in sensor networks, 2007. ACM, 69-78.

MULLOY, J. 2004. Ultra wideband RFID technology [Online].

PEINADO, S. P., RICO, A. J. V., CAON, J., DE LAS HERAS, J. J. & MIERES, J. M. RFID-based quality and safety building site improvement during execution phase. Industrial Electronics, 2009. IECON'09. 35th Annual Conference of IEEE, 2009. IEEE, 2659-2664.

TEIZER, J., CALDAS, C. H. & HAAS, C. T. 2007. Real-time three-dimensional occupancy grid modeling for the detection and tracking of construction resources. Journal of Construction Engineering and Management, 133, 880-888.

WU, W., YANG, H., CHEW, D. A., YANG, S.-H., GIBB, A. G. & LI, Q. 2010. Towards an autonomous real-time tracking system of near-miss accidents on construction sites. Automation in Construction, 19, 134-141.

ZHANG, S., TEIZER, J., LEE, J.-K., EASTMAN, C. M. & VENUGOPAL, M. 2013. Building information modeling (BIM) and safety: Automatic safety checking of construction models and schedules. Automation in Construction, 29, 183-195.

ZHU, X., XUE, X., CHEN, M. & ZHOU, H. 2013. Mobile IT used in construction: a case for scaffolding safety management. Bridges, 10, 9780784413135.046.

ZOU, P. X.W. & SUNINDIJO, R. Y. 2015. Strategic Safety Management in Construction and Engineering, Wiley-Blackwell.

A BIM DATABASE FOR CONSTRUCTION SITE SAFETY CHOICES

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Construction site planning starts from the early design phase in order to drive all designers to safety-oriented choices. Therefore, a great deal of collaboration between designers of different disciplines is necessary, starting from the first steps of each project. Nowadays BIM is certainly the best method to provide a good design and great interoperability between different actors. Nevertheless, a lack of BIM tools for site designers is apparent. In particular, there is the need of specific tools in order to study working places and their interference situations that mainly affect safety. A database of technical solutions for potential neighbouring working places has been developed and is reported herein. It is primarily made up of a BIM objects library of construction site facilities and safety devices to be used by the site-designer in the model in order to simplify and accelerate construction site choices. The database has been created to be suitable for a number of typological projects, but also usable for situations not yet completely clear due to an early stage of design. For this reasons it has to be complete and standardized enough, with a detail level appropriate to represent working situations and related risks. The definition of the database elements has followed the sequent empirical steps: (i) definition of a typological solution for neighbouring working-places; (ii) research of a specific solution developed in past interventions and/or manufacturers' datasheets; (iii) parametric modelling of the facility; (iv) testing its use in a case study; (v) object adjustments according to case studies results; (vi) retesting on another case study, etc. The first three complete tests demonstrated the usefulness of the case studies in database increasing implementation. Application in case studies has demonstrated also the usefulness of such a database for safety planning during design, in particular for risk assessment and site logistic planning.

Keywords: construction site logistics, construction planning, health and safety, risk identification, BIM.

INTRODUCTION

A typical construction project is characterized by some overall needs. For example quality, expected time and cost compliance, productivity, profitability. Good performance can be achieved if compromise between all these needs is found. However, workers' health and safety has always to be guaranteed among these needs.

In order to better evaluate the satisfaction of these needs, a questionnaire has been completed by construction professionals directly involved on safety matters. One hundred construction professionals have been involved in completing the questionnaire during training courses for health

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and safety coordinators. The questionnaire, carried on by the authors, is made up of twenty multiple-choice questions. The first questions concern the feelings about the present of construction industry trying to underline strength and weakness of construction works. Other questions concern the possible future of construction industry. The final questions concern position and competences of the interviewees in order to characterize the survey sample. Construction sites has been characterized by value (from <700 k€ to >10M€) in order to better categorize the sample. Figure 1 highlights the survey findings that each type of site is often characterized by extra costs and delay.

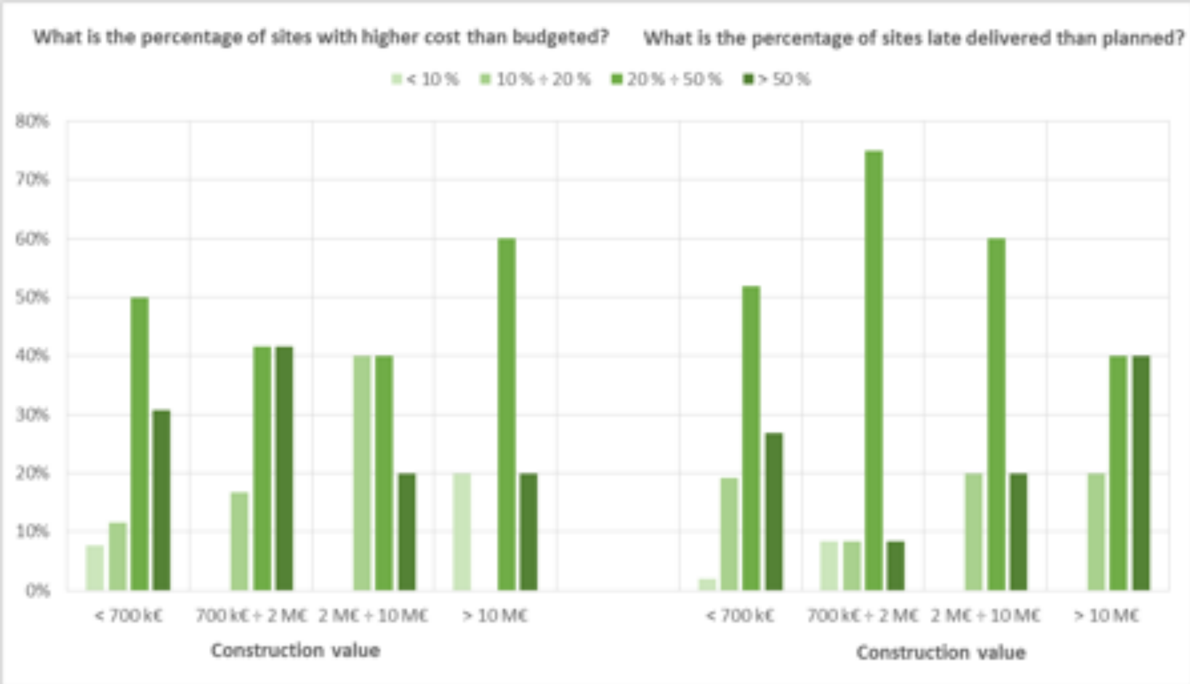

Figure 1: Extra-costs and extra time results according to the questionnaire.

According to the majority of respondents, these problems also cause safety difficulties due to the attempts to make up for lost time and for extra costs. The main problem observed by respondents is the lack of a complete operational design. This lack of completeness led to lots of in progress decision making that may affect both times and cost but, above all, workers' safety. Actual compulsory safety plans are not considered (more than 60% of sample) useful for a complete site design. In fact, the production of a safety plan is considered as the filling out of a compulsory document to begin works. A point of interest from the results is that more than 80% of the sample think that a more developed construction site design could guarantee more satisfaction of site needs, if carried out from early design phase in close cooperation with the whole design team. Building Information Modelling (BIM), although not completely widespread in Italy, has been considered by respondents a possibility to improve construction site design by 3D visualization and operational information sharing.

RESEARCH BACKGROUND

International research poses the question of whether BIM can be a solution to improve workers' health and safety (Ku 2008). A particular attention is visible in BIM production of safety plan (Zhang 2013) or "falling prevention plan" (Kiviniemi 2011). The possibility of a real-time collaboration and of a previous visualization of construction developments through 4D planning (Zhou, 2012) improved a lot studies on construction planning. Nevertheless, site safety BIM implementation needs the development of objects libraries of temporary structures (Kim 2014) and equipment (Sulankivi 2010). These elements need to be inserted in the model in order to represent prevention and protection devices for workers' safety (Trani 2012). BIM safety implementation concerns not only 3D objects visualization but also safety information that can be inserted into a BIM (Sulankivi 2013) in order to check automatically safety rules (e.g. automatic control of falling risk and need of falling protection guardrail). The main goal is to simplify and improve safety planning production ensuring a detail level suitable for hazard identification before starting construction (Azhar 2012) and to realise thus a proper prevention through design - PtD (Kamardeen 2010). This kind of research has also been materialized in some abroad guidelines such as CoBIM Finland standard Series 13 (dedicated to BIM for construction) and NYC Building Information Modelling Site Safety Standards.

The research presented herein follows these issues to develop a standardized approach for construction site planning and safety. The starting point of the research is the thought that, workers' safety could be improved since the possibility exists, with a careful site design, to previously face and solve lots of construction criticalities of execution phase (Turchini 2007). Nevertheless the availability of operational information about works can drive the site designer towards more reasonable safety-oriented choices (Di Melchiorre 2005).

For these reasons, a methodological approach for construction site design using BIM tools is being developed. The main goal is to develop a method for improving a BIM with a proper Construction Site Information Model (CoSIM) able to contain an amount of information useful for execution phase (Trani 2014). A CoSIM is then an information model completely dedicated to the construction phase of the building process. In particular CoSIM is composed of: (i) the development of a BIM with operational information related to building elements and (ii) the site technological-productive elements (e.g. cranes, scaffolds, fences, etc.) characterized by their own information. Such a developed CoSIM is able to manage information for carrying on construction site design in a BIM design team.

In order to improve the CoSIM method, the research progressed the application of BIM for construction site design through application by design teams on real case studies. Modelling difficulties and the tight deadline granted showed the need to have at the team’s disposal a pre-made BIM library of site-technical elements (scaffolds, boardwalks, sheds, etc.) to be used in each application in order to guarantee a faster and a more careful design. For these reasons the objects of the library, as well as to be graphically developed, need to be populated by specific information related to their utility on site.

Thanks to this additional information, the site designer has at his disposal the necessary starting point for construction site choices in order to develop proper site and working spaces plan. Starting from a possible hazard detected, safety information added to the model permits the user to find a feasible solution to avoid the hazard itself and to insert it in the design model. Flexibility of the models permits a solution to the particular context of each construction site. (Trani 2015)

Graphical issues and related information (both useful for site design) have also to be addressed, as minimum design CoSIM requires elements to be inserted in the database and used for each project.

RESEARCH METHOD

The presented research concerns the elements creation for populating the site BIM libraries. The main task has been the creation of detailed enough elements, simple to use and useful for the site design in order to guarantee prevention (through design) from hazard for workers. To reach this goal a precise sequence, specifically created by the authors for the task, has been followed in order to gain a wide range of BIM site facilities. The first step of database elements definition has been the classification of construction site facilities in function of their characteristics. The main categories consist of technological elements (scaffolds, fences, etc.) and productive elements (e.g. cranes, earthworks machines etc.). The latter concern in particular productive information while the first, here presented, are mainly characterized by safety-oriented information.

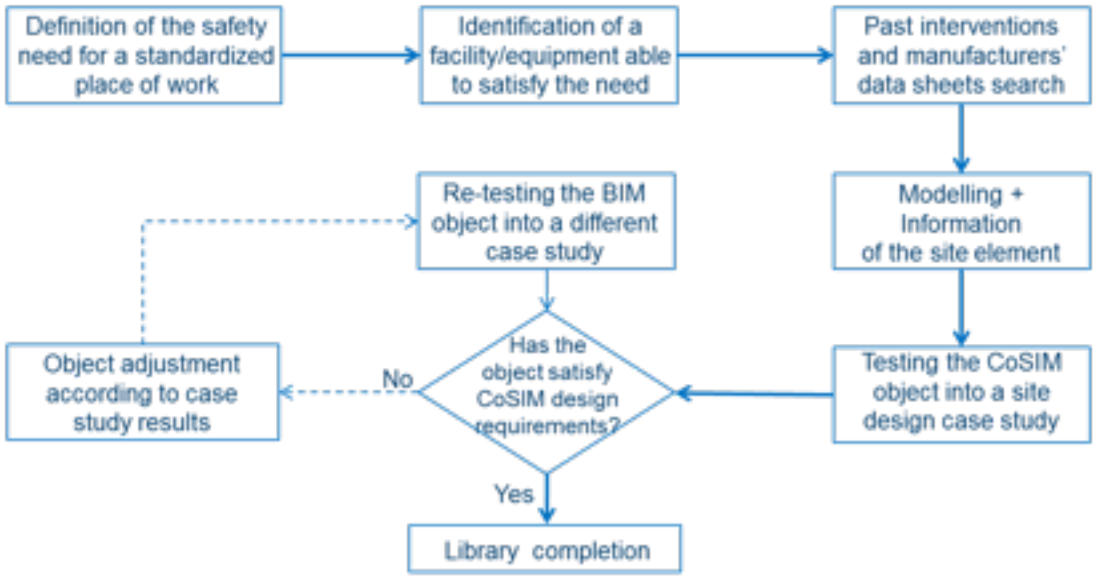

Figure 2: Research method flowchart.

Figure 2 highlights the research steps undertaken for the development of each element of the library. In order to achieve the safety task a facility has to satisfy a precise need to achieve workers' safety in a specific situation. In particular, the safety need could be identified by a solution to avoid a possible hazard due to a particular condition such as an interference between neighbouring working-places. If a time-shift solution is not possible, there is the need of a technical solution (a facility) that alleviates the identified hazard. For these reasons the creation of the elements start from (i) a study of some standardized places of work underlining the possible hazards and, then, the "safety need" to avoid them. The second step is the (ii) identification, inside the classification carried out before, of the facilities that can represent the technical solution able to satisfy the "safety need". For each technical solution (iii), thorough research has been carried on among previous experiences and facilities manufacturers' data sheet wide, in order to point out the characteristics of each facility. After this research is concluded it is possible to (iv) model the facility and to populate it by useful information able to satisfy CoSIM requirements. In order to refine this model for CoSIM requirement satisfaction, each element has been tested (v) on a real case study and adjusted (vi) if required. In fact tests, developed in several cases study if required, show if the element design skills are developed and standardized enough in order to be simply used for other construction sites. Once completely developed the object can become one of the database elements at disposal of site designer for its technical choices against hazards.

APPLICATION OF THE METHOD

The empirical method proposed above has been applied by the authors for several technical solutions. In order to better understand the development of each database object, an example is provided. The particular situation taken into consideration is the interference between a height working-place inside the construction site and an off-site pedestrian way below the working place. The possible hazard related to this interference is the falling of objects from the height working-place that may hit pedestrians walking below. The safety solution for this hazard, since both places need to be used simultaneously, is to physically divide the places by protect pedestrian way with roofing. Everyday experience suggest a scaffold as a suitable facility to satisfy this need. It represents the classical solution, for example, in façade working in which scaffold is used not only as a height working-place, but also as protection facility for the sidewalk. The use of this example permitted to study together both protection for pedestrian ways and scaffolds with their possible configurations. Figure 3 represents the above situation, that has been modelled following manufacturers' datasheets characteristics for a prefabricated scaffold frame.

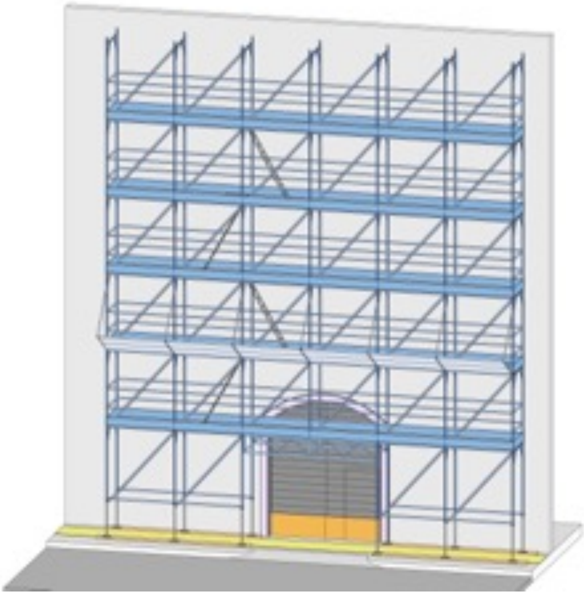

Figure 3: Standard scaffold system with pedestrian way (yellow).

This model is taken as a starting point for developing the "scaffold pedestrian walk protection" CoSIM element. This type of element has been tested in three different case studies through which has been gradually developed in function of specific needs of each construction site. The development concerns also the level of graphical detail of each solution. In fact, each element has not only represented as the real product, but also provides flexibility in dimensions for designers to use.

For this reason the detail level of the scaffold model has been developed by finding a level of compromise between these two issues. The tests also helped in studying information development of the CoSIM objects. In fact, some parameters have been added to the BIM object itself.

Test 1 - Metal carpentry mounting

The first test concerns the mounting of a metal carpentry platform to realize a raised site for the facade restoration of a tall building. The metal carpentry consists of a structure placed against the facade itself (see figure 4). The construction of this metal carpentry covers almost all the boundaries of the tower. For these reasons it has been necessary to provide protection for the people working or living in the building. In fact the rear of the ground floor of the building is characterized by the presence of shops and a backdoor of the building itself. Obviously, the extent of the construction site cannot interfere with these commercial activities/function. At an early design stage, a similar solution of that showed in figure 3 has been inserted in the CoSIM of this intervention. At the beginning, it seems suitable to the site since the need to cover with a protection scaffold the rear side of the tower. The only adjustment to be made in the model is the addition of fencing in order to divide the pedestrian public way under the scaffold and neighbouring construction site. At a more developed design stage, however, it has been expressed there is a need to guarantee an emergency escape way from the backdoor exit useful for more people than initially estimated. For these reasons the pedestrian way behind the tower needs to be enlarged to guarantee the passage of many people in case of emergency in the tower. The prefabricated frames of the scaffold do not provide the minimum width required and it is not possible to double the solution since the resulting presence of hurdles due to prefabricated frames structure. For these reasons, a change to the scaffold solution is unavoidable. An all-around scaffold system, able to guarantee a more flexible solution, is then studied in order to assure a wider escape way without hurdles. Figure 4 shows the new solution inserted in the CoSIM.

Such a wide scaffold permit also to use it as a safer working-place for metal beams mounting on the plates fixed on the façade.

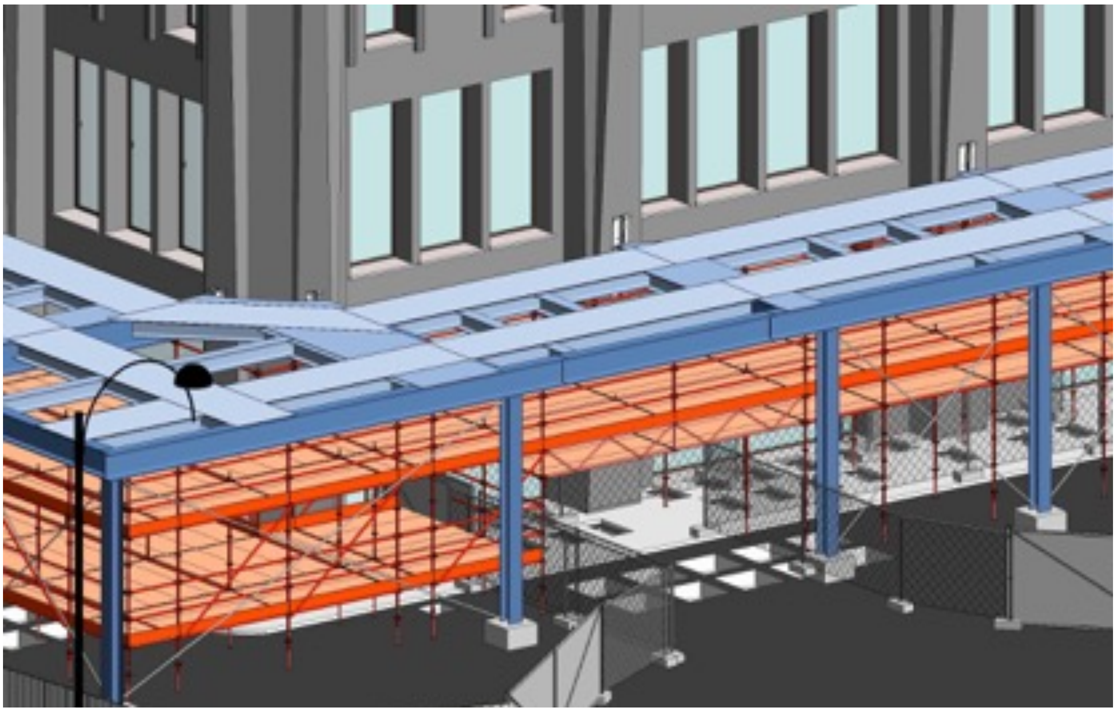

Figure 4: All-around scaffold solution. (N.B. holes in the slab are covered by iron grids)

Test 2 - Cathedral restoration

Test 1 showed the possible need to change safety technical solution during the design phase. In particular, the described change involved a large amount of work because a new scaffold type has been modelled and inserted in place of the previous. This work brought gave rise to a more flexible model that could represent each scaffold type. For these reasons Test 2 has been carried on with a BIM object with a lower graphical detail level. However this object has been characterized by more marked flexibility that permits the user to manage simpler the occurring design changes. Therefore the model does not represent details of each scaffold type but only a generic scaffold structure in which dimensions can be transformed by the simple insertion of the required sizes. These sizes have been set, thus, as parameters of the model, useful to verify the compliance of this design model with real products that have to be used during construction. As a result, this simplified object brought about a faster management of design changes allowing the early design of the scaffold in a difficult context like that of a cathedral. Test 2 is actually based on the complete restoration of Basilica di Collemaggio (L'Aquila, Italy) after its partial collapse due to an earthquake. In particular, the main interventions are the reconstruction of the collapsed transept and the structural rehabilitation of columns, walls, and roofs. The design of a protection against falling objects in a walkway is due to the need to guarantee, in some periods, the usability of the nave during walls and roofs works. Figure 5 shows the scaffold designed in order to satisfy both this need and production and safety requirements of the construction site. The scaffolds on two sides of the naves have been generated as wall reinforcement working-places. Their width has been chosen in response of the need of realizing a usable working-place with the addition of a suitable space for a temporary material and equipment stockpiling. The central part of the designed scaffolding system also creates a roof working-place and the protection for people walking in the nave (see red carpet). In particular, the lower scaffold slab is only used as a protection layer and it is not accessible to workers.

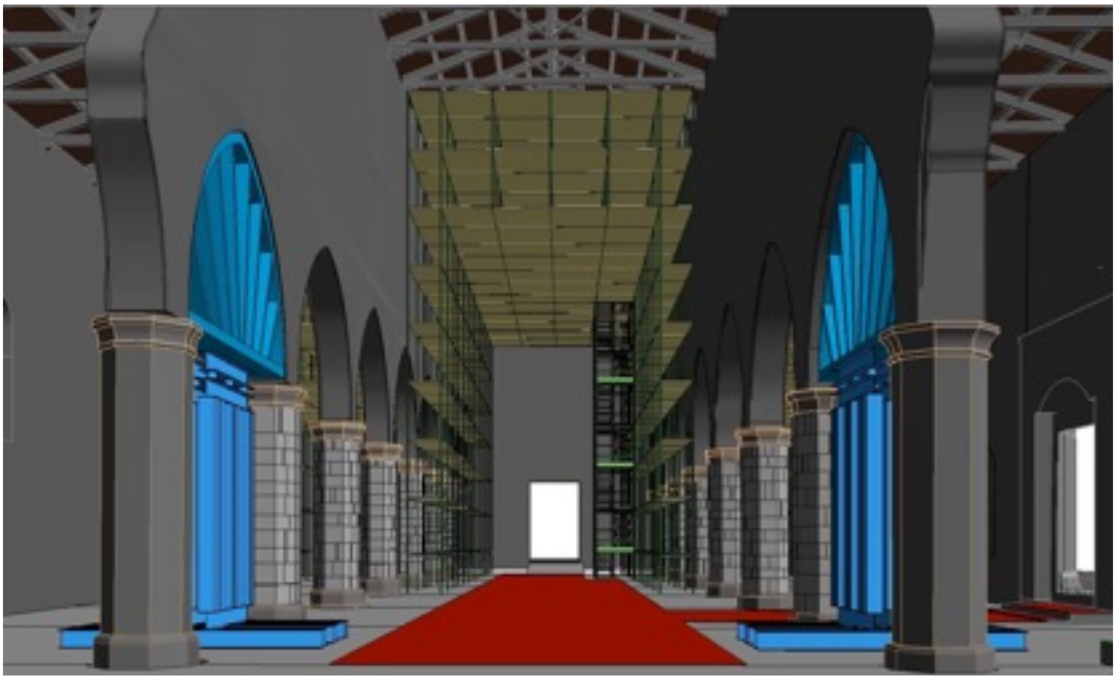

Figure 5: Cathedral scaffold for walkway protection. (N.B. Guardrails and fences are hidden)

The results obtained from this model highlighted the benefits of dimensionally flexible system. As information parameters this CoSIM object has also been characterized by the possibility of automatic calculation of scaffolding areas and thus, of the total cost of the system.

Test 3 - Construction site on public area

The parametric model improved in test 2, although is too schematic from a graphical point of view, has been used for a third case study. The test concerns the construction site design for the demolition of a building. The model created has been used for the early scaffold design of the building to be demolished. The flexibility of the model permits the user to quickly manage the design of the scaffold all around the building. To better visualize the structure of this scaffold, the graphical representation has been replaced by a more detailed version (but not so flexible in design). However, the generic scaffold created permits the user to manage the design of the structure and its changes in a simple way. This generic model has also been used for another task that follows the original “safety need” of protect an off-site walkway. In fact the logistic area of this construction site needs to be placed on a public street. Therefore the sidewalk continuity needs to be guaranteed despite the presence of the construction site. For this reason a new pedestrian walkway has been designed. A protection roofing system must cover it since the proximity with the crane operating area. Thanks to its flexibility, the CoSIM object used is the same scaffold with the addition of new items showed in figure 6. As showed in test 1, the neighbouring construction site requires a fencing solution. On the other side, the neighbouring street is characterized by a large amount of city traffic since the site is located near a busy area. For this reason, it has been necessary to add a different fencing solution made up of concrete safety barriers and wooden guardrails. These items have been characterized by parameters that follow the flexibility of the scaffold used in test 2. As visible in the figure below another item inserted is a wooden platform in order to guarantee the continuity with the walkway without the presence of height differences. This item, in the same way, has been made flexible, also to guarantee a precise height drop.

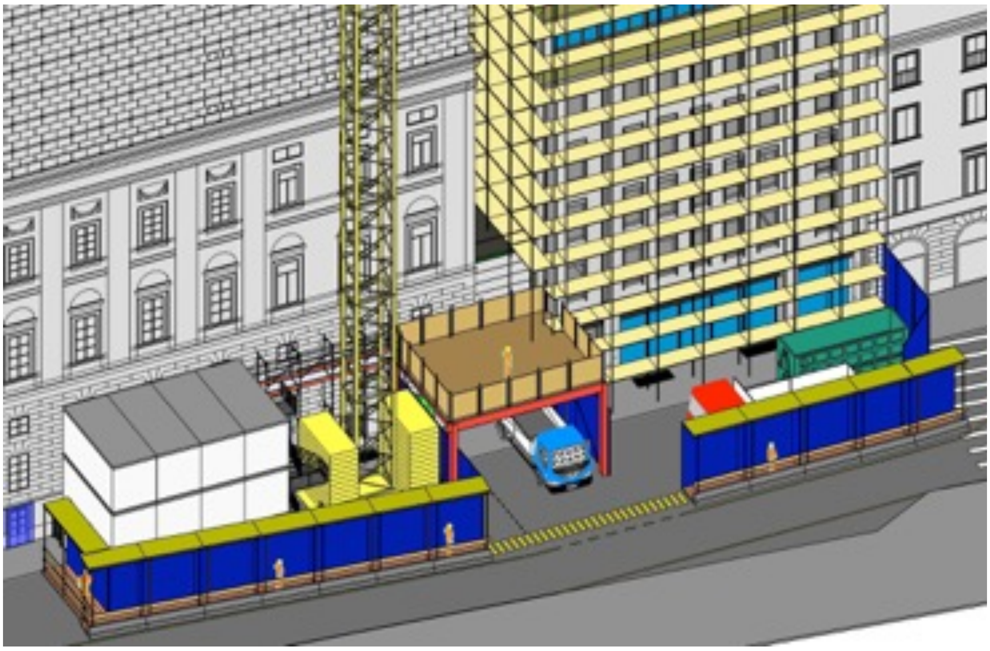

Figure 6: Protected walkway for a construction site on public area

The adding of the items required for this construction site has taken a relatively small amount of time used to develop as CoSIM objects. In addition, once created these objects are available for use for the next construction site to be designed. In fact, the fence for the neighbouring construction site, added in the test 1 has been re-used here by merely changing its type.

CONCLUSIONS

The case studies report the usefulness, through field testing, in developing a tool to better design a construction site in order to guarantee health and safety solutions before starting construction. In general, the three steps can be summarized in three different development areas of the same objects. In particular, Test 1 concerns product development highlighting the need of the use of a different product to guarantee a safer solution. Test 2 demonstrates the development of BIM objects and the use on CoSIM with information development. Test 3 develops new items to add to the object in order to complete its safety task. The table below shows in detail the single developments of the CoSIM object for each test. In particular, item development is concerned with the insertion in the facility model of some additional safety devices. Graphical development concerns are focused on improvements/ simplifications made to the model from a graphical point of view in order to achieve a good compromise between visualization and simple usability of the model. Information development is concerned with the amount of information added to the model for carrying out the case study.

Table 1: Summary of CoSIM object developments during field tests

	Test 1	Test 2	Test 3
Items developments	Fence for adjacent site	Temporary stair system	Concrete barriers Wooden guardrails Wooden platform
Graphical developments	Modelling of an all-around scaffold	Modelling of a generic structure suitable to all scaffold types and flexible in use	Use of detailed scaffold for a better visualization after design
Information developments	Minimum width	Other dimension Area calculation Cost Calculation	Roof minimum load

These developments will be used for other tests in future with the hope to complete the model. It's important to underline that the "detailed" scaffolds modelled at the beginning (prefabricated frames) and for test 1 (all around system) still have usefulness as also explained in test 3. In fact a more detailed model (graphically) can be used in a different design stage where visualization is more important than design simplicity (for example for safety communication for workers).
The continuous development permits to better design construction site objects in future tests and so the design quality improves iteratively as well as decreasing the design time. The method shown here has been applied, with good results in terms of design simplicity and speed, for each element used in each construction site since the tests have been carried out by designing the three discrete sites.

REFERENCES

Azhar S., Behringer A., Sattineni A., Mqsood T., (2012), BIM for facilitating con-struction safety planning and management at jobsites, Proceeding of the CIB W099 International Conference on "Modelling and Building Health and Safety", pp., 82-92.

COBIM Common BIM Requirements (2012), Series 13, Use of models in Construction, Finland

Di Melchiorre S, Trani M, (2005) Operating & safety information in the construction stage a performance-based approach. In: "CIB W102-2005", Lisbon, Portugal

Kamardeen, I. (2010), 8D BIM modelling tool for accident prevention through design. 26th Annual ARCOM Conference, (September), 281–289.

Kim K., Teizer J. (2014), Automatic design and planning of scaffolding systems using building information modeling. Advanced Engineering Informatics, 28(1), 66–80.

Kiviniemi M., Kähkönen K., Mäkelä T., Merivirta M.L., Sulankivi, K. (2011), BIM-based Safety Management and Communication for Building Construction. VTT – Research Notes 2597.

Ku K., Mills T., (2008), Research needs for Building Information Modeling for Construction Safety. ASC Annual Proceedings.

NYC Department of Buildings (2013), Building Information Modeling Site Safety Submission Guidelines and Standards.

Sulankivi K., Kähkönen K, Mäkelä T, Kiviniemi M, (2010), 4D-BIM for Construction Safety Planning, CIB W099 Conference, Salford, United Kingdom, 117-128.

Sulankivi K, Zhang S, Teizer J, Eastman C, Kiviniemi M, Romo I, Granholm L. (2013), utilization of BIM-based automated safety checking in construction planning, CIB world building congress construction and society.

Trani M, Bossi B, Cassano M, (2012), BIM Technology for Restoration Site Design. In: “Research, Development, and Practice in Structural Engineering and Construction” ASEA-SEC-1, November 28-December 2, Perth, Australia.

Trani M., Cassano M., Minotti M., Todaro D., (2014), Construction site BIM requirements In: Procs 30th Annual ARCOM Conference, 1-3 September 2014, Portsmouth, UK, Association of Researchers in Construction Management, 663-672.

Trani M, Bossi B, Cassano M, (2015), BIM oriented equipment choice on construction site. In: “Sustainable Solutions in Structural Engineering and Construction” ISEC, Sydney, Australia. Forthcoming.

Turchini G, Trani M, (2007), The criticality report as a tool for time and cost critical factors analysis for renovations and recovery intervention in Italy. In “Innovation in structural engineering and construction” ISEC, Melbourne, Australia.

Zhang S, Teizer J, Melzner J, Hollerman S, Bargstädt H, (2013), safety planning based on an object-oriented building model.

Zhou, W., Heesom, D. & Tah, J. (2013), A distributed Virtual Reality application framework for collaborative construction planning using BIMserver. In: N. Dawood and M. Kassem (Eds.), Proceedings of the 13th International Conference on Construction Applications of Virtual Reality, 30-31 October 2013, London, UK

INTEGRATING EMERGING TECHNOLOGIES FOR THE EFFICIENT MANAGEMENT OF HEALTH AND SAFETY IN ALTERATION AND REFURBISHMENT PROJECTS

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By 2025, the UK Government is aiming to maximise efficiency in the construction industry through legislation and best practices. These are to: lower costs; speed delivery; lower emissions and increase exports. Whilst efforts are being made to ensure the attainment of these targets, the continuous challenges to health and safety performance cannot be over-emphasized. Several prior but recent research work postulate that Building Information Modelling (BIM) provides opportunities to improve Health and Safety at all stages of a project life cycle. In building projects, the interoperability of the BIM model requires that drawings, master building specifications, standards, regulations, manufacturer product specifications, cost and procurement details, environmental conditions (emissions data), critical paths, clash detection and submittal processes are integrated. The whole process is about disparate digital documentation managed within the heart of the building information model. However, previous work had established that whilst the influence of BIM on integrated health and safety management is positive and important to promote, the considerations for such applications within the building alteration and refurbishment projects are significantly different when compared to the new build projects. This work seeks to review the potential of emerging technologies to be integrated with BIM and propose a conceptual model that could be developed for the management of Health and Safety throughout the project lifecycle. Using design/specification information from an alteration and refurbishment case study, health and safety management information are collated as a basis for the development of the schematic of the proposed integrated platforms. Further work will involve the use of these conceptual models as a basis for detailed design of the interphases and a validation and testing regime. It is thus envisaged that the resulting platform will be customisable integrated tools that will significantly enhance the lifecycle management of health and safety in alteration and refurbishment projects.

Keywords: alteration, BIM, health and safety, refurbishment, technologies.

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INTRODUCTION

The UK Government like most of the European Governments is seeking to maximise efficiency in the construction industry by 2025 through legislation and best practices. These are to: lower costs of procurement, delivery and sustainability; speed delivery; lower emissions and increase exports. Whilst efforts are being made to ensure the attainment of these targets, the continuous challenges to health and safety performance cannot be over-emphasized. Several prior but recent research work postulate that Building Information Modelling (BIM) provides opportunities to improve Health and Safety at all stages of a project life cycle. Early BIM demonstration projects have already achieved savings of around 20% during the construction phase, whilst up to 33% savings over the life of the building is still being envisaged in several cases with future projects targeting even greater savings. BIM can be seen in the wider context as a methodology of designing buildings and managing the design, construction and facility management processes by computer modelling (Grimes et al, 2013).

BIM involves creating a holistic information resource that also includes 2D data sources, documents, spreadsheets, and more. BIM is also not best realised by a single, lowest-common denominator data model imposed on every organisation in the supply chain. BIM it is a business process, not a technology. (Glenville, 2013). BIM is a fusion of both 'information management' and 'information modelling'. Contractors, for example, can feed design information into project planning tools and resolve potential conflicts before arriving on site (Oloke, 2012). The sharing of space information with facilities management teams before the building goes live, to drive effective upfront planning is also enhanced. BIM thus, by implication, promotes the sharing of other crucial design, engineering, and construction information, that can be used later to help drive cost-effective operations decision making and renovations work (ibid). In terms of building components, there is multi-disciplinary design information to coordinate with the elements and systems best suited for each discipline such as: design and presentation information in 3D models; layout information in 2D drawings; schedule information in spreadsheets; procurement information in estimating and purchasing databases; specifications in documents; construction changes in transmittals; field changes in mark-ups; approvals history and audit trails; site photographs; maintenance information and operating instructions. All these also have associated health and safety information which have to be managed accordingly.

The existence of multi-profession parametric object models facilitates more complex integrated building analyses at an earlier stage. Such include addition to structural analysis, space planning, energy use, sustainability assessment and acoustic and lighting studies (so called 'n-D' analyses). Better quality programme and cost (so called '4-D' and '5-D') analyses are also possible facilitating 'Target Value Design' and other 'Lean' type design and construction approaches. Energy analysis is primarily the preserve of the building services engineer (Doyle, 2013). The incorporation of safety management through all these phases can also not be over emphasised. Building Information Modelling (BIM) has thus come to the forefront of building design for structural and civil engineers, architects, mechanical and electrical engineers, contractors and clients. To form a strong project team where each discipline is seamlessly linked to the other is vital for the economic and timely delivery of the project (Miller, 2013).

Furthermore, safety management considerations using BIM would be enhanced by applying BIM to different sectors are illustrated by a crude classification into different geometries. Buildings generally take a vertical form of construction; horizontal floor plates are stacked vertically and the interfaces tend to be internal rather than external. In contrast, infrastructure projects tend to take a horizontal form. Transportation design typically extend along a linear corridor governed by cross-sectional and alignment rules. Other forms of infrastructure projects such as energy installations could be considered as surface-based. These concepts greatly enhance the modelling of health and safety parameters. BIM also provides a 'digital life' which ensures continuity of asset records. In the longer term if this aim is fulfilled, then the need for modelling existing assets could reduce.

However, most existing structures currently have an extensive 'pre-digital' life including modifications, maintenance and change of use; some of the viaduct structures have already been widened two or three times (Stacy and Birbeck, 2013). Alteration and refurbishment projects have the peculiarity whereby the existing structures are the starting point. The structural model thus plays a most significant role in defining the architectural arrangement and the routing of services in the MEP model as well as overall co-ordination (Oloke, 2012). This opportunity also provides a platform for the integration of several other emerging technologies that can aid the capture and modelling of various parameters that may be integrated within a proposed BIM model for managing Health and Safety in alteration and refurbishment projects (Teizer and Reynolds, 2012).

In the light of foregoing, therefore, this works sets out to: review the potential of emerging technologies when integrated with BIM and propose a conceptual model that could be developed for the management of Health and Safety throughout the building refurbishment project lifecycle. Using design/specification information from an alteration and refurbishment project case study, health and safety management information are collated as a basis for the development of the schematic of the proposed integrated platform.

BIM IN BUILDING PROJECTS

Co-ordinating the use of the BIM model needs a well-defined strategy. In buildings, these require an effective definition and co-ordination of the various professional inputs which link the architect to all the others. Within the individual disciplines, BIM also exists to help integrate the sub-elements of associated discipline. At the development stage of the structural BIM, for instance, the model is issued to all parties but is primarily used by fabricators and contractors. This process ensures that the fabricator or contractor is working to the latest information and has fully understood the building being modelled. Connections, structural detail and relevant buildability and safety information are subsequently incorporated into the model by the fabricator/contractor for overall checks and approval as a model file, before release for final fabrication. Similarly, the designer may need to input into a BIM model that is created by others and be able to accurately and quickly interrogate the information to ensure it meets with design intent. (Grimes et al, 2013).

The BIM goals for a building project should normally include a fully coordinated, multi-discipline federated 3D model, and to produce COBie (Construction Operations and Building Information Exchange) data drops 2A and 2B, to provide an outline solution for the project (Glennon and Brown, 2013). In such projects, the interoperability of the BIM model requires that drawings, master building specifications, standards, regulations, manufacturer product specifications, cost and procurement details, environmental conditions (emissions data), critical paths, clash detection and submittal processes are integrated. The whole process is about disparate information resources feeding into a central store of digital documentation, which then becomes the heart of the building information model. These aspects are managed by a wide range of Duty Holders and thus it is pertinent that an enabling environment for the co-ordination of duties continues to be paramount in the process (Oloke, 2011). For example, contact collisions between construction workers on the ground and construction equipment can be attributed to: the lack of knowledge of existing specific risk factors, distractive forces on site and the unavailability of real-time data concerning incidents. (Teizer and Reynolds, 2012). Also, buildings with heavily congested services and plant need to be co-ordinated and supported. The 3D modelling environment facilitates the understanding of the routing of services and the support and positioning of plant, especially given the large number of technicians and engineers that may be working on the many different process areas of the building at the same time. The clash detection system saves significant time in checking drawings enables clashes to be detected at the design stage as opposed to on site (Boyle and Robinson, 2013).

According to Sulankivi, et al, (2014) recent BIM applications and development include: BIM-based site layout plans and crane reach visualizations related to lifting work and risk of crane collapse;

visualization of demolition work procedures and sequences; modelling of e.g. safety railings and floor covers into a BIM-based fall protection plan; 4D visualization of workflow including safety aspect, such as precast concrete frame construction, or floor form work together with needed fall prevention solution; expert analyses with the aid of virtualised construction site; automatic safety analysis using BIM technologies, and site safety communication with help of BIM; as well as testing automated fall protection planning. Additionally, research and test trials has been carried out bringing designers and builders together to promote active discussion and engagement with safety issues using detailed digital design models and 3D stereo displays in a digital laboratory.

In planning for other aspects of safety management, pro-active and early pre-application discussions enable the technical and engineering team to contribute to the design process before major decisions are made. Therefore, early discussions with the fire engineers for instance, will enable the determination of proposals will encompass principles of fire safety design. For fire safety, it is essential to undertake risk assessments that may necessitate a further evaluation to ensure that the proposal will satisfy the requirements of the regulations, without restricting the purpose and architectural aspects of the design. In addition, it is imperative to collaborate with the local fire authority early design meetings with the development team. (Jones, 2005). This is an essential component of planning for fire safety.

Furthermore, security, site entry and egress, site induction, hazards, delivery of materials/storage, machinery and processes and temporary works are also essential aspects of health and safety management that can be similarly co-ordinated within the BIM environment (Structural Engineer, 2014).

ALTERATION AND REFURBISHMENT

Previous work had established that whilst the influence of BIM on integrated health and safety management is positive and important to promote, the considerations for such applications within the building alteration and refurbishment projects are significantly different when compared to the new build projects (Oloke, 2013; 2014).

In terms of refurbishment, a point cloud survey of the whole building is first undertaken and converted into a full Revit® model. This helps to gain an understanding of the layout of the building in 3D. The proposed major interventions would thus mean that it is essential to understand the structural framing of the building in detail. (McNally, et al, 2013). The planning of alteration and refurbishment construction projects involves complex activities such as collecting and analysing various information coming from different sources related to the existing structure. Furthermore, all building end-of-lifecycle operations have safety risks due to the many unknown conditions of the building (McAleenan and Oloke, 2010).

Whilst BIM initially found the quickest application with new builds, the process continues to evolve substantially into the alteration and refurbishment sector of the industry. Several organisations have therefore provided a wide ranging opportunity for clients to utilise BIM on their alteration/ refurbishment project. In the UK, companies like Severn Partnership® (www.severnpartnership.com), continue to take a lead in the provision of services that allow the full scan of floor plans, roof plans, elevations and sections through to a parametric BIM model - an operation well-suited for building renovation, refurbishment and retrofit. Various standard scale floor plans are surveyed in the field with high accuracy reflector less total stations and bespoke building survey software. This can also be useful for picking up floor levels, overhead beams, walls, doors, window openings, heads & cills and reflected ceiling pans of required (Oloke, 2014).

CASE STUDY: SAFETY INFORMATION MANAGEMENT

The case study used to collate risk management information for this project was based on the alteration work to the basement to a 5-storey building in London, UK (Oloke, 2014). The work which also incorporated a side extension entailed a three-stage development as follows: Stage 1 – Initial strip out and full structural appraisal including the commissioning of utility/geotechnical/asbestos and other relevant surveys. Stage 2 – Engineering Designs and Removal/demolition of partitions and a limited number of beams including the installation of props and other temporary works. This also included excavation of the extension section of the basement. Stage 3 – Design and Construction works to enable the creation of the proposed new space, fit out and reinstatement - including drainage, civil and services works. This incorporated newly designed steel 'box' frames which replaced demolished structural walls.

About 12 major risk factors were analysed and the Duty Holders responsible for mitigating these risks were identified. Under the newly introduced Construction Design and Management Regulations (CDM) 2015, the key Duty Holders include: the Client, Principal Designer, Designers, Principle Contractor and Contractors. Figure 1 illustrates the information flow structure based on the requirements of the CDM 2015. This flow structure largely underpins the concept of information flow management throughout the project lifecycle.

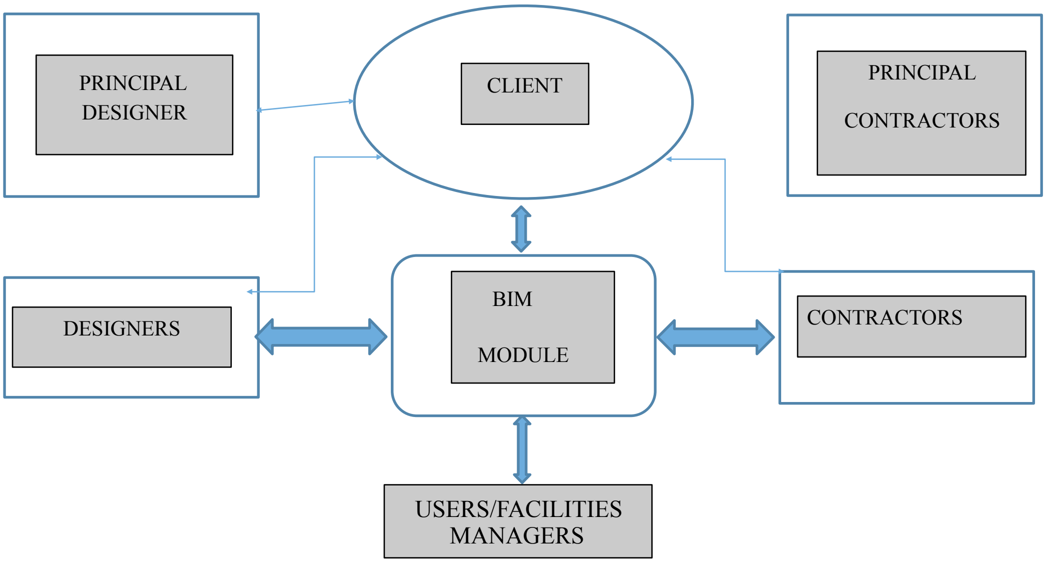

Figure 1: Health and Safety Information Flow Based on CDM 2015

EMERGING TECHNOLOGIES

It is becoming more and more possible to integrate and leverage the potential of advanced technologies in the construction industry applications. Behavioural safety management and policy changes can also improve safety performance in construction as had been proven (Teizer and Reynolds, 2012). Also, significant improvements can be gained in construction safety where technology is deployed to improve safety management practices. It is important to examine existing technologies and how they can assist construction personnel facing hazards in real-time. Moreso, there is a growing recognition that designers have a responsibility to produce designs with minimal hazards to constructors and operators of facilities (Hayne et al, 2014). Location and movement of resources can also be developed to help construction firms integrate emerging technologies with work site safety (Teizer and Reynolds, 2012). Significantly, the recent rise in popularity of Augmented Reality (AR) is in parallel to the increased power of mobile and wearable computing. Potential AR devices such as Google Glass® have the potential to overlay a range of H&S information about the construction site to operatives. Grayson (2014) highlights the potential safety benefits of Google Glass® including monitoring workers' health to accessing safety information in real time and augmenting the view with this data. Other wearable AR devices such as Meta Glasses® (https://www.spaceglasses.com/) have the potential to transform how documents and safety related data are viewed on the construction sites. The potential exists to link AR technologies with data stored within the BIM data so as to allow context-specific safety information to be viewed in real time and potentially without the need for handheld devices. In addition, the opportunity to link these devices with tracking technologies will allow location based specific safety data to be delivered directly to the viewer. Moore (2013) also developed a prototype system that linked an IFC based 4D model with wearable augmented reality glasses built into a safety helmet. The headwear also contained GPS location and compass technologies and thus created a wide area, context aware augmented reality system overlaying the 4D BIM on the real world.

Alteration and refurbishment projects also present the opportunities to monitor the performance of structures in real time. In this wise, there is a need to install a regime of Structural Health Monitoring (SHM). SHM involves data collection and alerts on threshold crossing incorporating health monitoring. It encompasses sensor, data acquisition and transmission technologies and the interpretation and provision of information and knowledge on structural loading and behaviour. Incorporating this with the appropriate BIM structural models will allow operators make better informed decisions (Brownjohn, 2011).

Sensors are also now frequently used in Building Management Systems to assist in controlling power usage and temperature and these can be used over wireless transmitters to begin the automation process (Grindvoll et al., 2012). However there exists much more potential for sensors and Radio Frequency Identification (RFID) in the construction industry as they can be used to monitor the location of objects (and people) in relation to safety. Arslan et al. (2014) proposed a system which monitors temperature and humidity in relation to a workers location and relays potential safety problems to a H&S manager through a BIM interface. Incorporating the concept of wearable computers such as Smart Watches (e.g. Samsung Gear or Sony Smartwatch) imply that users could be directly alerted to potential safety issues from sensors in their vicinity.

CONCEPTUAL MODEL

Bringing together some of the existing and emerging technologies, it becomes possible to of the construction project development in the nearer future. Retinal scanning can be used to clock-in site operatives and visitors to give a full indication of who is working on or a visiting a site at a particular point in time, a typical site operative will be wearing the standard PPE but will also be wearing a smart watch. This watch will be monitoring heart rate and body temperature. The watch may also have the ability to test alcohol levels of the wearer if they are operating heavy machinery (TokyoFlash, 2014). This data will be fed back to an intelligent online database, which will monitor all of the data in real time and feedback any potential health issues to the site management team. Longer term prospects will be to incorporate this data into the BIM model for special relativity and visualisation.

Also, location sensors and other RFID devices can be located within the hard hat. The location sensors can include GPS for outside tracking and utilize indoor location tracking or Active RFID when the operative moves indoors. The location sensors located through the BIM design process will be able to report operative locations on the site back to a central database and could also be used to alert people when they are moving towards potential hazard areas. When moving towards an area of danger, a buzzer may go off in the helmet or a message sent to the smart watch to alert them. These sensors will then be left in the building and will remain a H&S tool during the operation stage alerting facilities management personnel to potential H&S issues (Ibid).

The BIM process to be ultimately developed and the 4D model to be generated should incorporate H&S issues during the design stage and also during the pre-construction phases. As the BIM and 4D model are developed, workspace information will be included alongside potential hazard areas and details. In addition, method statements can be included into the various elements of the model and linked to the 4D simulation. This enable specific H&S data to be individually delivered to staff on site as required and in alignment with the project plan. To ensure the dynamic changes in the site are reflected as work progresses in-progress 3D laser scans can also be taken weekly and incorporated into the model – these are also then used for facilities management. Figure 2 is a basic illustration of the proposed conceptualised integrated model.

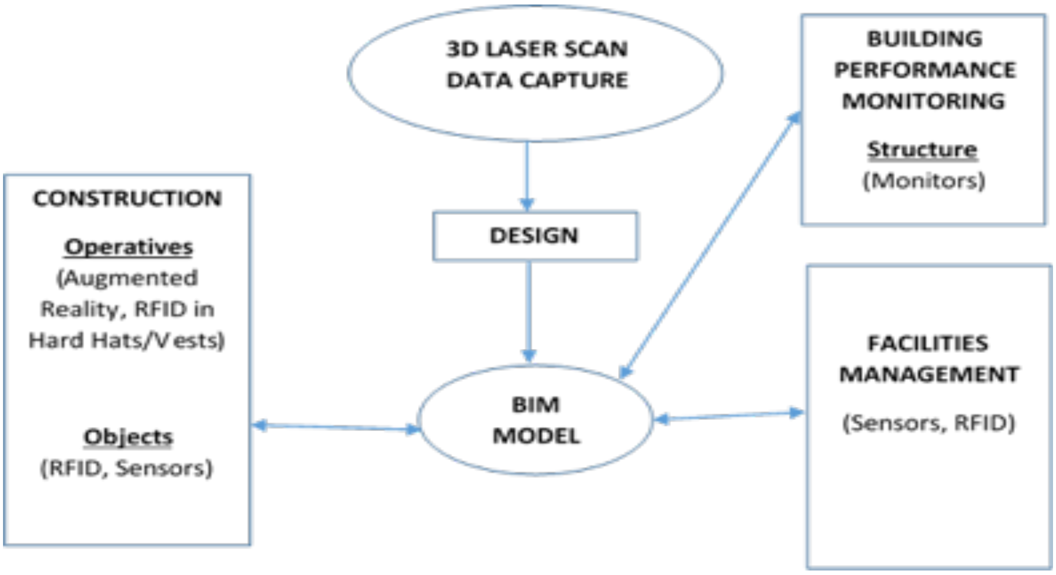

Figure 2: Proposed Conceptual Integrated Framework Model for Alteration and Refurbishment Projects

An operative will be wearing AR interface linked to a mobile phone or mini tablet, which is connected to a central (BIM) database. Using the sensor technology to locate their position and the information from the BIM/4D model, the wearer will be able to look at elements on the site and obtain specific data relating to the tasks happening or due to happen. Data (possibly even augmented drawings or models) will be displayed on the 'see through' interface. This conceptual model is based on recent findings on the potential of these tools and their interoperability (Hayne, et al, 2014; Grindvoll et al, 2012; Teizer, 2012)

CONCLUSION AND RECOMMENDATION

BIM involves finding the best way to share and integrate information from many sources, authors and systems in a managed, secure and trusted manner. An asset model can be created from day one that can be used consistently throughout the project to drive efficiencies and improve collaboration. It involves creating a holistic information resource that also includes 2D data sources, documents, spreadsheets, and more. In building projects, the interoperability of the BIM model requires that drawings, master building specifications, standards, regulations, manufacturer product specifications, cost and procurement details, environmental conditions (emissions data), critical paths, clash detection and submittal processes are integrated. The whole process is about disparate information resources feeding into a central store of digital documentation, which then becomes the heart of the building information model.

The planning of alteration and refurbishment construction projects involves complex activities such as collecting and analysing various information coming from different sources related to the existing structure. Furthermore, all building end-of-lifecycle operations have safety risks due to the many unknown conditions of the building. It is becoming more and more possible to integrate and leverage the potential of advanced technologies in the construction industry applications. Behavioural safety management and policy changes can also improve safety performance in construction as had been proven. Emerging technologies such as AR, RFID, Sensor technologies and other similar technologies present a huge potential when incorporated within the BIM environment. Such a platform is envisaged to effectively manage health and safety throughout the project lifecycle as presented in the conceptual framework model developed as part of this work based on the information structure from selected case studies. The model incorporates Regulatory compliant Duty Holder Information flow structure to ensure a sustainable future deployment.

Further work will, however, involve the use of this conceptual model as a basis for detailed design of the interphases and a validation and testing regime. It is thus envisaged that the resulting platforms will be customisable integrated tools that will significantly enhance the lifecycle management of health and safety in alteration and refurbishment projects.

REFERENCES

Arslan, M., Riaz, Z., Kiani, A., and Azhar, S. (2014). Real-time environmental monitoring, visualization and notification system for construction H&S management. Journal of Information Technology in Construction (ITcon), Vol. 19, pg. 72-91, http://www.itcon.org/2014/4

Boyle, Jason and Robinson, John (2013) BIM approach to a nuclear project: Sellafield Maintenance Facility; Project Focus, the Structural Engineer, November 2013, pp. 96-97

Brownjohn, James (2011) Structural Health Monitoring: Examples and Benefits to Structurre Stakeholders, May 2011, 89(9), pp24 -26

Doyle, Mark (2013) BIM and the Future of Structural Engineering Practice; Viewpoint, the Structural Engineer, November 2013, pp. 96-97

Glanville, Neville (2013) BIM - Business Enabler or Technology Red Herring; Viewpoint, the Structural Engineer, November 2013, pp. 100-101

Glennon, David and Brown, Allan (2013) HMYOI Cookham Wood: the first government scheme adoptive of BIM Level 2; Project Focus, the Structural Engineer, November 2013, pp. 12-14

Grayson, W. (2014) FACE THE FUTURE: 5 reasons construction companies need to buy Google Glass right now [online] Available at http://www.equipmentworld.com/5-reasons-construction-companies-need-to-buy-google-glass-right-now/#sthash.curHSYSD.dpuf Accessed 16 April 2015

Grimes, Paul; Sandbrook, Rachel; Bailiss, John; Davies, Chris (2013) How to Implement BIM (and the cost of Implementation); Viewpoint, the Structural Engineer, November 2013, pp. 90-91

Grindvoll, H., Vermesan, O., Crosbie, T., Bahr, R., Dawood, N. and Revel, G. (2012) A wireless sensor network for intelligent building energy management based on multi communication standards – a case study, Journal of Information Technology in Construction (ITcon), Vol. 17, pg. 43-62, http://www.itcon.org/2011/3. Accessed 16 April 2015

Hayne, G., Kumar, B., Hare, B., (2014) The Development of a Framework for a Design for Safety BIM tool. Computing in Civil Engineering and Building Engineering. Proceedings of the 2014 International Confernce on Computing in Civivl and Building Engineering pp. 49-56

Jones, Bob (2005) Fire Safety: A Partnership Approach, The Structural Engineer, October 2005, pp 22-23

McNally, Jim; McDonough, Rob and Brindle, Paul (2013) Manchester Town Hall transformation programme: the use of BIM in a major heritage refurbishment project

Miller, Andrew (2007) BIM for all in Construction. The Structural Engineer, July 2007, pp. 34-35

Moore, N. (2013) A model based system for contextual on-site construction planning in Augmented Reality. PhD Thesis. University of Wolverhampton

Oloke, D. (2011) Preventing Accidents and Major Injuries on Major Alteration/Refurbishment Works: A framework for Relevant and Effective Information Co-ordination. Proceedings of the CIBW099 Safety in Construction Conference, Washington DC, August.

Oloke, D. (2012), Health and Safety Management in Alteration and Refurbishment Projects using Building Information Modelling: Proceedings of the CIBW099 Safety in Construction Conference, Singapore, September.

Oloke, D (2014) Improving Construction Health and Safety Management in Structural Alteration and Basement Construction to Existing Structures. Proceedings of the CIBW099 Safety in Construction Conference, Sweden, June.

Stacy, Mungo and Birbeck, Julian (2013) BIM for the Northern Hub ECS1 programme, The Structural Engineer, Project Focus, November 2013, pp. 50-57

Sulankivi, K., Tauriainen, M and Kiviniemi, M (2014) Safety Aspects in Constructability Analysis with BIM. Proceedings of the CIBW099 Safety in Construction Conference, Singapore, September.

Structural Engineer (2014) Managing Health and Safety Risks, No. 25 Personal Safety on Site, March 2014 Edition, pp. 34-35

Teizer, Jochen and Reynolds, Mathew S (2012) Towards a Fully Automated Equipment Blind Spot Detection, Equipment Operator Visibility Monitoring, and Ground Personnel Proximity Warning and Alert System. http://www.irbnet.de/daten/iconda/CIB_DC24440.pdf. Accessed 16 April 2015

TokyoFlash (2014) Kisai Intoxicated Breathalyzer Watch. [online] Available at http://www.tokyoflash.com/en/watches/kisai/intoxicated_silicone/ Accessed 16 April 2015

A MODEL OF INTEGRATED MULTI-LEVEL SAFETY INTERVENTION PRACTICES IN CONSTRUCTION INDUSTRY

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Construction safety management could be aligned with the condition at the workplace. The implementation of the safety management system must be tailored to increase behavioural safety performance especially at the end user segment where most failures tend to occur. Although the importance of the implementation of safety practices has been acknowledged, the most significant safety practices at each intervention levels in improving behavioural safety performance of worker in construction industry has rarely been examined. The aim of this research is to identify the most significant safety practices at each intervention levels in improving behavioural safety performance of worker in construction industry. A literature review was used to identify the list of safety practices at each intervention levels. Safety experts to determine their relevance verified these safety intervention practices. A total of 43 safety practices at all intervention levels have been validated and has been included in the questionnaire. Questionnaires were then circulated to measure the level of significance of each safety intervention practices towards a positive behavioural safety performance of worker. The targeted respondents are safety personnel and middle level personnel from construction companies that manage different construction projects such as oil and gas, infrastructure and building projects. The data will be collected at least from 430 respondents and will be analysed using structural equation modelling (SEM) to determine the most significant safety practices at each intervention level. From the first result, references will be made to develop a dynamic model of integrated multi-level safety intervention practices in construction industry. The research findings are expected to be useful as a guidance in safety construction management for the integration of multi-level safety intervention and developing a system for safety control act as an important elements in order to improve behavioural safety performance and at the same time strengthen a safety culture among worker.

Keywords: behavioural safety performance, construction industry, safety intervention.

INTRODUCTION

According to the recent Department of Occupational Safety and Health (DOSH) occupational accident statistics by sector in Malaysia in 2014, it is estimated that there were a total of 184 fatal accidents in the workplace. Seventy of those fatal accidents in the workplace, which is the highest number has been recorded in the construction sector (DOSH 2014). As noted by Mohamed et al. (2009), the importance of hazard identification on site indicated that construction operations are habitually involved in hazard. In the construction industry, which involved dynamic environment with critical and heavy work, it is complicated to handle hazards that diminish injury rates. Therefore, construction can be considered as an industry that frequently exposed workers to accidents (Aksorn and Hadikusumo 2007). Numerous studies had noticed that the construction site is a hazardous place. Chong and Low (2014), Mohamed (2002) and Sawacha et al. (1999) stated that construction has been

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known as a vulnerable industry with hazard activities at the workplace which delineated a comparatively high number of injury and fatal accidents. Therefore, safety issues have gained vital attention in the construction industry as a whole (Choudhry et al. 2008). Workers as the end person who are exposed to on site hazard should be able to prevent the incident and accident from happening (Geller 2001; Mingzong Zhang and Fang 2013; Toole 2002; Zin and Ismail 2012). However, safety is a responsibility of every individual in a construction project organization. Hence, an integrated safety practices at each intervention level is necessarily crucial to be identified.

Problem statement

A recent study by (Chi et al. 2014) on Taiwan construction industry indicated that the main causes of accident can be categorized into five main causes where the percentage of frequency is shown in table 1. Based on the study, unsafe behaviour was discovered as the most frequent cause of accident with 47.9%. On top of that, unsafe work behaviour was found as the most frequent cause of accidents at construction sites according to some past studies (Choudhry 2014; Mengchun Zhang and Fang 2013; Sawacha et al. 1999).

Table 1: Frequency of accident causes

Accident cause	% of frequency
Unsafe behaviour	47.9
Unsafe machines and tools	5.5
Unsafe environment	32.7
Harmful environment	14
Unknown	0

Moreover, the Domino Theory of accident causation model developed by Heinrich (1980) found that 88% of all accidents are caused by unsafe acts, 10% are caused by unsafe conditions and 2% are unavoidable. Heinrich's Domino Theory shows that accidents occur from the chain of 5 sequential events (1-ancestry and social environment, 2-fault of person, 3-unsafe act together with mechanical and physical hazard, 4-accident and 5-injury). Removing of a key factor number 3 would prevent the start of the chain reaction resultant injury. This represents a useful lead to further a research focusing on safe behaviour of workers.

Zohar (2002) argued that leadership style influences safety behaviour performance of group members hence required more research on managerial practice issues and safety behaviour. According to Reason (2000), the Swiss cheese model shows how defences, barriers, and safeguards might be impaled by an accident. Two reasons that may emerge from the holes in the barriers are active failure and latent conditions. Unsafe acts committed by human who have direct exposure to work or a system are called active failures. While, the inevitable within the system or mistakes in making decision are so called as a latent condition. Hence, the system must be robust in dealing with human and operational hazards. Operations are also well managed if the company is good in managing safety. However, many companies are unable to achieve success in safety performance due to ineffective safety leadership (Cooper 2004). Generally, safety management system implementation must be tailored to increase behavioural safety performance especially at the end user segment where most failures tend to occur.

Kristensen (2005) showed some effectiveness of behaviour change from appropriate interventions (see Table 2). Some of these simple examples indicate the impacts of intervention on behaviour change. Therefore, there is an importance of well selection in safety practices at each intervention levels in construction industry to improve behavioural safety performance.

Table 2: A few examples of behaviour change as a result of imposed intervention

Intervention	Exposure/Behaviour
Rules on smoking at the workplace	Reduced passive smoking
Establishment of self-governing group	Increased decision latitude and social support
Course in lifting techniques	Reduced heavy lifting, adequate lifting behaviour
Health promotion program	Reduced smoking, better diet
Establishment of worksite safety committee	Better safety behaviour
Leadership training of front-line supervisors	Higher role clarity, less role conflicts, fewer conflicts

Wealth of safety research has been studied (Aksorn and Hadikusumo 2008; Al Haadir and Dyreborg et al. 2005; Luria and Morag 2012; Olsen et al. 2009; Panuwatwanich 2011) on the safety program which should be implemented by construction industry globally. In addition, there are huge number of behavioural safety research on Behaviour Based Safety (BBS) analysis in identifying the effectiveness of the program towards safe worker behaviour improvement such as Choudhry (2012, 2014), Ismail (2012), Mengchun Zhang and Fang (2013) and Sulzer-Azaroff and Austin (2000). Most of the findings indicated that management commitment is the most important factor to ensure the success of the BBS program.

Moreover, the previous researchers only focused on the single level of safety intervention practice (Hadjimanolis and Boustras 2013; Ismail 2012; Quinn,2010; Tam et al. 2004; Zohar and Luria 2003; Zohar 2002). Yet, very little research has been carried out by academics and practitioners on the appropriateness of multi-level safety intervention towards behavioural safety performance in the construction industry. According to (Wirth and Sigurdsson 2008), safety professional faced difficulties in order to select the best intervention practices. The reason behind this is lack of details documented on various behavioural safety processes in safety literature.

Rational of research

Haupt (2001) shared the notion that behaviours of worker should be altered from unsafe to safe attitudes to achieve preeminent site safety performance. Therefore, research in behavioural safety of worker is necessary in order to ensure the improvement of safety performance in the construction industry. In order to provide guidance to the construction industry to critically identify and prioritize the most significant safety intervention practices at each level, it is pivotal to exploit this research together with the necessity to fulfil significant gaps in recent research, which aims to identify the most influential multi-level intervention safety practices for improvement of worker safety behaviour. In the meantime, this research is expected to strengthen the safety culture within organizations.

Research objectives

The objective of this research is to evaluate the integration of multi-level safety intervention practices affecting behavioural safety performance of workers in Malaysian construction industry. To accomplish the research objective, two specific objectives are identified. The first objective is to identify the most significant safety practices at different intervention levels affecting positive behavioural safety performance of worker. While, the second objective is to develop a dynamic model of integrated multilevel safety intervention as a guidance to create a policy for safety management in construction industry.

The overall scope of safety interventions practice basically needs to be explored theoretically and practically to achieve the objectives as stated above. The results of the research will also be used as a tactical guideline in selecting the appropriate and successful safety intervention in order to change to a more positive behavior of workers in the workplace.

LITERATURE REVIEW

Malaysian construction industry

Although accident and death cases in workplace statistics in 2000 till 2009 as reported by Social Security Organization (SOCSO) highlighted by (Chong and Low 2014) indicated a slightly declining trend in the construction industry, the industry still has a poor reputation of being one of the worst industries in Malaysia in respect of high risk workplace accident. Occupational accidents causes injuries and fatalities bears an immense cost on the industry (Rikhardsson and Impgaard 2004). The construction industry is one of key economic contributor to the GDP of Malaysia. Therefore, it is better to prevent losses due to accidents at workplace. In addition to this, health and safety concerns in construction industry are vital to circumvent accident at workplace (Choudhry et al. 2008).

Safety intervention

The significance of safety interventions is recognized as one of the effective ways to improve safety performance and reduce hazards in the workplace (Dyreborg et al. 2005). In recent years, the effort in conducting safety interventions has become compulsory due to national Occupational Safety and Health regulations of each country and has increased dramatically since it showed a great potential in reducing injuries and accidents. The purpose of safety interventions in general is to control the work processes, equipment, environment and employees with the aim of reducing incidents and accidents in the workplace.

Definition

There are a number of safety interventions definitions as stated in some literature. Nevertheless, the meanings have similar perception that emphasize on the way individuals in the workplace are doing things in improving the organization's safety performance. Some definitions are expressed as follows:

"…intervention means changing external conditions of the system in order to make safe behaviour more likely than at risk behaviour…"

(Geller 2001)

"…very simply as an attempt to change how things are done in order to improve safety. Within the workplace it could be any new program, practice, or initiative intended to improve safety (e.g., engineering intervention, training program, administrative procedure) …"

(NIOSH 2001)

"…described as an attempt to alter or change how things are done in order to improve safety could be in the form of a new program, practice, or initiative and idea which is intended to improve safety…"

(Oyewole et al. 2010)

Moreover, Dyreborg et al. (2005) mentioned that safety intervention may run for a shorter or longer period of time or represent a permanent change, as for example new regulations or legislation. A safety intervention program can be initiated at the workplace by the employer or the employees, or initiated from outside the workplace by public authorities, social partners or other stakeholders. However, the intervention must take place and be aimed at improving safety in the workplace or during work.

Intervention is not constant and ever changing in terms of cost, business administration and participant involvement. Simple intervention is as written activators are often used such as signs, posters and the like while other activators require a lot of time and effort to deliver such training and technical commitment (Geller 2000).

Multi-level safety intervention

Oyewole et al. (2010) argued that safety interventions take place at different levels of safety implementation. Basically, the main safety selection and intervention attempts are usually directed towards the level of safety management system in organizations. The safety interventions implemented at different levels in the workplace safety system include safety management level and the level of human and technical systems within the organization (see Figure 1).

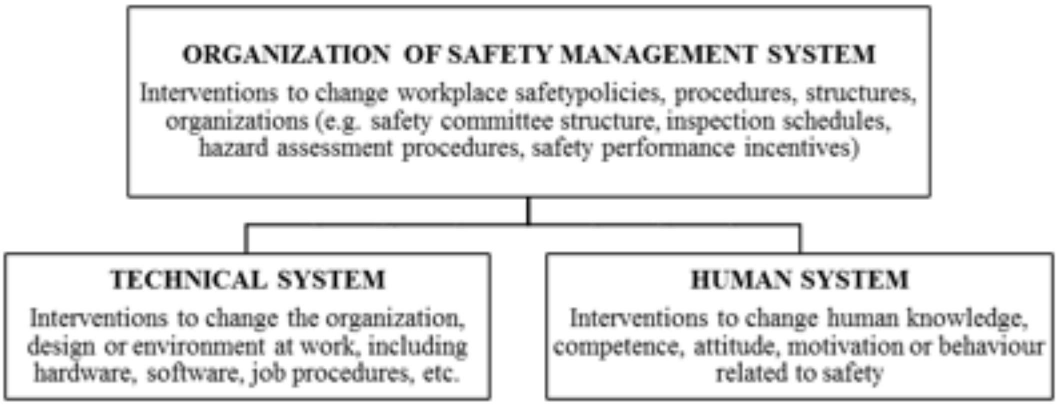

Figure 1: Intervention levels within workplace safety system

Source: Adopted from NIOSH (2001), Shakioye and Haight (2010)

List of safety intervention practices

There are numerous past safety researchers who had identified the safety practices in organization. The lists of safety practices (see Table 3) were classified into each intervention level, safety management system, technical system and human system based on the most stated in various related literature and validated by some expertise. NIOSH (2001) stated that safety could be improved by striving on the safety intervention as a strategy to reform how practices to be focused on are selected. Therefore, the list of multi-level safety intervention activities in construction industry is required.

Table 3: List of safety practices in each intervention levels

Level	Label	Safety Practices	Sources
Organization of Safety Management System	A1	Safety policy and standards	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004), Choudhry et al. (2008), Hadjimanolis and Boustras (2013)
	A2	Safety vision and objectives	Nielsen (2014)
	A3	Safety organization, Safety committee	Chan et al. (2004), Choudhry et al. (2008), Nielsen (2014)
	A4	Safety procedure/ Standardization	Tam et al. (2004)
	A5	Management worker interaction (Periodic safety meetings, Regular site visits)	Iyer et al. (2004), Maloney et al. (2006), Nielsen (2014), Oyewole et al. (2010), Paul and Maiti (2008), White and Executive (n.d.)
A	A6	Daily safety records	Yu et al. (2004)
	A7	Incident/Accident investigation, analysis and prevention	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004), Nielsen (2014), Oyewole et al. (2010)
	A8	In-house safety rules and regulations	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004)
	A9	Contracting strategy (Safety requirement and capability)	Chan et al. (2004), White and Executive (n.d.)
	A10	Safety information management and feedback	Iyer et al. (2004), White and Executive (n.d.)
	A11	Safety audit on overall safety management system	Iyer et al. (2004), Oyewole et al. (2010)
	A12	Reviewing and implementing safety programs	Iyer et al. (2004)
	A13	Delivering safety communication	Ismail et al. (2012), Iyer et al. (2004), White and Executive (n.d.)
Technical System	B1	Inspecting hazardous conditions, facilities, plant and equipment to affirm safe workplace	Choudhry et al. (2008), Iyer et al. (2004)
	B2	Personal protection equipment (PPE) program	Chan et al. (2004), Choudhry et al. (2008), Yu et al. (2014)
B	B3	Safe work practices/Safe operation procedure	Ai Lin Teo and Yean Yng Ling (2006), Paul and Maiti (2008), Quinn (2010)
	B4	Safety equipment availability and maintenance	Iyer et al. (2004), Paul and Maiti (2008), White and Executive (n.d.)
	B5	Implementation of safety inspection	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004), White and Executive (n.d.), Yu et al. (2014)
	B6	Scheduled maintenance for all machinery and equipment/ Safety process control program	Ai Lin Teo and Yean Yng Ling (2006)
	B7	Movement control and use of hazardous substances and chemicals	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004)

	B8	Emergency responses preparedness	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004)
	B9	Design safe temporary structure for construction	White and Executive (n.d.)
	B10	Implementation of safety permits for high risk operation	Oyewole et al. (2010)
	B11	Data base safety monitoring	Yu et al. (2014)
	B12	Physical safety settings	Woodson (1992)
	B13	Ergonomics machine design	Rowlinson (2004), Woodson (1992)
Human System C	C1	Behavioural-Based Safety (BBS) program	Choudhry (2012), Cox and Jones (2006), Godbey (2006), Ismail et al. (2012), Sulzer-Azaroff and Austin (2000)
	C2	Safety training	Ai Lin Teo and Yean Yng Ling (2006), Cameron and Hare (2011), Chan et al. (2004), Choudhry et al. (2008), Iyer et al. (2004), Misnan et al. (2008), Oyewole et al. (2010), Paul and Maiti (2008), Sheeran and Silverman (2003), Yu et al. (2014)
	C3	Safety inductions for a new worker	Makin and Winder (2008)
	C4	Safety awards/Safety promotion/Safety incentive	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004), Choudhry et al. (2008), Iyer et al. (2004), Oyewole et al. (2010), Zohar (2002)
	C5	Regular safety supervision	Oyewole et al. (2010), Paul and Maiti (2008), White and Executive (n.d.), Yu et al. (2014), Zohar and Luria (2003), Zohar (2002)
	C6	Safety awareness program/ Safety campaigns/Weekly safety topics	Nielsen (2014), Yu et al. (2014)
	C7	Safety information/Safety bulletin boards	Nielsen (2014), White and Executive (n.d.), Yu et al. (2014)
	C8	Requisite safety expertise for high risk operation	Yu et al. (2014)
	C9	Pre-task hazard assessments/ Job Hazard Analysis (JHA)/ Job Safety Analysis (JSA)	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004), Ismail et al. (2012) , Iyer et al. (2004), Oyewole et al. (2010), Yu et al. (2014)
	C10	Daily tailgate/Toolbox Meeting	Iyer et al. (2004), Oyewole et al. (2010)
	C11	Penalty/Accident repeater punishment program	Hopskins (2006)
	C12	Safety knowledge program/ Safety education	Makin and Winder (2008), Yu et al. (2014)
	C13	An employee safety plan	Ai Lin Teo and Yean Yng Ling (2006), Chan et al. (2004), Iyer et al. (2004)
	C14	Co-worker intervention	Paul and Maiti (2008)
	C15	Crew safety awareness inspections	Iyer et al. (2004)

RESEARCH METHODS

Selected research methodology to underpin research work and methods will be used in order to collect data. The first objective is quantitative data which measures variables and verifies hypotheses while for the second objective is to develop a dynamic model of integrated multilevel safety intervention practices based on the first objective's findings. It is to ensure that the model is relevant with the construction industry in Malaysia. The model will be more practically conducted and will be developed separately for each construction industry (oil and gas, infrastructure and building) within a period of at least six months.

Structural Equation Modelling

The hypothesized model of multilevel safety intervention is presented in Figure 2.

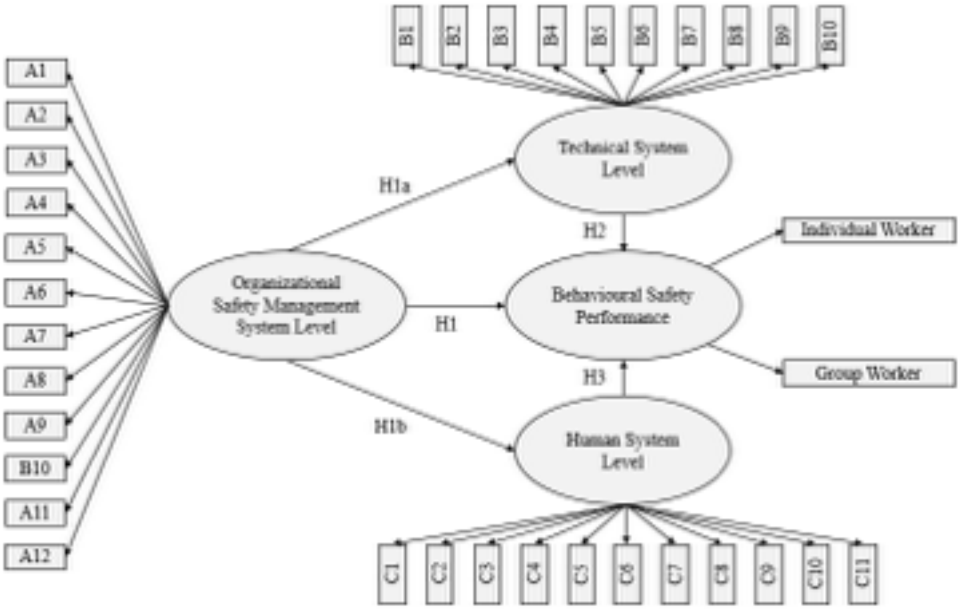

Figure 2: Hypothesized SEM model of integrated multilevel safety intervention

H1 : Management safety intervention has direct effect on behavioural safety performance of worker

H1a : Management safety intervention has influence on technical safety intervention

H1b : Management safety intervention has influence on human safety intervention

H2 : Technical safety intervention has direct effect on behavioural safety performance of worker

H3 : Human safety intervention has direct effect on behavioural safety performance

The abovementioned hypotheses will be analysed using Structural Equation Modelling (SEM) method. Structural Equation Modelling (SEM) will be the main analysis method in this research. Schumacker and Lomax (2004) define SEM as a statistical technique of multivariable able to describe the inter-relationship between multiple variables.

Even though there are other techniques in analysis such as correlation and regression, only independent equations and relationships within constructs are shown (Byrne 2010; Kline 2005). Hence, it is complicated for those findings to develop an overall integration model. These hypotheses will test the multi-level safety intervention practices towards the safety behavioural performance of workers.

SEM usually begins with the specification of a model (Hoyle 1995). SEM consists of measurement model and structural model (Lei and Wui 2007). The application of SEM is to confirm the relationship between the latent variables and groups of the observed variables. The measurement model in SEM is evaluated through confirmatory factor analysis (Byrne 2010; Lei and Wui, 2007). While structural model or a path model (Lei and Wui 2007) is used to define the relations among the latent variables. The causal and correlational are links between theoretical variables.

This research sets out to describe the development and empirical testing of a structural equation model of integrated multi-level safety intervention in constructions. This research empirically tests the interactions and causal relationships of safety practices in three intervention levels (i.e. Management level, Technical level and Human level) and behavioural safety performance (i.e. Individual safe behaviour and Group safe behaviour). It is known that construction's workplace involve a multitude of workforce where according to Geller (2000), behavioural safety should not only consider an individual but as a group. For example, an actively caring person shows the willingness to help others is often work safely. Hence, it shows that a positive behavioural safety performance should seriously be taken into account.

Measurement model

The hypothesized model of integrated multilevel safety intervention will take a confirmatory (hypothesis testing) approach in order to determine the consistency between a hypothesized model with collected data to confirm the theory. A good measurement model is required to be established to prevent meaningless or unsuccessful testing of the structural model (Chinda and Mohamed 2008).

Structural model

The next step after the measureable model is to establish confidence, where a SEM will be able to be developed and tested to evaluate the predicted relationships direction between the four latent variables, as the arrows linking each other will be shown.

Amos

SEM software program, Amos (analysis of moment structure), is expected to be used to analyse the hypothesized model. Lei and Wu (2007) stated that it comprises of two components namely Amos Graphics (allows by drawing diagram in the model specification) and Amos Basic (the specifications generated from equation of statement).

Content validity

Initially, 42 safety intervention practices were identified. Five safety experts to evaluate the content validity and relevance in behavioural safety performance verified the list. The experts were required to evaluate the relevance, clarity and comprehensiveness of the safety activities list in each intervention levels. The experts are three safety officers from building construction, one from infrastructure construction and one from oil and gas construction with more than 5 years of construction safety experience. Eight of the safety intervention practices (one from management level, three from technical level, four from human level) from the list was discarded and the other 33 safety intervention practices were retained as in Figure 2. This expert review was to ensure that the safety intervention activities were relevant prior to the actual data collection in the Malaysian construction industry.

Data collection

Malaysian construction industry is selected to be the target population for this research. Anderson (2005) noted that if engineering, technical and system aspects are in place and adequately managed then behavioural interventions would be successful. Hence, before a company with major hazard sites embarks on a behavioural safety intervention, it has to ensure that safety organization of the company has satisfied several conditions in safety management. Consequently, the focus of this study is to conduct a research on the construction company that shows high commitment to safety management.

A large construction company is expected to comply with a safety management system that fully implemented the safety intervention practices at all level of safety control. Using a list of contractor companies registered as grade (G7) from the Construction Industry Development Board (CIDB), 600 questionnaires designed by using Google Form and the link, were sent via email. Afterwards, the construction companies were contacted via telephone to follow up with the survey feedback. At least 430 questionnaires feedback are required to run SEM analysis. In the beginning, the respondent response rate achieved was under 10%. A few weeks after, the respond rate had shown to be quite low. Therefore, personal visits to the companies and construction sites in the cities of Kuala Lumpur, Selangor, Pulau Pinang, Sabah, Sarawak and Johor were the selected solution in order to accelerate the response rate. Data collection is expected to be complete by June 2015.

System dynamics

System Dynamics (SD) is a selected methodology and modelling technique in understanding the integration of multi-level safety intervention practices and in discussing the outcome of worker safety behaviour performance. Forming a dynamic hypothesis is necessary in order to explain the dynamic characteristic problem in terms of the feedback system. The modelling process is moved forward through the real application that is subjected to revision and abandonment (Sterman 2000). Previous studies reveal that incident rates is dramatically influenced by safety intervention practices such as safety training, job planning, technical trainings, facilities inspections, audits and assessments, and preventive maintenance activities (Iyer et al. 2004; Shakioye and Haight 2010), which in turn cause the dynamics of behaviour safety performance (Bouloiz et al. 2013).

The dynamic hypotheses of this research are thus constructed and divided into four parts (organization safety management, technical system, human system and positive behavioural safety performance). Therefore, to get the specifics about the causal relationships, the feedback loops will be based on the first objective findings. The expected feedback loop will focus on organization safety management level, technical level and human level.

CONCLUSIONS

It is acknowledged that this research is a work in progress. An expected gap in knowledge on this research is to identify the most significant safety practices in each intervention level to develop an integrated model as a number of past study only focus on single intervention level. The possible research finding will be an expectation on safety personnel to be able to decide on the adequate actions to improve safety behaviour performance. In addition, the finding will contribute as a strategic guideline in selecting appropriate safety practices at each intervention level in managing safety intervention towards a worker effectively.

ACKNOWLEDGEMENTS

This research is supported by the research project allocation provided by the Faculty of Civil Engineering, Universiti Teknologi MARA Malaysia.

REFERENCES

Ai Lin Teo, E and Yean Yng Ling, F (2006) Developing a model to measure the effectiveness of safety management systems of construction sites. "Building and Environment", 41(11), 1584-1592.

Aksorn, T and Hadikusumo, B (2007) Gap Analysis Approach for Construction Safety Program Improvement. “Journal of Construction in Developing Countries", 12(1), 77–97.

Aksorn, T and Hadikusumo, B H W (2008) Critical success factors influencing safety program performance in Thai construction projects. "Safety Science", 46(4), 709–727.

Al Haadir, S and Panuwatwanich, K (2011) Critical success factors for safetyprogram implementation among construction companies in Saudi Arabia. “Procedia Engineering”, 14, 148–155.

Bouloiz, H, Garbolino, E and Tkiouat, M (2013) Modeling of an Organizational Environment by System Dynamics and Fuzzy Logic, “Open Journal of Safety Science and Technology”, 96–104.

Byrne, B M (2010) “Structural equation modelling with AMOS: Basic concepts, applications, and programming”. 2nd Ed. Routledge, New York.

Chan, A H S, Kwok, W Y, and Duffy, V G (2004) Using AHP for determining priority in a safety management system. “Industrial Management & Data Systems”, 104(5), 430-445.

Chi, C F, Lin, S Z and Dewi, R S (2014) Graphical fault tree analysis for fatal falls in the construction industry. “Accident Analysis & Prevention”, 72, 359-369.

Chinda, T and Mohamed, S (2008) Structural equation model of construction safety culture. “Engineering, Construction and Architectural Management”, 15(2), 114-131.

Chong, H Y and Low, T S (2014) Accidents in Malaysian Construction Industry: Statistical Data and Court Cases, International Journal of Occupational Safety and Ergonomics, 20(3), 503-513.

Choudhry, R M (2012) Implementation of BBS and the Impact of Site-Level Commitment. “Journal of Professional Issues in Engineering Education and Practice”, 138(4), 296-304.

Choudhry, R M (2014) Behavior-based safety on construction sites: A case study. “Accident Analysis and Prevention”, 70, 14-23.

Choudhry, R M, Fang, D and Ahmed, S M (2008) Safety Management in Construction: Best Practices in Hong Kong. “Journal of Professional Issues in Engineering Education and Practice”, 134(1), 20-32.

Cooper, D (2004) “Improving people performance in construction”. Gower Publishing, Ltd.

Cox, S and Jones, B (2006) Behavioural safety and accident prevention: short-term ‘fad’ or sustainable ‘fix’? “Process Safety and Environmental Protection”, 84(3), 164–170.

Dyreborg, J, Nielsen, K, Kines, P, Rasmussen, K, Olsen, O and Hester, J (2005) Title registration for a review proposal : Safety Interventions for the Prevention of Accidents in the Work Place, 1–12.

Geller, E S (2001) Behavior-based safety in industry: Realizing the large-scale potential of psychology to promote human welfare. “Applied & Preventive Psyhology”, 105(10), 87-105.

Geller, E S (2000) The psychology of safety handbook. CRC Press.

Hadjimanolis, A and Boustras, G (2013) Health and safety policies and work attitudes in Cypriot companies. “Safety Science”, 52, 50–56.

Hare, B and Cameron, I (2011) Site manager safety training. “Engineering, Construction and Architectural Management”, 18(6), 568-578.

Haupt, T C (2001) "The performance approach to construction worker safety and health" Unpublished Doctoral Dissertation, Department of Design, Construction and Planning, University of Florida.

Heinrich, H W, Petersen, D and Roos, N (1980) Industrial accident prevention (p. 27). New York: McGraw-Hill.

Hopkins, A (2006) What are we to make of safe behaviour programs? “Safety Science”, 44(7), 583-597.

Hoyle, R H (1995) “Structural equation modelling: Concepts, issues, and applications”. (Ed.). Thousand Oaks, California: Sage Publications.

Ismail, F (2012) Steps for the Behavioural Based Safety: A Case Study Approach. International “Journal of Engineering and Technology”, 4(5), 594–596.

Ismail, Z, Doostdar, S, and Harun, Z (2012) Factors influencing the implementation of a safety management system for construction sites. “Safety Science”, 50(3), 418–423.

Iyer, P S, Haight, J M, Del Castillo, E, Tink, B W and Hawkins, P W (2004) Intervention effectiveness research: Understanding and optimizing industrial safety programs using leading indicators. “Chemical Health and Safety”, 11(2), 9–19.

Kline, R B (2005) “Principles and practice of structural equation modelling”. (2nd Ed.). New York: Guilford Press.

Kristensen, T S (2005) Intervention studies in occupational epidemiology. “Occupational and Environmental Medicine”, 62(3), 205–210.

Lei, P W and Qiong Wu (2007) Introduction to structural equation modelling: Issues and practical considerations. “Educational Measurement: Issues and Practice”, 26(3), 33-43.

Luria, G and Morag, I (2012) Safety management by walking around (SMBWA): A safety intervention program based on both peer and manager participation. “Accident Analysis and Prevention”, 45, 248–257.

Makin, A M and Winder, C (2008) A new conceptual framework to improve the application of occupational health and safety management systems. “Safety Science”, 46(6), 935–948.

Maloney, W F, Cameron, I and Hare, B (2007) Tradesmen involvement in health and safety. “Journal of Construction Engineering and Management”, 133(4), 297-305.

Misnan, M S, Hakim, A, Yusoff, W and Mahmood, W (2008) Development of Safety Culture in the Construction, “2nd International Conference on Built Environment in Developing Countries, (ICBEDC)”, 1902–1920.

Mohamed, S (2002) Safety Climate in Construction Site Environments. “Journal of Construction Engineering and Management”, 128(5), 375–384.

Mohamed, S, Ali, T H, & Tam, W Y V (2009) National culture and safe work behaviour of construction workers in Pakistan. “Safety Science”, 47(1), 29–35.

Nielsen, K J (2014) Improving safety culture through the health and safety organization: A case study. “Journal of Safety Research”, 48, 7-17.

National Institute for Occupational Safety and Health, NIOSH. Department of Health and Human Services (2001) Guide to evaluating the effectiveness of strategies for preventing work injuries: how to show whether a safety intervention really works (pp. 106-107). Cincinnati, OH: NIOSH.

Oyewole, S A, Haight, J M, Freivalds, A, Cannon, D J and Rothrock, L (2010) Statistical evaluation and analysis of safety intervention in the determination of an effective resource allocation strategy. “Journal of Loss Prevention in the Process Industries”, 23(5), 585-593.

Paul, P S, & Maiti, J (2008) The synergic role of sociotechnical and personal characteristics on work injuries in mines. “Ergonomics”, 51(5), 737-767.

Quinn, K (2010) An in depth study of how the psychological behaviours affect construction safety.

Reason, J (2000) Human error: models and management. “Bmj”, 320 (7237), 768-770.

Rikhardsson, P M and Impgaard, M (2004) Corporate cost of occupational accidents: An activity-based analysis. “Accident Analysis and Prevention”, 36(2), 173-182.

Rowlinson, S (2004) Construction safety management systems. (Ed.). Routledge.

Sawacha, E, Naoum, S and Fong, D (1999) Factors affecting safety performance on construction sites. International Journal of Project Management, 17(5), 309-315.

Schumacker, R E and Lomax, R G (2004) A beginner's guide to structural equation modelling. Psychology Press.

Shakioye, S O and Haight, J M (2010) Modelling using dynamic variables - An approach for the design of loss prevention programs. “Safety Science”, 48(1), 46-53.

Sheeran, P and Silverman, M (2003) Evaluation of three interventions to promote workplace health and safety: Evidence for the utility of implementation intentions. “Social Science and Medicine”, 56(10), 2153-2163.

Sterman, J D (2000) Business dynamics: systems thinking and modelling for a complex world (Vol. 19). Boston: Irwin/McGraw-Hill.

Sulzer-Azaroff, B and Austin, J (2000) Does BBS work. “Professional Safety”, 45(7), 19-24.

Tam, C M, Zeng, S X and Deng, Z M (2004) Identifying elements of poor construction safety management in China. “Safety Science”, 42(7), 569-586.

Toole, T M (2002) Construction Site Safety Roles. “Journal of Construction Engineering and Management”, 128(3), 203-210.

White, P and Executive, S (n.d.) Changing the health and safety culture of the UK construction industry Fatal Accidents – numbers and rates.

Wirth, O and Sigurdsson, S O (2008) When workplace safety depends on behaviour change: Topics for behavioural safety research. “Journal of Safety Research”, 39(6), 589-598.

Woodson, W E, Tillman, B and Tillm an, P (1992) Human factors design handbook: information and guidelines for the design of systems, facilities, equipment, and products for human use.

Yu, Q Z, Ding, L Y, Zhou, C and Luo, H B (2014) Analysis of factors influencing safety management for metro construction in China. “Accident Analysis and Prevention”, 68, 131-138.

Zhang, M and Fang, D (2013). A continuous Behaviour-Based Safety strategy for persistent safety improvement in construction industry. “Automation in Construction”, 34, 101-107.

Zhang, M and Fang, D (2013) Construction Management and Economics A cognitive analysis of why Chinese scaffolders do not use safety harnesses in construction, (April), 37-41.

Zin, S M and Ismail, F (2012) Employers’ Behavioural Safety Compliance Factors toward Occupational, Safety and Health Improvement in the Construction Industry. “Procedia - Social and Behavioural Sciences”, 36, 742-751.

Zohar, D (2002) Modifying supervisory practices to improve subunit safety: a leadership-based intervention model. “The Journal of Applied Psychology”, 87(1), 156-163.

Zohar, D and Luria, G (2003) The use of supervisory practices as leverage to improve safety behaviour: A cross-level intervention model. “Journal of Safety Research”, 34(5), 567-577.

EXPLORING THE POTENTIAL OF USING TEXT MINING TO DEVELOP SAFETY LEADING INDICATORS BASED ON FREE TEXT DATA

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Effective construction safety management is dependent on systematic data analysis of safety data and information. Past research had shown that machine learning techniques such as artificial neural network and decision tree are useful for analyzing safety data. However, current research were focused on quantitative data and had neglected the vast amount of construction safety data in free text format, e.g. meeting minutes, safety briefing, inspection and audit findings. These free text data can be analysed using text mining and natural language processing (NLP) techniques. For example, text mining can be used to analyse daily construction progress reports, meeting minutes and inspection reports to develop safety leading indicators. Text mining techniques require free text data to be catalogued, partitioned into training and test sets before specific machine learning methods like decision tree, artificial neural network etc. can be utilised. Resulting models have to be evaluated for their performance and the most accurate models can then be selected. Thus, despite its potential, application of text mining techniques can be challenging. This paper highlights the importance of safety leading indicators, summarises a possible approach to applying text mining techniques in developing safety leading indicators, and evaluates the opportunities and difficulties in such studies.

Keywords: Risk; construction safety and health; data analysis; machine learning; natural language processing; text mining

INTRODUCTION

According to the Workplace Safety and Health Institute (WSHI), the construction industry has had the highest workplace fatal injury rate (Workplace Safety and Health Institute 2013). This is despite a decrease in total number of fatalities in all sectors (WSHI 2013). At the same time, the construction sector has expanded by 7.3% yearly and grew by 16.5% on a quarterly basis (Bucknall 2013). This indicates that if the fatality rate remains high, a growing construction sector equates to more fatalities. Construction accidents not only cause significant human suffering, they affect project progress and costs and the poor safety records damages the reputation of the industry and the companies involved. However, the increasing complexity of construction projects and the need to improve productivity present a significant challenge to WSH interventions. Many have proposed the use of leading indicators such as inspection findings, audit score and safety climate surveys to help construction-related organisations (Hallowell et al. 2013; Toellner 2001), e.g. large developers and contractors, forecast safety performance and improve safety risk controls proactively. However, these leading indicators are not known to be reliable and the artificial nature of the data collection process makes the development of these leading indicators susceptible to manipulation.

Construction projects produce a myriad of text documents such as meeting minutes, risk assessments, training records, inspection records, expenditure reports, variation orders and

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specifications. These documents contain important information that can be used to develop useful leading indicators of safety risks. For example, many major accidents have been linked to production pressure, thus project progress and cost reports can provide indications of the current level of production pressure. In addition, meeting minutes and daily reports will highlight site issues that can impact on safety, e.g. delays in delivery of material, and problems in getting sub-contractors to mobilise, but senior managers (e.g. Director of Projects, Chief Risk Officer, and Corporate Quality, Safety, Health and Environment Manager) are usually not aware of these details. However, it is not feasible for senior managers to plough through large volume of text documents to get an insight on the safety risk of the projects. Senior managers overseeing portfolios of projects need to understand the safety risk levels of their projects efficiently. Research has shown that senior managers that are not in the know of safety risks cannot display effective safety leadership, which is a common underlying factor of major accidents (Goh and Soon 2014). Even though Workplace Safety and Health Officers (WSHOs) may have a better sense of the safety risk of the project that they are overseeing, they typically constrain themselves to safety-related information and do not scout other project documents to gain a broader perspective of safety risks. Furthermore, WSHOs will need better leading safety indicators to guide their effort and to benchmark against other projects.

Thus, it is proposed that text mining and natural language processing (NLP) techniques be applied to develop leading indicators that will help organisations identify, evaluate and control risks proactively. It is noted that operational risks can include a range of issues such as safety risks, delays, budget over-run and quality issues, but this study will be focusing on safety risks. Evaluation of “naturally occurring” construction records and documents is a novel and potentially more reliable approach (compared to current safety leading indicators) in forecasting the safety performance and risks of a portfolio of projects. Once an analytic model is developed, the model can be used to analyse the construction-related documents periodically to evaluate the safety risks that the projects face. Based on the risks highlighted by the model, senior managers can then take appropriate measures to mitigate the identified risks. Text mining approaches have not been applied in the area of construction safety and possibly safety management in general. Text mining approaches are also new in the context of construction management.

SAFETY LEADING INDICATORS

Even though a workplace safety and health officer (WSHO) is required to identify and assess risk and recommend safety measures to reduce the risk at the project level, senior managers are still accountable for accidents. Thus, senior managers are expected to maintain safety oversight across projects. However, senior managers lack time to plough through volumes of project documents and information submitted by the different projects. Moreover senior managers may not have the expertise to understand all the relevant information presented to them. Even construction safety professionals struggle to develop effective leading indicators to help them prioritise their efforts and resources effectively (Hallowell et al. 2013). Thus, it is important to develop a set of safety leading indicators, condensed from project information and documents, to help senior managers and safety professionals evaluate project risks. The proposed indicators should be presented in a management dashboard to allow senior managers to easily understand critical information quickly and take proactive actions to reduce project risks. It is believed such a system would help senior managers understand the underlying factors that affect safety and gain sufficient insight to substantiate proactive actions. Many studies have shown that it is important for the senior managers to be informed of the key WSH risks that their organization is facing. For example, Reason (1997) argued that an informed culture, where senior managers are well-informed of key safety and health risks, is the cornerstone of a positive safety culture. The proposed dashboard containing the leading indicators derived from project data and documents would guide senior managers’ investment of time and effort on different projects.

Safety performance has traditionally been measured by metrics such as recordable injury rates, and experience modification rate (EMR) that are gathered after losses have been incurred and cost assessments have been made (Grabowski et al. 2007). Toellner (2001) describes these traditional metrics or lagging indicators as measurements that are linked to the outcome of an accident. Lagging indicators are necessary, but over-reliance on them does not promote proactive safety management. In contrast, leading indicators are predictors of future levels of safety performance and they frequently measure the adequacy of actions taken to prevent accidents. Leading indicators can be based on conditions, events, or measures that precede an incident and allows forecasting of risk of accident, incident and unsafe conditions (Grabowski et al. 2007; Manuele 2009). Leading indicators are known to be related to the safety culture of a project or company, which is a critical success factor to sustained low accident rates. When one or more leading indicators suggest a deteriorating safety management system or safety culture, interventions can be implemented before accidents happen.

However, leading indicators need to be credible for them to function effectively. To ensure credibility, the leading indicators have to be validated, updated and resistant to manipulation. Current leading indicators seldom meet these criteria. Moreover, whenever indicators are tied to incentives and disincentives (e.g. safety bonus for achieving training targets), they become prone to manipulations. Thus, as proposed, one possible solution is to develop leading indicators based on construction documents and data that are part and parcel of any project. The evaluation will be holistic and will not be constrained to safety documents because it is believed that safety problems are intertwined with project management issues.

TEXT MINING IN CONSTRUCTION

Owing to the large volume of construction documents, it would be an arduous task to analyse the documents manually. Text mining and machine learning techniques can be applied to overcome such difficulties. Text mining, in a narrow sense, is the methodology used for refining given organized documents into something with a smaller volume and higher value, i.e. knowledge (Fan et al. 2006; Hearst 1999). Simoff and Masher (1998) highlighted that a key issue in managing construction information is the diversity of data types, including:

1. Structured data files stored in database management system or specific applications, such as data warehousing, enterprise resource planning, cost estimating, scheduling, payroll, finance, and accounting;
2. Semi-structure data files, such as Hyper Text Markup Language (HTML), Extensible Markup Language (XML), or Standardized General Markup Language (SGML) files; and
3. Unstructured text data files such as contracts, specifications, catalogs, change orders, requests for information, inspection reports, safety briefing or training sessions, risk assessments etc.

The difficulties mentioned above has been ameliorated by the usage of centralized databases and document management systems in recent days. Recent research addressed some of the issues related to unstructured text data mining. There have been applications of text mining to construction management, but such techniques has not been applied on project risks, particularly safety risks. Past studies were focused on information systems and algorithms designed to improve document management (Fruchter and Reiner 1996; Hajjar and AbouRizk 2000; Zhu et al. 2001). Controlled vocabularies (thesauri) were also used to integrate heterogeneous data representations including text documents (Kosovac et al. 2000; Lee et al. 2006; Turk 2006). Various data analysis tools were also applied on text data to create thesauri, extract hierarchical concepts, and group similar files for reusing past design information and construction knowledge (Scherer and Reul 2000; Wood 2000; Yang et al. 1998). More recent studies by Cheng et al. (2010) have used association rules to identify the cause effect relationship in many factors that are related to accident causation in construction industry. Montella et al. (2012) have used similar approach in analysis of powered two-wheeler crashes in Italy. Text mining has also been applied to construction project documents to predict the cost overrun involved in the project (Williams and Gong 2014).

With the development of text mining algorithms in recent years, it is now viable to devise leading indicators of project safety risks based on project documents. Nevertheless, current research have not utilised text mining and machine learning approaches in this aspect.

PROPOSED RESEARCH APPROACH

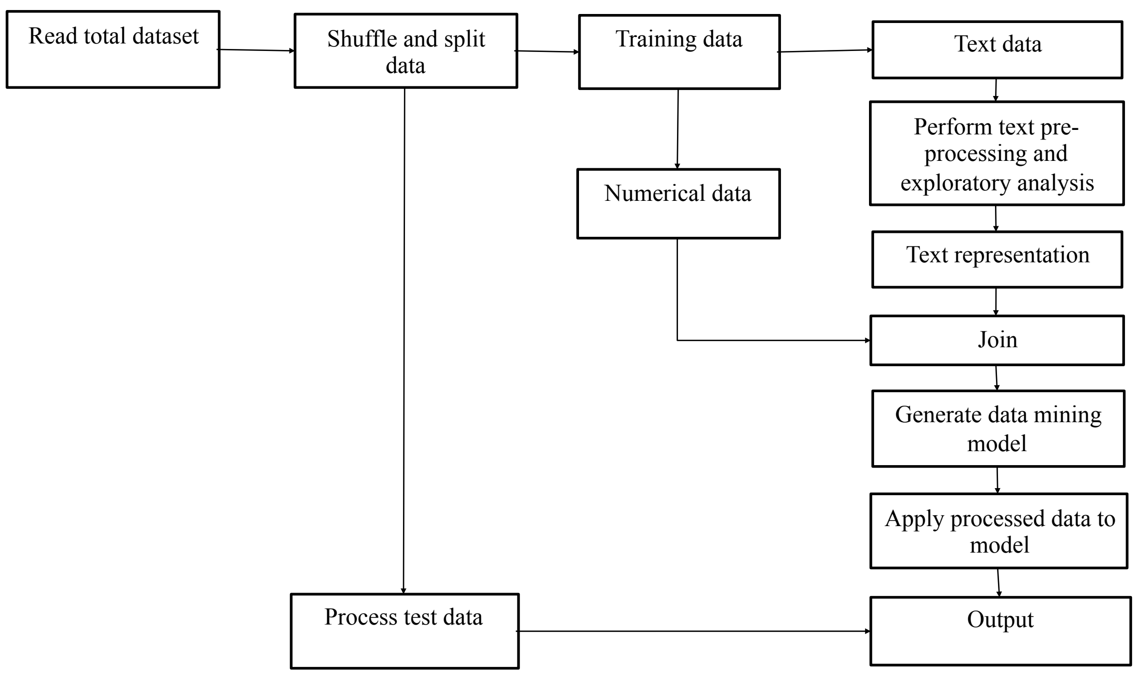
In order to develop safety leading indicators and help senior managers understand the safety performance of their project, the following components must be developed:

1. A predictive model that comprise safety leading indicators which forecast the likely safety performance of a project; and
2. A visualization component/dashboard that helps senior managers to understand the safety performance of ongoing projects.

To develop the two components highlighted above, the text mining study should comprise of three main phases: data collection, data preparation and modeling, and data visualization.

Data Collection

Data collection phase involves collection and compilation of typical project information to facilitate application of text analytics techniques. Documents such as audit records, minutes of meeting, and progress records would constitute the text corpora which would be analysed. Since machine learning algorithms tend to perform better with bigger dataset, a sample size of about 100 projects should be targeted.



Data preparation and modeling

The projects' lagging safety performance indicators, such as Total Recorded Incident Rate (TRIR), should be categorised based on a safety performance scale of say 1-5. This means that each project will have a set of time-stamped documents and a safety performance score at regular time intervals. In this way, the research problem can be redefined into a classification task, where the text in the project documents would be used to predict the safety performance of an ongoing project at each time interval. This predicted safety performance score will then function as a leading indicator. During data preparation, data quality issues will also be addressed, where irrelevant or erroneous documents have to be removed. Data collected will need to be assessed by checking its volume, accessibility and availability of attributes, types and range. Before the commencement of text pre-processing, care should be taken to extract the unstructured text information from the construction documents.

A typical construction document would comprise structured and unstructured components. Take safety audit record as an example. Each record will contain information such as audit purpose, safety scores, and number of workers, which are the structured components in the document. The audit records will also contain accident preventive action which is an important unstructured data. The structured data that are available in numerical form can be processed by the machine learning algorithms without much pre-processing. Whereas unstructured text data would require text pre-processing to be applied before they can be processed by the classification algorithms. Hence the training data from Figure 1 has to be split into numerical data and text data. To extract unstructured data, techniques such as regular expression matching (Thompson 1968) can be applied to the documents to parse and extract the relevant information from the documents to build the text corpus. Figure 1 illustrates the general data preparation and modeling approach, detailed explanation of each phase will be explained in the following text.

4.2.1 Text pre-processing and exploratory analysis

The first step in handling text data is to break the stream of characters into precise units, called tokens. Each token would represent a word or a pair of words. Once the character stream has been segmented into a sequence of tokens, the next step is to convert each of the tokens into a standard form, a process usually referred as stemming or lemmatization. Porter stemmer (Porter 1980) is a popular choice when it comes to stemming in text mining. In addition, stopword removal has to be conducted. Common words such as 'The' and 'and', which are functional words which do not contribute to any meaningful information in text analysis should be removed. After analysing the outcome of the stop word removal process additional hand curated list of stopwords may be included to remove redundant domain specific terms such as 'Construction'. Stemming and stopword removal significantly reduces the size of the input matrix for model development.

Other transformations may need to be applied to the text corpus before it can be fed to the classifier algorithm. For example, concept extraction and classification can be applied to a safety audit report (see below for a sample extract) to extract concepts that are indicative of the level of implementation of safety management.

> *"Finding 03-09: Malfunction fuel gauge which always indicate "empty"; indication was ignored by operator for almost 2 years. Engine stalled due to no fuel could impact lifting operation.*
>
> *Recommendation: Conduct regular checks to ensure equipment and machineries are maintained in functional condition.*

Concept extraction involves analysis of the text corpus to identify repeating or important terms (tokens). During the extraction process, each token is checked to ascertain whether the word is registered in a key concept dictionary. If the word is linked to a concept in the dictionary, the word is classified under the concept. Using the extract above, "malfunction" and "improvised" may be classified under the concept of “unsafe conditions or acts”. Common grammatical errors and polysemy (word with multiple meanings) can be addressed by highlighting these possible errors and multiple meanings in the concept dictionary. Sometimes single word tokens are too general or ambiguous to represent a concept. Multiword features may be utilized to represent a concept. Statistical approaches can be used to identify the multiword features based on the co-occurrence frequencies, i.e. two tokens occurring together in a corpus more frequently than their chance alone would suggest.

The IBM SPPS text mining packages provide useful resources for getting started with concept extraction and classification of the text corpora. However, not every single domain dependent term appearing in the corpus will be classified by such dictionaries. Hence, concept extraction would require further analysis of terms and building hand curated rules to supplement the concept extraction procedure. Qualitative domain knowledge such as the Modified Loss Causation Model (Chua and Goh 2004), are essential for guiding the concept extraction and classification process. Accident causation models help to identify concepts that have an influence on safety performance (e.g. production pressure, competency of workers, safety commitment of middle managers). Furthermore, existing work on the leading indicators of construction safety performance (Hallowell et al. 2013; Hinze et al. 2013) will provide guidance in choosing the concepts and determining their relative importance as predictors. In addition, experienced WSH professionals should be interviewed to identify and validate the identified concepts.

Besides concept extraction and classification, link analysis should also be applied to facilitate development of the safety leading indicators. Link analysis is the process of building up networks of interconnected objects in order to explore patterns and trends of the relationship between the objects (Berry and Linoff 1997). For example, a link analysis can be conducted to uncover the relationship between various accident causation factors such as production pressure, safety culture, and near miss rates. These relationships will then serve as useful knowledge to guide the development of the data mining model. If the association analysis proves to be computationally expensive, there are available techniques, known as apriori algorithms (Inokuchi et al. 2000), that can be applied to reduce the computational load.

4.2.2 Development of data mining model

Once the text has been mapped to their respective concepts using the constructed dictionaries, they can be represented in the input matrix either in binary forms or using tf-idf (term frequency- inverse document frequency) transformations (Salton and McGill 1983). The input matrix would be split into training and test sets, where 70% of the available data would constitute the training set and 30% as the test set. If necessary, data bootstrapping technique can be applied to supplement low volume of training data. Some of the data mining prediction techniques that could be applied for text mining include (Weiss et al. 2010): similarity and nearest-neighbor methods, document similarity, decision rules, decision trees, scoring by probabilities, and linear scoring methods.

Due to the sparse nature of text data, where the matrix rows are mostly zeros, Ridor Rules and Latent Dirichlet Allocation (LDA) can be used to build the prediction models. Ridor Rules is an algorithm that automatically generates a set of classification rules from the input data (Cleary and Trigg 1995). The Ridor algorithm learns rules with exceptions by generating a default rule. The default or top-level rule is the class of the output that occurs most frequently. Then the algorithm uses incremental reduced-error pruning to find exceptions with the smallest error rate, finding the best exceptions for each exception and iterating. LDA is meant to find short descriptions of the members of a collection that enable efficient processing of large collections while preserving the essential statistical relationships that are useful for basic tasks such as classification (Blei et al. 2003). LDA can be considered as a dimensionality reduction technique. It has proven to be more efficient than Latent Semantic Indexing (LSI) (Deerwester et al. 1990) in the sense that the proportion of data used for training is reduced. The statistical software *R* has implementation of LDA that can be applied to the text corpus.

The data mining models produced using the range of techniques identified above have to be tested and validated using the test data. The test data consist of pre-classified set of documents that have not been used to train the model. This test data will be used to evaluate the model based on commonly used metrics such as precision, recall and F-measure. The predictions of the validated models can then be used as safety leading indicators to guide managers overseeing the portfolio of projects.

Data Visualization

Senior managers and safety officers managing the construction projects need to understand the safety performance of their projects to promote necessary actions. Visualizations are valuable tools to highlight the safety performance indicators. They may either reflect the past data which helps managers learn retrospectively or provide safety indicators of ongoing projects. Figure 2 represents a sample management dashboard indicating the risk scores of ongoing construction projects, proportion of major and minor accidents in projects and breakdown of claim amount for each accident category.

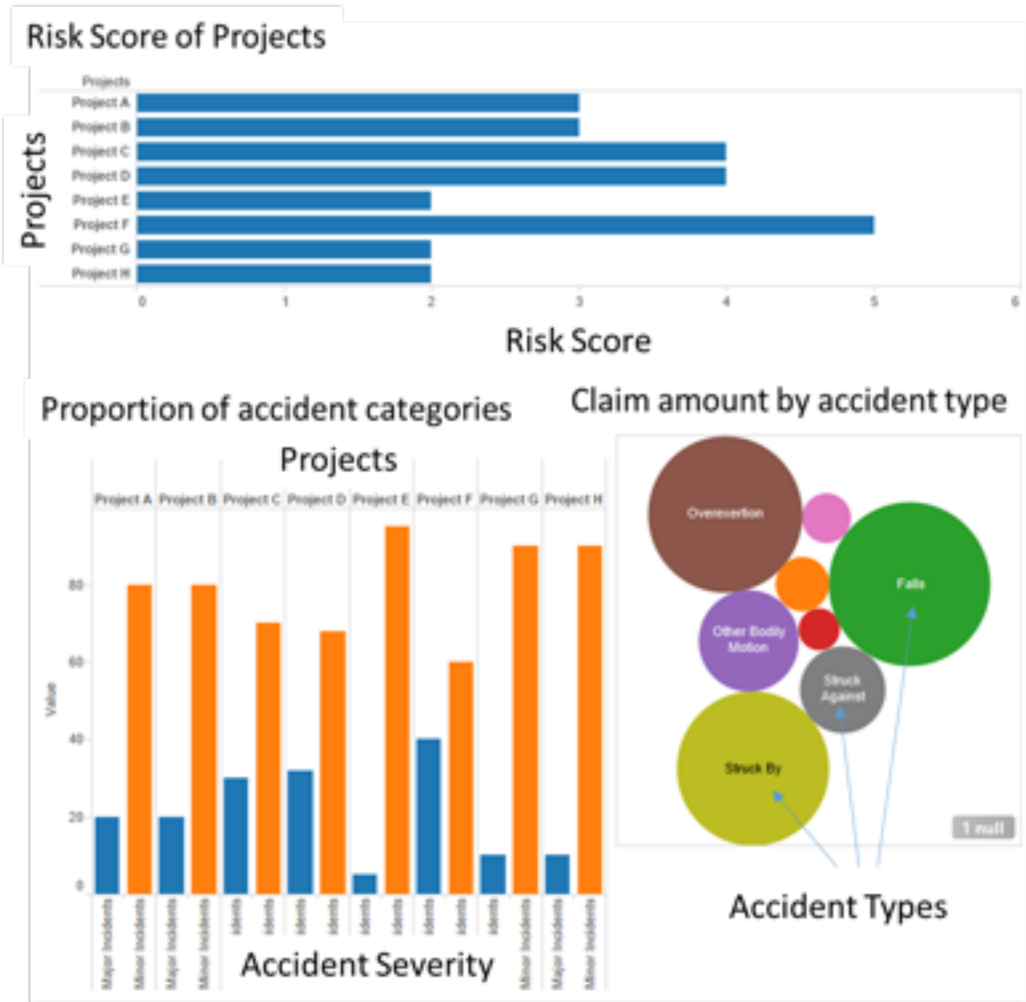


Figure 2 : A sample management dashboard

LIMITATIONS AND CONCLUSIONS

This paper explains the importance of leading indicators in construction safety, highlights the inadequacies in current approach and proposes a text mining approach. The text mining approach can be used to develop leading safety indicators from naturally occurring construction documents and is more resistant to manipulation. Numerous text mining and natural language processing techniques were highlighted, and a systematic procedure was discussed. In addition, it was proposed that data visualisation dashboards have to be developed to help senior managers and safety officers comprehend the wide range of data and indicators compiled by the text mining approach.

The proposed method is scalable to a large number of projects and it can cope with a variety of electronic documents generated in a construction project. The developed models can be deployed on ongoing construction projects to provide periodic overview of the safety status of a portfolio of projects and help senior managers take preventive measures to improve the safety performance of the project.

However, it should be noted that the text mining approach will only be able to find the patterns in the underlying data. The quality of results produced will be directly dependent on the information contained in the reports. Hence significant effort will be required in carefully selecting the reports and pre-processing the textual information. Organisations reliant on paper based reports will have to perform additional process of digitization which may introduce errors in the reports. Future research would consist of implementing the suggested approach with real world construction data, validating the results with industry experts and extending the application of techniques to predict other aspects of operational risks such as budget overruns and operational delays.

REFERENCES

Berry, M. J., and Linoff, G. (1997). *Data mining techniques: for marketing, sales, and customer support*, John Wiley & Sons, Inc.

Blei, D. M., Ng, A. Y., and Jordan, M. I. (2003). "Latent dirichlet allocation." *the Journal of machine Learning research*, 3, 993-1022.

Bucknall, R. L. (2013). "Construction Market Quarterly Update Issue No. 62 (June 2013)."

Cheng, C.-W., Lin, C.-C., and Leu, S.-S. (2010). "Use of association rules to explore cause–effect relationships in occupational accidents in the Taiwan construction industry." *Safety science*, 48(4), 436-444.

Chua, D. K. H., and Goh, Y. M. (2004). "Incident causation model for improving feedback of safety knowledge." *J. Constr. Eng. and Manage. - Am. Soc. of Civ. Eng.*, 130(4), 542-551.

Cleary, J. G., and Trigg, L. E. "K: An instance-based learner using an entropic distance measure." *Proc., Proceedings of the 12th International Conference on Machine learning*, 108-114.

Deerwester, S. C., Dumais, S. T., Landauer, T. K., Furnas, G. W., and Harshman, R. A. (1990). "Indexing by latent semantic analysis." *JAsIs*, 41(6), 391-407.

Fan, W., Wallace, L., Rich, S., and Zhang, Z. (2006). "Tapping the power of text mining." *Communications of the ACM*, 49(9), 76-82.

Fruchter, R., and Reiner, K. "Model-centered world wide web coach." *Proc., Computing in Civil Engineering (1996)*, ASCE, 1-7.

Goh, Y. M., and Soon, W. T. (2014). *Safety Management Lessons from Major Accident Inquiries*, Pearson, Singapore.

Grabowski, M., Ayyalasomayajula, P., Merrick, J., and Mccafferty, D. (2007). "Accident precursors and safety nets: leading indicators of tanker operations safety." *Maritime Policy & Management*, 34(5), 405-425.

Hajjar, D., and AbouRizk, S. (2000). "Integrating Document Management with Project and Company Data." *Journal of Computing in Civil Engineering*, 14(1), 70-77.

Hallowell, M. R., Hinze, J. W., Baud, K. C., and Wehle, A. (2013). "Proactive construction safety control: measuring, monitoring, and responding to safety leading indicators." *Journal of Construction Engineering and Management*, 139(10).

Hearst, M. A. "Untangling text data mining." *Proc., Proceedings of the 37th annual meeting of the Association for Computational Linguistics on Computational Linguistics*, Association for Computational Linguistics, 3-10.

Hinze, J., Thurman, S., and Wehle, A. (2013). "Leading indicators of construction safety performance." *Saf. Sci.*, 51(1), 23-28.

Inokuchi, A., Washio, T., and Motoda, H. (2000). "An apriori-based algorithm for mining frequent substructures from graph data." *Principles of Data Mining and Knowledge Discovery*, Springer, 13-23.

Kosovac, B., Froese, T., and Vanier, D. (2000). "Integrating heterogeneous data representations in model-based AEC/FM systems." *Construction information technology*, 2, 556-567.

Lee, G., Eastman, C. M., Sacks, R., and Navathe, S. B. (2006). "Grammatical rules for specifying information for automated product data modeling." *Advanced Engineering Informatics*, 20(2), 155-170.

Manuele, F. A. (2009). "Leading & Lagging Indicators." *Professional Safety*, 54(12), 28-33.

Montella, A., Aria, M., D'Ambrosio, A., and Mauriello, F. (2012). "Analysis of powered two-wheeler crashes in Italy by classification trees and rules discovery." *Accident Analysis & Prevention*, 49, 58-72.

Porter, M. F. (1980). "An algorithm for suffix stripping." *Program*, 14(3), 130-137.

Reason, J. (1997). *Managing the risks of organizational accidents*, Ashgate, Aldershot.

Salton, G., and McGill, M. J. (1983). "Introduction to modern information retrieval."

Scherer, R. J., and Reul, S. "Retrieval of project knowledge from heterogeneous AEC documents." *Proc., Proc. of the 8th Int. Conf. on Comp. in Civil and Building Eng*, 812-819.

Simoff, S. J., and Maher, M. L. "Ontology-based multimedia data mining for design information retrieval." *Proc., Proceedings of ACSE Computing Congress*, Cambridge, MA: ACSE.

Thompson, K. (1968). "Programming techniques: Regular expression search algorithm." *Communications of the ACM*, 11(6), 419-422.

Toellner, J. (2001). "Improving safety & health performance: Identifying & measuring leading indicators." *Professional Safety*, 46(9), 42-47.

Turk, Ž. (2006). "Construction informatics: Definition and ontology." *Advanced Engineering Informatics*, 20(2), 187-199.

Weiss, S. M., Indurkhya, N., and Zhang, T. (2010). *Fundamentals of predictive text mining*, Springer Science & Business Media.

Williams, T. P., and Gong, J. (2014). "Predicting construction cost overruns using text mining, numerical data and ensemble classifiers." *Automation in Construction*, 43(0), 23-29.

Wood, W. H. (2000). "THE DEVELOPMENT OF MODES 1N TEXTUAL DESIGN DATA."

Workplace Safety and Health Institute (2013). "Workplace Safety and Health Report 2012." <https://www.wshc.sg/wps/PA_InfoStop/download?folder=IS2013032100730&file=Workplace_Safety_and_Health_Report_2012.pdf>. (26 Apr 2013).

Yang, M. C., Wood, W. H., and Cutkosky, M. R. (1998). "Data mining for thesaurus generation in informal design information retrieval." *Proc. 1998 Int. Congr. Civil Engineering*, 18-21.

Zhu, Y., Issa, R., and Cox, R. (2001). "Web-Based Construction Document Processing via Malleable Frame." *Journal of Computing in Civil Engineering*, 15(3), 157-169.

TOWARDS ZERO CONSTRUCTION MOTOR VEHICLE ACCIDENT IN SOUTH AFRICA

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Industry reports and empirical studies have confirmed the rise in motor vehicle accidents (MVAs) in South African construction. The rise in MVAs has impacted on the direct and indirect cost of accidents in South Africa. To address this worrying trend, a longitudinal study commenced in 2012 / 2013. This paper reports on findings using the archival research method supplemented with the findings of an exploratory survey so as to develop working hypotheses and theoretic propositions for further inquiry relative to mobility (MVAs and Struck-by) related accidents in South African construction. The analysed data suggest that MVAs and struck-by accidents in South Africa lead to loss of life, permanent and non-permanent disabilities, lost work days, and financial loss. The mobility related accidents also have multiple causal pathways, which require a study that recognises the need for contextualisation and analytic generalisation. The value of the exploratory study is that compliance to regulations has failed to stem the trend of fatalities and disabilities in the sector. The apparent compliance failure is a motivation to look at health and safety (H&S) management programmes that can change construction practice with significant success. 'Zero Target', is a programme to be considered. The approach could substantially reduce accidents and eventually stem the tide of fatalities.

Keywords: Accidents, Construction, Health and Safety, Motor Vehicle, South Africa

BACKGROUND

At the start of a longitudinal construction motor vehicle accident (MVA) study, Emuze and Smallwood (2012) concluded that MVA has become a major source of fatalities among construction workers in South Africa. This conclusion was premised on theoretical and statistical analysis, which shows that MVAs recorded against construction work in South Africa, is on the upward trajectory. Beyond the statistics, Emuze and Smallwood (2012) also used newspaper reports to illustrate how fatalities occurs with an example of an accident in which three people lost their life when the driver of a ready mix concrete truck lost control of the vehicle. As an illustration, Figure 1 shows an accident in which two construction workers sustained severe injuries through a truck that over turned. It was reported that the construction workers had loaded the truck with concrete pipes and were transporting them to the top of the road where site activities were taking place. Somehow the weight of the pipes shifted and caused the truck to overturn while they were going up the unpaved road. The accident shown in Figure 1 occurred in 2010 when the industry began to take note of the rise in MVAs in South African construction.

As early as 2009, the Construction Industry Development Board (cidb), which is mandated to regulate and provide leadership in South Africa construction (Republic of South Africa, 2000), raised the alarm concerning the increase in the rate at which MVAs are killing both workers and the public in South

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Africa (cidb, 2009). The cidb report says that MVAs account for 100 fatalities per year on average. A 2014 online media report says that the statistics of the Federated Employer's Mutual Assurance Company (FEM) shows that fatalities in the construction industry is estimated to be 150 based on about 400 accidents that occur annually in South African construction (Protectin, 2014). Construction fatalities now surpass that of the mining industry in South Africa (Protectin, 2014). Fatalities associated with MVAs are not limited to South African construction. Hobson et al. (2014) highlight the impact of the people-plant interface on fatalities in an article in which the construction industry in the United Kingdom (UK) was flagged as a major offender concerning struck-by either plant or vehicles.

Figure 1: Example of a construction MVA in South Africa (Source: ER24)

To address this worrying trend, a longitudinal study commenced in 2012 / 2013. This paper thus reports on the analysis of archival statistical records from the mutual construction workers' compensation insurance firm in South Africa - FEM. A comparison of the FEM data and the findings of an empirical survey show that the current approach to MVA reduction is in need of a rethink along the lines of 'zero target'.

ZERO TARGET: CONCEPT & REALITY

In an industrial production environment, the absolute definition of a 'safe' worksite is the one with zero injuries and fatalities - zero accidents. However, empirical studies have documented the extent of the efficacy of such a target. A New Zealand study observes that even though an aluminium smelter company have adopted and focused on a 'zero target / vision' for over two decades, attainment is elusive (Young, 2014). The company has however recorded an extraordinary reduction in lost time injuries (LTIs) over a significant period of time owning to the use of automation, personal protective equipment, a cycle of improvement, and proprietary behaviour interventions. Though the pursuit of this H&S vision by the firm has been difficult, it may have induced prolonged efforts within the firm for the steady reduction in LTIs to form a notable trend. The New Zealand firm is not alone in the pursuit of the zero accidents vision, since major firms around world, either in the construction industry or manufacturing sector, have adopted similar targets in order to protect their employees from work-related harm (Van Scyoc, 2008; Wilkins, 2011).

In the construction industry context, Sherrat (2014) used a social constructionist methodology with discourse analysis to examine the practical realities of 'zero target' / 'zero vision' of H&S in the UK. The findings, which are based on the information collected from five large contractors operating 'zero target' H&S programmes, show that 'zero' was viewed as both a philosophy and a target with different interpretations between top and site management in practice. Sherrat (2014) notes that although the incoherence and inconsistency concerning the understanding of what constitute 'zero' exist, the concept of 'zero' was observed to be a necessity for H&S management so as to improve construction practice.

RESEARCH METHOD

The paper is based on the archival research method that is supplemented with the findings of an exploratory survey on MVAs in South African construction. The 'what' questions, which are beginning to emerge from the longitudinal study, are now a form of 'how many' or 'how much' line of inquiry (Yin, 2014). These methods (archival and survey) are expedient when the research goal is either to describe the prevalence of a phenomenon or the prediction of possible outcomes is necessary. In essence, this exploratory phase of the study is aimed at developing pertinent hypotheses and propositions for further inquiry relative to mobility related accidents in South African construction. For this study, archival research was done by locating, evaluating, and interpreting (systematic) the information on the FEM database (Lewis-Beck et al., 2004). The data sourced on the online portal of FEM were refined and scrutinised with the direct data supplied to the research team by the manager in charge of FEM data, upon the request from the researchers. The data were consulted and analysed for purposes other than those for which they were originally collected by FEM - to ask new questions relative to construction mobility related fatalities and disabilities in South Africa. Although the data provide a comparison over time, and between provinces of South Africa, a national perspective is presented in this paper. The archival data allow the research team to verify existing findings (the exploratory survey), and then, use these evidences from disparate sources to provide an enhanced overview of the issue in South Africa. The FEM data included data as recent as December 2014. With respect to the exploratory survey data, the self-administered questionnaire that was used consisted of 10 questions, 4 of which were 5-point Likert scale type questions. Due to the delicate nature of the subject, demographic questions were not included, despite assurances of anonymity. The limited number of responses suggests that only descriptive statistics in the form of percentages and mean scores could be computed for the presentation of the findings. The entire survey results can be found in Emuze and Smallwood (2013).

RESEARCH FINDINGS & DISCUSSION

Table 1 is a representation of how many MVA incidences have been recorded in South African construction in the past decade. The table shows the year of event, the percentage and number of accidents in each year, the number of MVA related fatalities and permanent disabilities (both pensionable and non-pensionable), all classes of accidents and fatalities in the FEM database per year, and the percentage MVA fatalities constitute of the total fatalities recorded in the construction industry in each year. Overall, an estimated 347 MVA fatalities were recorded in this period, and the number constitute 48.8% of the total number of fatalities recorded in the construction industry over a ten year period.

A year-on-year analysis indicates a spike in MVAs between 2010 and 2013. South Africa hosted the Football World Cup in 2010 and the industry experienced a boom period in the years leading up to the World Cup (Baloyi and Bekker, 2011). The increased work rate / activity in the industry may be a contributing factor during the preparation for the World Cup. Beyond 2010, this explanation cannot hold true as the industry has been bearish (De Valence and Runeson, 2011; Emuze et al., 2013), even up till 2015. The table further shows that MVAs constitute more than 66% of all fatalities in 2010, 59% of fatalities in 2012, and 48% of fatalities in 2013. In absolute numbers, 63 MVA fatalities were recorded in 2010, whereas 42 MVA fatalities were recorded in 2012. In general, the observed information shows that MVAs constitute a major percentage of fatalities recorded in South African construction despite the absolute number of MVAs remaining on the lower end of the total number.

Table 1: Overview of FEM MVA statistics for the period 2005 to 2014

Year	MVA Accidents	Fatalities	Disabilities	All Classes	MVA fatality

	(%)	Number			Accidents	Fatalities	% of total
2014	10.5	799	26	31	7584	54	48.1
2013	12.5	1 061	40	87	8501	83	48.2
2012	12.1	1 013	42	98	8347	71	59.2
2011	12.0	963	25	66	8021	51	49.0
2010	10.8	989	63	70	9189	95	66.3
2009	9.1	950	31	52	10391	73	42.5
2008	8.3	910	30	25	10928	66	45.5
2007	8.3	871	30	39	10501	72	41.7
2006	7.0	629	34	29	9056	70	48.6
2005	7.5	674	26	22	8944	76	34.2
Total			347			711	48.8

These records of MVAs show that for a decade, the cost of accidents, both direct and indirect, has been relatively high. For instance, Table 2 indicates the lost days and average cost (in South African Rand) pertaining to MVAs in a given year. It is notable that the highest average cost of accident occurred in 2013 as opposed to 2010 when the highest number of MVAs was recorded. Also notable is the observation that the number of lost days in 2010, which is the highest in the 10 year period, can be seen in the light of the MVA related fatalities and disabilities that occurred in the year. Although the year 2014 recorded the least lost days according to Table 2, the average cost for the year is 3rd on the table. Invariably, the relationship between the cost of accidents and MVAs appears to have multiple causal pathways and as such, requires a study that recognises the need for contextualisation and generalisation (analytic) in order to provide more insights into it (Verweij, and Gerrits, 2013). Risk controls, timing of the controls, and good site operational practices are important in terms of the improvement of H&S management, which reduces MVA and Struck-by fatalities and disabilities in the construction industry (Edwards and Holt, 2010; Lingard et al., 2015).

Table 2: Impact of MVAs in terms of lost days and average cost for contractors and FEM

Year	Impact	
	Lost Days	Average cost (R)
2014	2 852	41 595
2013	14 535	56 112
2012	17 421	54 625
2011	12 943	40 685
2010	18 852	40 995
2009	17 540	22 833
2008	9 619	16 822
2007	16 511	28 602
2006	10 230	33 855
2005	10 448	21 000
Cumulative	130 951	357 124
Average	13 095.10	35 712.40

Note: Cost in Table 2 is in South African Rand

To further recognise the menace that mobility related accidents seem to be evolving in South African construction, Table 3 and 4 are herein used for illustration. The term 'struck-by' refers to accidents that occurred when moving plant, equipment, and vehicle, struck either a worker or a member of the public because of on-going construction operations. Struck-by statistics thus involve motor vehicles, albeit in varying proportions. Table 3 shows the year of event, the percentage and number of accident in each year, the number of truck-by related fatalities and permanent disabilities (both pensionable and non-pensionable), all classes of accidents and fatalities in the FEM database per year, and the portion of MVA fatalities among the total fatalities recorded in the construction industry in each year. It is notable that whereas the fatalities recorded against struck-by appears to be lower than MVAs, the number of struck-by accidents far exceed MVAs (Table 3). The absolute numbers for permanent disabilities in Table 3 (struck-by) are however higher than the number in Table 1 (MVA). As a result, it can be hypothesised that 'MVAs lead to more fatalities than disabilities when compared with struck-by accidents in South African construction'. This working hypothesis can further find resonance in another hypothesis, which is formulated as 'struck-by accidents are more likely to lead to permanent disabilities among victims as opposed to fatalities when compared with MVAs'. These two working hypotheses should find operationalisation in the theoretical propositions that should give a detailed study direction.

Table 3: Overview of FEM struck-by statistics for the period 2005 to 2014

Year	Struck-by Accidents		Fatalities	Disabilities	All Classes		Struck-by fatality
	(%)	Number			Accidents	Fatalities	% of total
2014	39.5	2 997	8	158	7 584	54	14.8
2013	40.9	3 473	12	211	8 501	83	14.5
2012	40.0	3 341	13	227	8 347	71	18.3
2011	40.6	3 259	11	195	8 021	51	21.6
2010	39.9	3 668	11	149	9 189	95	11.6
2009	40.6	4 216	20	133	10 391	73	27.4
2008	43.1	4 706	17	167	10 928	66	25.8
2007	44.1	4 626	11	132	10 501	72	15.3
2006	43.8	3 963	9	120	9 056	70	12.9
2005	45.9	4 101	22	173	8 944	76	28.9
Total			134			711	18.9

Similar to MVAs, all the struck-by yearly reports have a cost impact in terms of lost days and money (Table 4). Table 4 shows the lost days and average cost (in Rand) pertaining to struck-by accidents in a given year. Both on the cumulative 'lost days' and the 'average cost' indices, and it can be seen that the impact of struck-by accidents is higher than that of MVAs. Given that struck-by accidents also involve motor vehicles used in construction, the total impact and frequency, both in absolute numbers and percentages, is a major cause for concern. For instance, in 2010 in which more activities occurred in the industry due to the World Cup stadia and infrastructure projects, the impact of MVAs and struck-by cannot be overlooked. In that year alone, 63 MVA related fatalities and 70 permanent disabilities were recorded, while 11 struck-by fatalities and 149 permanent disabilities were recorded. The industry is thus in a quagmire with respect to how to mitigate injuries and fatalities related to mobility.

Table 4: Overview of FEM struck-by accidents for the period 2005 to 2014

Year	Impact	
	Lost Days	Average cost (R)
2014	8 129	15 817
2013	18 993	11 569
2012	24 587	14 070
2011	21 032	13 235
2010	23 518	8 983
2009	28 672	9 876
2008	32 261	8 966
2007	31 209	6 780
2006	31 809	9 189
2005	32 348	9 330
Cumulative	252 558	107 815
Average	25 255.80	10 781.50

Note: Cost in Table 2 is in South African Rand

The 'how' and 'why' questions would have to take cognisance of the results presented in Table 5. An Australian study that examined the 'how' and 'why' of plant related fatalities in the construction industry observe that most events involved excavators, and trucks that struck people at work sites, all the victims being construction workers (Lingard et al., 2013). The practical implication of the Australian study was that struck-by fatalities occur as a result of multiple causes, both upstream and downstream of construction work. Table 5 emerged from a pilot survey, which recorded 15 responses in 2013 as mentioned earlier in the methodology section of this paper. The aim of of the survey was to comprehend the major causes of MVAs from the view of professionals in practice. The respondents were general contractor (GC) members of the East Cape Master Builders Association (ECMBA). Based on the South African construction industry experience of the GCs, the self-administered structured questionnaire elicited responses to causes of MVAs in construction operations in terms of percentage responses to a scale of 1 (minor) and 5 (major), and a mean score (MS) between 1.00 and 5.00.

Table 5: Causes of fatalities and disabilities due to construction mobility

Incident	MS	Rank
Fall from vehicle in motion while getting on / off	3.46	1
Fall from vehicle in motion	3.45	2
Collision with other vehicles	3.08	3
Collisions between vehicle and other equipment	2.91	4
Crunched / run-over by highway vehicle	2.50	5
Crunched / run-over by manoeuvring vehicle	1.80	6
Worker struck by vehicle exiting work area	1.64	7
Worker struck by vehicle entering work area	1.45	8
Worker struck by vehicle inside work area	1.42	9
Crunched / run-over by vehicle entering the site	1.36	10

The mid-point score of the Likert scale is 3.00. The ranking in Table 5, which is based on the MS shows that only three incidents have MSs greater than 3.00, which indicates that in general, these incidents were perceived as major as opposed to minor by the respondents. It is notable that these three possible causes mainly refer to MVAs, and none of them target stuck-by accidents. Possible causes of struck-by fatalities and permanent disabilities record lower MSs, which ranged from 1.42 to 1.64. A fall from vehicle in motion, either getting into the vehicle or already inside the vehicle, as illustrated in Figure 1, is an area in which much mobility related fatalities and permanent disabilities may be occurring in the sector. This argument is crucial as all survey respondents always transport workers to and from, and between construction sites with either a light delivery vehicles (LDV) referred to as 'pickup' truck in the United States of America (USA), or a flatbed truck. More worrisome is the discovery that six respondents confirm that simultaneous transportation of materials, plant and equipment, and workers is done in their firms. Five of the survey respondents affirm the use of LDVs for the simultaneous mobility, while only one mentioned that flat beds are used by his employer. It is also notable that some of the survey respondents report that their firms have recorded mobility related accidents, which result in fatalities and permanent disabilities. The aforementioned accidents involve the use of LDVs for simultaneous movement of people and goods.

Tables 1 - 5 provide evidence for the plausible causes of the mobility related fatalities and permanent disabilities that are on-going in South African construction. The spike in the MVA fatalities is occurring in the face of legislation and regulations that should prevent them. The Construction Regulations (Republic of South Africa, 2003) made explicit and implicit provisions for the prevention of various forms of accidents, including mobility rated fatalities. The regulations, which have been revised in 2014, are not lacking in accident prevention clauses, but the implementation / compliance thereof is reportedly sub optimal (cidb, 2009). In other words, compliance is still a major issue in South Africa construction, especially among emerging contractors. The attempt to promote compliance to regulations in South Africa may have inadvertently created bureaucratic accountability mode of H&S management. Although bureaucratic accountability of H&S that is driven by regulations has engendered tight control, it has also created problems pertaining to the inability to predict unexpected events - accidents (Dekker, 2014).

Given the apparent need to look beyond the regulations for the reduction of mobility related fatalities and permanent disabilities, it is pertinent to understand the phenomenon through multiple views so that appropriate H&S management programme can be engendered in the industry. A possible way forward is 'zero target', despite its vulnerability to multiple interpretations and understandings among project actors in the construction industry (Sherrat, 2014). Examples of a major reduction in fatalities through H&S programmes support this argument. For instance, Wright (2012) reports that zero fatalities was recorded in the London Olympic project in which the Olympic Delivery Authority adopted a 'zero tolerance' approach to unhealthy and unsafe construction practices. This major project involves 12 000 people, who worked for 80 million person hours in five years without a single fatality despite the enormous mobility / logistic requirements of the project. The reality of the approach is the zero fatality H&S record; in spite of the non-attainment of 'zero harm' / 'zero accident' target (Sherrat, 2014).

CONCLUSION

A worrying trend related to MVAs and struck-by fatalities and permanent disabilities is afoot in South African construction. The exploration of factual statistical data and the perceptions of GCs in the sector reveal a range of insights concerning the problem. The reported number and percentage contributions of MVAs and struck-by to fatalities and permanent disabilities in South African construction mean a policy / strategic direction is needed to safe people in the industry. This is where 'zero' target comes into the picture based on its potential to bring change into H&S programmes deployed for construction practice. As mentioned by Sherrat (2014), simply setting the target in a manner of putting regulations in place will not eliminate the record number of fatalities. Instead, the industry in South Africa should look beyond the numbers / statistics, and ask people why practice is more concerned with compliance to regulations and view 'zero' as a target that is unattainable? There is a need to confirm the apparent lack of a potential for zero harm / accident in South Africa, if the statistics presented in this paper continue unabated.

The data in Table 1-4 shows that the manifestations of MVAs and struck-by accidents in South Africa leads to loss of life, permanent disabilities, lost work days, and loss of money. These manifestations thus appear to have multiple causal pathways and as such, require a study, which recognises the need for contextualisation and analytic generalisation that can only emerge through case based research methods. Future research would therefore examine the characteristics of the phenomenon with case based methods that should be guided by the theoretical propositions derived from the exploratory studies so far. It is anticipated that future research endeavours will go beyond exploratory, and engage with the need for description and explanation for the mobility related fatalities and disabilities problem in South African construction.

Working hypotheses that can be useful for the future study should address 'MVAs lead to more fatalities than disabilities when compared with struck-by accidents in South African construction', and struck-by accidents are more likely to lead to permanent disabilities among victims as opposed to fatalities when compared with MVAs. The future study would attempt to propose a way forward after revealing the 'how' and 'why' MVA and struck-by incidents have remained high in South African construction.

REFERENCES

Baloyi, L. & Bekker, M.C. (2011) Causes of construction cost and time overruns: the 2010 FIFA World Cup stadia in South Africa. Acta Structilia, 18(1), 51-67.

Construction Industry Development Board. (2009) Construction Health and Safety in South Africa: Status and Recommendations. Pretoria: CIDB.

Dekker, S.W.A. (2014) The bureaucratization of safety. Safety Science, 70(1), pp. 348-357.

De Valence, G. & Runeson, G. (2011) On the state of the building industry after the GFC and the Euro crisis. Australasian Journal of Construction Economics and Building, 11(4), pp. 102-113.

Edwards, D. & Holt, G.D. (2010) Case study analysis of construction excavator H&S overturn incidents. Engineering, Construction and Architectural Management, 17(5), pp. 493-511.

Emuze, F.A. and Smallwood, J.J. (2012) Construction Motor Vehicle Accidents in South Africa: Preliminary Findings. In: Proceedings of CIB W099 International Conference 2012: Modelling and Building Health and Safety, 10-11 September 2012, Singapore, 203-208.

Emuze, F.A. and Smallwood, J.J. (2013) Construction Motor Vehicle Accidents in South Africa: Causes and Impact. In: Proceedings of the 29th Annual Association of Researchers in Construction Management (ARCOM) Conference, 2-4 September, Reading, UK, pp. 311-321

Emuze, F.A., Sanderson, T.M. and Shakantu, W.M. (2013) Perceived impact of the market on the business of regional contractors: a South African context. In: Proceedings of the 29th Annual Association of Researchers in Construction Management (ARCOM) Conference, 2-4 September, Reading, UK, 201-211.

Health and Safety Executive (HSE) (2002) Revitalising health and safety in construction. London: HSE.

Hobson, P., Emery, D., Brown, L., Bashford, R. & Gill, J. 2014. People-plant interface training: targeting an industry fatal risk. Proceedings of the Institution of Civil Engineers - Civil Engineering, 167(3), pp. 138-144.

Lewis-Beck, M.S., Bryman, A. & Liao, T.F. 2004. The SAGE Encyclopedia of Social Science Research Methods. London: Sage.

Lingard, H., Cooke, T. & Gharaie, E. (2013) The how and why of plant-related fatalities in the Australian construction industry. Engineering, Construction and Architectural Management, 20(4), pp. 365-380.

Lingard, H., Saunders, L., Pirzadeh, P., Blismas, N., Kleiner, B. & Wakefield, R. (2015) The relationship between pre-construction decision-making and the effectiveness of risk control: testing the time-safety influence curve. Engineering, Construction and Architectural Management, 22(1), pp. 108-124.

Protectin (2014) Deaths and accidents in the construction industry can be reduced [online]. Available from: http://www.protectin.co.za/about-safety/33-deaths-and-accidents-in-the-construction-industry-they-can-be-prevented.html

Republic of South Africa (2003) Construction Regulations. Government Gazette No. 20095. Pretoria: RSA.

Republic of South Africa (2000) Construction Industry Development Board Act No. 38 of 2000. Government Gazette No. 21755, 17 November, 2000. Cape Town: Juta

Sherrat, F. (2014) Exploring 'Zero Target' safety programmes in the UK construction industry. Construction Management and Economics, 32 (7-8), pp. 737-748.

Van Scyoc, K. (2008) Process safety improvement - quality and target zero. Journal of Hazardous Material, 159(1), pp. 42-48.

Verweij, S. & Gerrits, L.M. (2013), Understanding and researching complexity with qualitative comparative analysis: evaluating transportation infrastructure projects. Evaluation, Vol. 19(1), pp. 40-55.

Wilkens, J.R. (2011) Construction workers' perceptions of health and safety training programmes. Construction Management and Economics, 29(10), 1017-1026.

Wright, E. (2012) Olympic health and safety: record breakers. Building, 1 June, 2012.

Yin, R. (2014) Case study research: design and methods. London: Sage.

Young, S. (2014) From zero to hero. A case study of industrial injury reduction: New Zealand Aluminium Smelters Limited. Safety Science, 64(1), 99-108.

IMPACT OF EXPERIENCE AND NON-PRACTICE IN THE USE OF WIND TURBINE RESCUE DEVICE RG9A

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The trend of onshore wind energy is gradually tending towards more maintenance and less construction due to the rapid development of this energy sector over the last decade. With maintenance taking centre stage in the near future, wind technicians will be exposed to hazards and risks and as such, it is expected that they are trained in safety and emergency procedures above the basic competency currently set out by the regulating bodies. The rapid development of the wind sector is creating severe skill shortages of appropriately qualified staff (trained and experienced workers especially in operation and maintenance activities). Therefore, safe working at height all of which requires robust procedures will involve training, practice and experience; as the learners become expert, they can apply their understanding to other situations, while also evaluating its appropriateness. The essential aim of this paper is to establish the occupational health and safety challenges in the wind energy industry in relation to wind technicians' experience and non-practice in the safe use of a rescue and evacuation device (Constant Rate Descender RG9A) in emergency situations. Longitudinal assessment was adopted in order to track changes over time. The findings suggest that experienced technicians performed better in skilled tasks over the three month test period as compared to less experienced technicians and that longer non-practice led to decay in performance and proficiency. Results from this study are currently being considered for implementation by industry partner in the design of rescue device and for height safety training. Limitation to these types of studies is the lack of intensive 'in-situ' real life long term assessments.

Keywords: Maintenance, Construction, Competency, Wind turbine, Onshore.

INTRODUCTION & BACKGROUND

Wind technicians may work for years without being involved in a major wind farm disaster that requires emergency rescue or evacuation. Although these technicians may experience extended periods of non-practice of such skills, they are still expected to perform at optimum proficiency with little or no retraining should an emergency or disaster occur up to 24 months after training. Within the wind industry, benchmark standards have been developed to address significant risks specific to the wind sector. These are supported by third party accreditation systems like RenewableUK (RUK) and Global Wind Organisation (GWO) involved in developing a common training standard for the wind energy sector - 'Basic Safety Training'.

Procedural tasks account for a significant proportion of height safety and rescue, yet trainees often do not retain much of what they have learnt over the course of working on the job (Vineberg 1975; Schendel et al., 1978; Hagman & Rose 1983). Some of the contributing factors to this loss consist of type and complexity of the job-task, amount and quality of initial training, length of time without practice, and amount and quality of experience acquired on-the-job (Wetzel et al., 1983; Farr 1986).

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Another factor associated with this problem is that several types of equipment used to train these skills are similar, but sometimes not absolutely identical to the equipment the technicians use on the job. Therefore, in addition to memory loss, job performance may be further degraded if technicians have difficulty transferring skills learned during training to slightly different equipment on the job. One way to counter the loss of procedural skill is to develop instructional materials that are more resistant to forgetting and more likely to promote transfer of skills to similar tasks and equipment (Whitehill & Ellis 1995); though literatures are however, unspecific about the refresher training instructional methods. Procedural tasks are regarded as ordered sequences of steps or actions performed on a single object or in a specific environment or situation to accomplish a goal. They involve few decisions and are usually executed the same way each time. Procedural tasks differ in the extent of planning required, the number of steps in the process, the amount of inherent cues, the number of decision points or branches, any variations in the order of the steps, and the objectives of the task. Konoske & Ellis (1986) suggested taxonomy of procedural tasks based on the range and variety of the tasks like maintenance; repair or assembly tasks; operator tasks; paper-based tasks; and tasks of locating information or objects.

The works of Chi et al. (1988) and Ericsson & Smith (1991) on expert performance and expertise show that important characteristics of experts' superior performance are attained through experience and that the effect of practice on performance is larger than earlier believed possible. According to Cannon-Bowers et al. (1998), practice is the physical act or mental rehearsal of a task undertaken with the implicit or explicit goal of attaining some level of proficiency in performing that task. Evidence suggests that for a successful transfer of training, trainees need both the resources and available opportunities to practice and perform the newly acquired skills (Clarke 2002; Salas et al. 2006; Burke & Hutchins 2007; Weissbein et al. 2011). Similarly, there are consistent demonstrations from research regarding the positive relationship between skill decay and non-practice of newly acquired skills (Clarke 2002; Salas et al., 2006; Lawani et al. 2014a), also, see meta-analysis of Arthur Jr. et al. (1998). Therefore, the significance of applying training-related skills and knowledge through practice by technicians is paramount.

Deliberate practice is an important skill-training strategy in rescue and evacuation and this can be easily depicted using the learning curve which displays the relationship between repetitive practice and proficiency. Forgetting curve displays the opposite, and demonstrates how skills decay over a period of time when not reinforced. Skills not practiced can decay at an astonishing rate most especially discrete skills that are amenable to deliberate practice as defined by Ericsson (2004). Frequently practiced skills can help the individual's performance remain competent for the whole of his or her career while those of higher complexity with limited opportunities for workplace practice (e.g. non-routine wind rescue) will degrade in the absence of refresher practice (Sauer et al. 2008, Kluge et al. 2010 and Lawani et al. 2014b).

The frame of reference gained from hands-on involvement in the operation and maintenance environment is considered as experience. It entails all the infinite impressions and intangibles derived from being immersed in the actual work environment as opposed to having it described in the artificial environment e.g. training. Although training is invaluable, without a frame of reference to translate them into coherent actions, their effectiveness and value reduces considerably, (Kavanagh 2005). Experience can be gained along with greater responsibility, breadth of assignments, confidence and knowledge of the job. Experience charts can be useful as a conceptual framework that helps trainers plan and assess training with emphasis on skill durability, (Kavanagh 2005). The number of years of service is generally used as a determinant for participant experience (refresher and fresher). In many other domains, the highest level of expert performance is displayed by individuals with more than 10 years of experience, (Phelps & Shanteau 1978; Patel & Groen 1991). However, mere repetition of an activity will not automatically lead to improvement e.g. in accuracy of performance (see, Trowbridge & Cason 1932) cited in Ericsson et al. (1993), but some form of practice of a skill can mitigate skill decay during longer periods of non-use.

The work at height and rescue training which is primarily hands-on involve how to successfully carry out rescue and evacuation operation. One major factor inhibiting deliberate practice by wind technicians can be associated to high operational deployment tempo or their peripatetic work pattern. This impinges on the available time to practice already acquired non-routine skills, thus resulting in less experienced technicians incapable of dealing with the complexities of rescue under intense pressure. Lack of on-the-job rescue experience and higher task complexity can leave technicians at all levels not only unable to make complex decisions, but also unaware of the difficulties they face during such rescue processes. No precise 'on-site' retention study has been conducted on the relative impact of experience and non-practice of discrete procedural skills specific to wind technicians. Therefore, this paper proposes the need to put systems in place to advance the awareness of deliberate practice; and that experience is needed to enhance the skills that ensure safe and effective tactical response.

One of the backdrops for embarking on this study was based on the prognosis that the absolute number of fall from height accidents will increase as more wind turbines are built. HSE statistics in 2013/14 recorded 19 fatal falls from height injuries within the UK construction industry and this accounts for 45% of the total fatal injuries to construction workers.

OBJECTIVES

This study assesses the impact of experience and non-practice of rescue and evacuation device RG9A. Performance data were acquired from wind technicians by primary measurements at the end of one and three month retention. The objective was to establish the impact of experience and lack of practice over this time period.

METHODS

Participants:
The participants were those registered to undertake the basic RUK and GWO approved height safety and rescue training. The final participant attrition was 63% at three months with 37% of the participants (30) continuing till the end of the test. The research implemented longitudinal design for data gathering (de Vaus 2001) to enable tracking of changes over time and establishing the sequences of events.

Variables:
The two variables investigated were experience based on number of years working within the industry and non-practice period taken as retention test at one and three month.

Assessment:
Skill pre-acquisition and acquisition involved hands-on practical exercises using the automatic CRD RG9A, (Lawani et al. 2014a). Only 'refresher' participants (returning trainees) were assessed during pre-acquisition because they have used this device in previous training sessions. Situational Judgement Tests (SJT) according to Lievens & Coetsier (2002) was adopted during skill retention test of the components of skill performance. The participants were required to evaluate the randomized written performance description with associated pictograms by correctly sequencing the procedural performance of the use of RG9A for rescue and evacuation, (Lawani et al. 2014b; Cameron et al. 2011). The SJT with pictograms is allied to symbolic rehearsal instructional designs based on the theoretical assumption of mental practice; see (Driskell et al. 1994; Farr 1986; Kluge et al. 2012). This test engaged participants in the use of computer-based 2D pictograms of the RG9A. A closed-ended questionnaire was employed for knowledge tests from pre-acquisition to retention and this was designed based on ‘Job Knowledge Test’ (Teachout et al. 1993). The SJT and JKT were administered online at intervals of one and three months and conformed to the approved RUK and GWO height safety and rescue training.

The skill performance test was based on the number of device steps recalled and recognised in the correct order and the number of job knowledge information correctly recalled. SJTs may be classified as simulating "real-life" criterion situation (Lievens & Coetsier 2002). This is because simulations are based contemporarily on the assumption that one can predict how well a participant may perform on a job based on how the participant performs on the simulation of the job, (McDaniel & Nguyen 2001). Chan & Schmitt (1997) and several authors view SJT as measurement methods designed to measure variety of constructs, e.g. cognitive abilities.

RESULTS & DISCUSSIONS

The results depict the impacts of experience and non-practice on trained personnel. Initial pilot study obtained an internal consistency reliability value (Cronbach's alpha) of 0.810. The rating for both SJT and JKT employed the cumulative system approach with only one correct answer to every question. A correct answer earns a point and an incorrect answer earns no point. This study having been piloted, reviewed and amended was based on results of 30 study participants that fully participated all through the assessment period.

Impact of Experience on performance

The ability to recall previous experience can help in understanding the complexities and focus of a task by generating a plan for resolving the problem. Recall and application of knowledge gained in dealing with previous unique tasks can also cut down the amount of time and reasoning necessary to resolve a new problem and prevent failures from being repeated, (Kolodner 1988). Table 1 depict the mean group performance of participants with varying years of on-the-job experience. Participants with ≥10 year experience attained significant performance level as compared to participants with less experience during the skill test. Comparatively, participants for the knowledge test attained mean performances ≥70% which is advocated as the benchmark. Ericsson et al. (1993) highlighted that expert performance is acquired slowly over a very long time as a result of practice and that the highest levels of performance and achievement appear to require at least around 10 years of intense prior preparation. However, the relationship between acquired performance and the amount of practice and experience was found to be weak to moderate in their earlier review. Table1indicates increase in mean group performance with experience; though participants grouped at 6-7 years performed remarkably low in skill test. Knowledge results also indicate distinctive increasing trend in mean grouped performance with experience of the participants.

Table 1: Experience of participants versus performance scores – Skill and Knowledge Test

	Skill & Knowledge Test						
	Experience in Years	**0 - 1**	**2 - 3**	**4 - 5**	**6 - 7**	**8 - 9**	**10 +**
	No. of participants	**15**	**4**	**5**	**2**		**4**
Mean performance score %	**Skill T_2 @1M**	65.33	65	74	60		82
	Skill T_3 @3 M	59.33	67.5	58	35		80
	Knowledge T_3 @1 M	76.93	81	85.6	88.5		83.25
	Knowledge T_4 @3M	77.33	85	80	86.5		85

Figure 1a-5a show individual skill performances of < 70% and ≥ 70% benchmark at one and three month. It is argued that the role of experience in skilled job between technicians with ≥10 years of experience is superior to technicians with one, six or more years of experience when evaluated individually. This is because learning of job skills needed for effective job performance takes place mostly in the early years of experience and each additional years of experience contributes less and less of job skill, an effect which is obvious even in grouped mean test scores.

Experience in 'job knowledge' between a technician with one and up to 10 years differ, though not significantly, see Figures 1b-5b. The individual performances show that 25(83%) and 24(80%) participants attained ≥ 70% benchmark at one and three months. Therefore, adopting this line of reasoning, it can be said that the relationship between experience and performance is more critical in skilled task for all levels of experience. There is no major difference in knowledge performance for participants with extensive and minimal amounts of experience. The works of Patel & Groen (1991) and Phelps & Shanteau (1978) also emphasized that in many domains, the highest level of expert performance is displayed by individuals with more than 10 years of experience. However, Ericsson et al. (1993) believe it is incorrect to state that a sufficient amount of experience or practice leads to maximal performance. This result show that optimum level of performance is not attained automatically as a function of extended experience, but the level of performance can be increased even by highly experienced individuals as a result of 'deliberate practice'. Table 2 show the statistical analysis for normality, Levene's test for equality of variance, the independent-samples t-tests and effect sizes (eta squared). This was done by testing the statistical significant difference between the two groups (refresher/fresher) from pre-acquisition to retention. Table 2 show the statistical and non-statistical significance for refresher and fresher participants at various times.

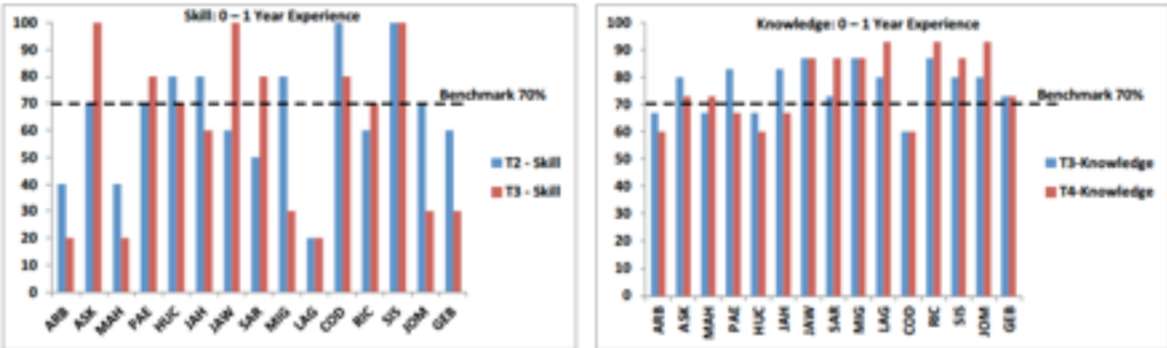

Figure 1a & b: 0-1 year of experience with performance at 1 & 3 month retention

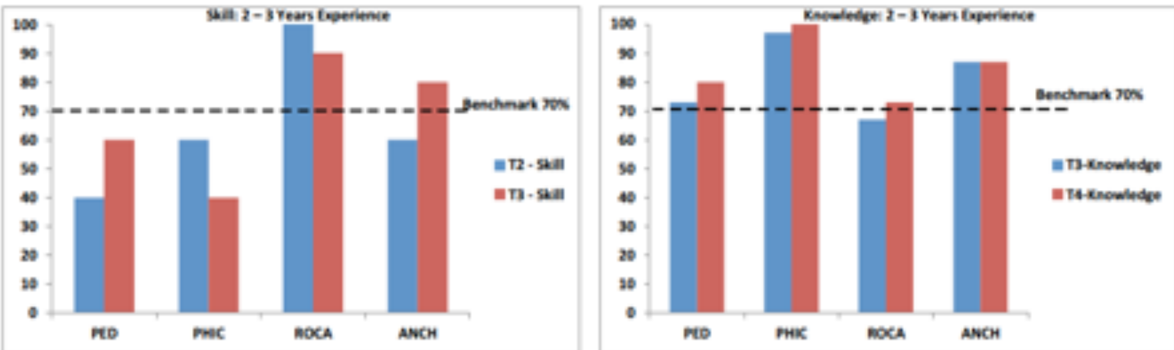

Figure 2a & b: 2-3 years of experience with performance at 1 & 3 month retention

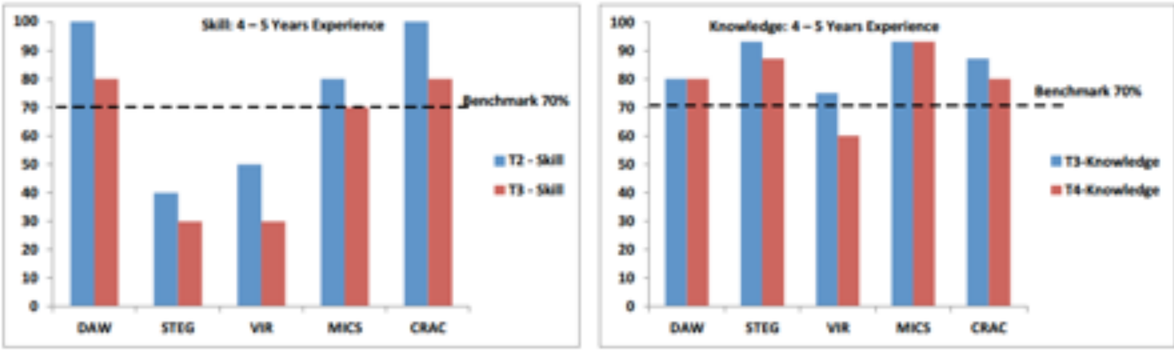

Figure 3a & b: 4-5 years of experience with performance at 1 & 3 month retention

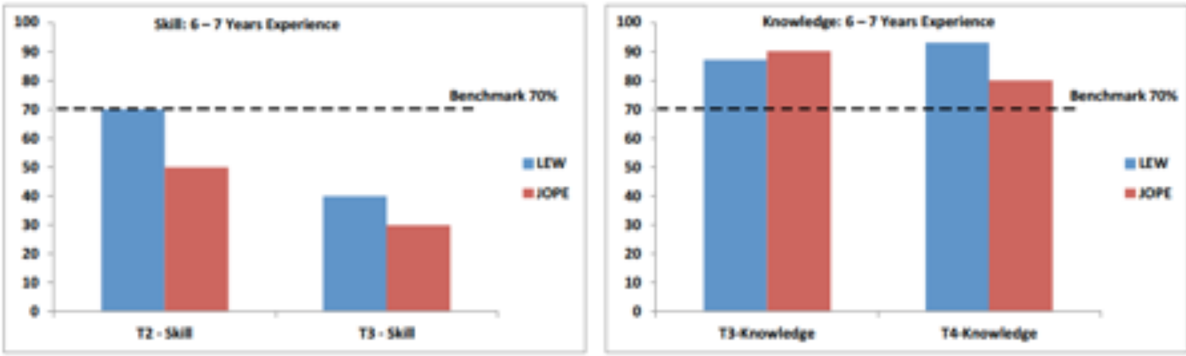

Figure 4a & b: 6-7 years of experience with performance at 1 & 3 month retention

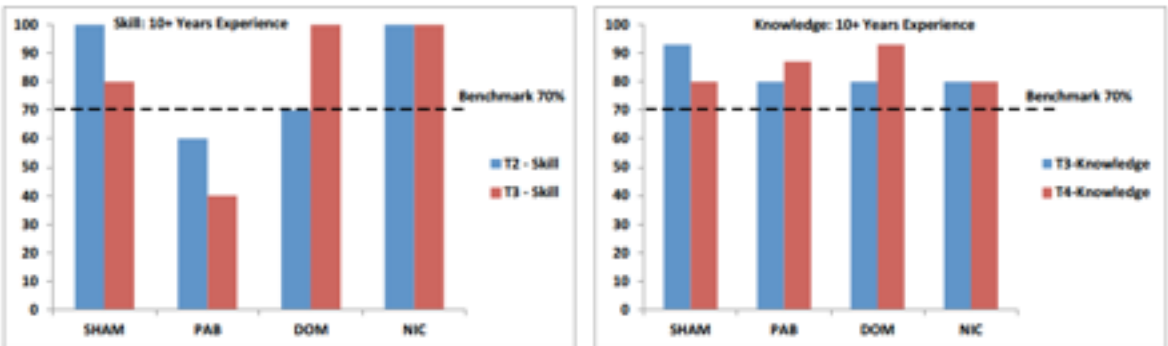

Figure 5a & b: 10+ years of experience with performance at 1 & 3 month retention

Table 2: Statistical Results – Skill and Knowledge Test (refresher & fresher)

Statistics	Skill test	Knowledge test
Test of normality: Kolmogorov-Smirnov @ (α= 0.01)	T_0 & T_1 = non normal T_2 & T_3 = normality	T_2 = non normal T_0, T_1, T_3 & T_4 = normality
Levene's test for equality @ (α= 0.05)	$T_0 \leq 0.05$ = equal variance not assumed T_1,T_2 & $T_3 > 0.05$ = Equal variances assumed	T_4 = equal variance not assumed T_0, T_1, T_2, T_3 = Equal variances assumed
Independent-Samples T-test @ Sig. (2-tailed) (α= 0.05)	$T_0 \leq 0.05$ = stat. significant T_1,T_2 & $T_3 > 0.05$ = not stat. sig.	T_4 = stat. significant T_0, T_1, T_2, T_3 = not stat. sig.
Effect size (eta squared) proposed by (Cohen, 1988)	T_0 = Large effect T_1,T_2 & T_3 = Small effect	T_0,T_3 & T_4 = Moderate effect T_1, T_2 = Small effect

Impact of Non-practice

Arthur Jr. et al. (1998) identified the importance of considering training to a specified level of accuracy and training for a fixed amount of time when investigating skill retention and performance after extended periods of non-practice. The phase of skill acquisition for this study involved deliberate practice by the technicians defined as both fixed amount of training time available and training to a specified level of performance (Arthur Jr. et al. 1998). Skills that are regularly practiced during work can impact on individual's performance and competency while those of higher complexity with limited or no opportunities for workplace practice will decay in the absence of refresher practice, (Lawani et al. 2014a).

Figure 6a & 6b show that with increase in deliberate practice, the performance of technicians reliably improves and the technicians move up the learning curve. At some point, the technicians cross a competency threshold in which they can perform the skill independently, (Pusic et al. 2012). However, the law of diminishing returns supervenes such that in the absence of practice, the technicians are rewarded with progressive decrease in both skill and knowledge performance. This study also show that the technicians' peak performance is not attained automatically as a function of extended experience, but performance level increases even by highly experienced individuals as a result of deliberate efforts to practice and improve (see Figures 6a & 6b). Hence, stable performance levels with extended experience can be further improved by deliberate practice, (Kluge et al. 2009; Kim et al. 2013). Therefore, we can speculate that practice brings improvement, and more practice brings more improvement while non-practice brings no improvement.

Figures 6a & 6b also depict the relationship between deliberate practice and proficiency (learning curve), while the no practice curve depict skill decay over a period of time when it is not reinforced (retention curve).

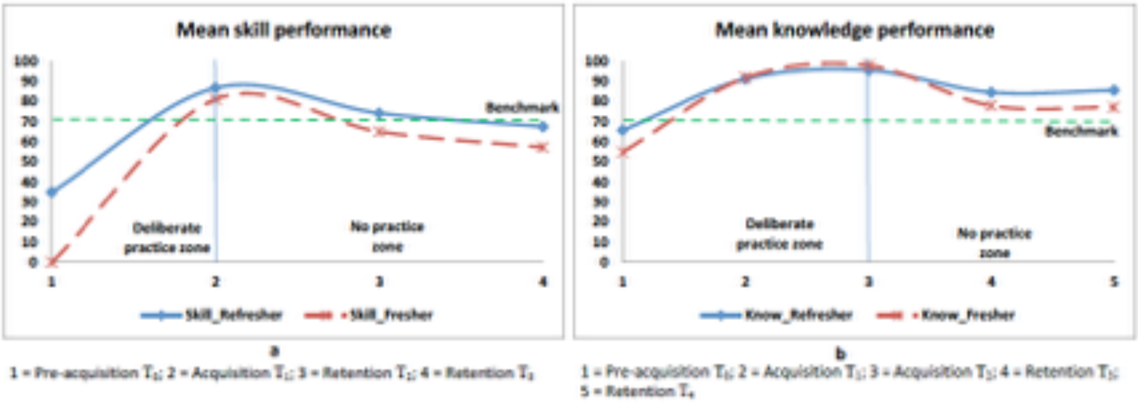

Figure 6: Mean skill and knowledge performance showing deliberate practice and no practice zones

CONCLUSIONS

The performance charts show that skills with the highest losses occur with a skilled task soon after training irrespective of experience. The performance charts showed that experienced technicians performed better in skilled tasks over the three month assessment period as compared to less experienced technicians. Clearly, it indicates that higher levels of performance in non-routine tasks will be maintained only through regular hands-on or frequent synthetic practice leading to experience.

Given the prevalent use of simple tasks coupled with very short non-practice intervals in existing literature, the primary implication of the findings is that the longer the non-practice of the rescue device, the more deficient the participant performance and proficiency becomes and a viable means of enhancing long-term skill retention for cognitively complex tasks is through deliberate practice. Also, the lack of consistency in retention timeframes, differences in participant groups, instructional designs, research methods, and outcome measures constitutes a major setback towards unifying different research results. This study provides useful guidance to height and rescue training system designers and therefore, suggests a follow on. Introduction of an intervention phase of deliberate simulation practice drill is considered a beneficial investment to prepare technicians for non-routine rescue and evacuation procedures. This is cost effective, less downtime, promotes safe system of work and risk management thereby impacting on practice and experience of technicians.

REFERENCES

Arthur Jr., W., Bennett Jr., W., Stanush, P.L. & McNelly, T.L., 1998. Factors that influence skill decay and retention: A quantitative review and analysis. Human Performance, 11(1), pp.57-101.

Burke, L.A. & Hutchins, H.M., 2007. Training transfer: An integrative literature review. Human Resource Development Review, 6(3), pp.263-96.

Cameron, I., Hare, B., Duff, R. & McNairney, F., 2011. Using pictures in training: The impact of pictorial OSH training on migrant worker behaviour and competence. IOSH Research Committee: 11.2. Leicestershire, UK: IOSH Glasgow Caledonian University.

Cannon-Bowers, J.A., Rhodenizer, L., Salas, E. & Bowers, C.A., 1998. A framework for understanding pre-practice conditions and their impact on learning. Personnel Psychology, 51(2), pp.291-320.

Chan, D. & Schmitt, N., 1997. Video-based versus paper-and-pencil method of assessment in situational judgment tests: subgroup differences in test performance and face validity perceptions. Journal of Applied Psychology, 82(1), pp.143-59.

Chi, M.T.H., Glaser, R. & Farr, M.J., eds., 1988. The nature of expertise. Hillsdale, NJ: Erlbaum.

Clarke, N., 2002. Job/work environment factors influencing training effectiveness within a human service agency: Some indicative support for Baldwin and Fords' transfer climate construct. International Journal of Training and Development, 6(3), pp.146-62.

de Vaus, D.A., 2001. Research Design in Social Research. London: Sage Publications.

Driskell, J., Copper , C. & Moran, A., 1994. Does mental practice enhance performance? Journal of Applied Psychology, 79(4), pp.481-92.

Ericsson, K.A. & Smith, J., 1991. Prospects and limits of the empirical study of expertise: An introduction. In K.A. Ericsson & J. Smith, eds. Toward a general theory of expertise: Prospects and limits. Cambridge, England: Cambridge University. pp. 1-39.

Ericsson, A.K., 2004. Deliberate Practice and the Acquisition and Maintenance of Expert Performance in Medicine and Related Domains. Academic Medicine, 79(10), pp.S70-81.

Ericsson, A.K., Krampe, R.T. & Tesch-Romer, C., 1993. The Role of Deliberate Practice in the Acquisition of Expert Performance. Psychological Review, 100(3), pp.363-406.

Farr, M.J., 1986. The long-term retention of knowledge and skills: A cognitive and instructional perspective. IDA Memorandum Report M-205. Alexandria, Virginia: IDA Institute for Defence Analyses.

Hagman, J.D. & Rose, A.M., 1983. Retention of Military Tasks: A Review. Human Factors, 25(2), pp. 199-213.

Kavanagh, J., 2005. Determinants of Productivity for Military Personnel: A Review of Findings on the Contribution of Experience, Training, and Aptitude to Military Performance. TR-193-OSD. Santa Monica: National Defense Research Institute National Defense Research Institute.

Kim, J.W., Ritter, F.E. & Koubek, R.J., 2013. An integrated theory for improved skill acquisition and retention in the three stages of learning. Theoretical Issues in Ergonomics Science, 14(1), pp. 22–37.

Kluge, A., Burkolter, D. & Frank, B., 2012. Being Prepared for the Infrequent: A Comparative Study of Two Refresher Training Approaches and Their Effects on Temporal and Adaptive Transfer in a Process Control Task. In Proceedings of the Human Factors and Ergonomics Society 56th, 2012.

Kluge, A., Sauer, J., Burkolter, D. & Ritzmann, S., 2010. Designing Training for Temporal and Adaptive Transfer: A Comparative Evaluation of Three Training Methods for Process Control Tasks. Journal of Educational Computing Research, 43, pp.327–53.

Kluge, A., Sauer, J., Schuler, K. & Burkolte, D., 2009. Designing Training for Process Control Simulators: A Review of Empirical Findings and Current Practices. Theoretical Issues in Ergonomics Science, 10, pp.489–509.

Kolodner, J.L., 1988. The Role of Experience in Common-Sense and Expert Problem Solving. ARO 21697.11-MA. Research Triangle Park, NC: U. S. Army Research Office U. S. Army Research Office.

Konoske, P.J. & Ellis, J.A., 1986. Cognitive factors in learning and retention of procedural tasks. NPRDC TR 87-14. San Diego, California: Navy Personnel Research and Development Centre Navy Personnel Research and Development Centre.

Lawani, K., Hare, B. & Cameron, I., 2014a. Skill decay of wind turbine technicians in the use of rescue and evacuation device during emergency. In Aulin, R. & Ek, Å. eds. Proceedings of CIB W099 International Conference Achieving Sustainable Construction Health and Safety. Lund, Sweden.

Lawani, K., Hare, B. & Cameron, I., 2014b. Wind turbine rescue: Emerging skill retention issues and challenges. In Raiden, A.B. & Aboagye-Nimo, E., eds. Procs 30th Annual ARCOM Conference. Portsmouth, UK.

Lievens, F. & Coetsier, P., 2002. Situational Tests in Student Selection: An Examination of Predictive Validity, Adverse Impact, and Construct Validity. International Journal of Selection and Assessment, 10(4), pp.245-257.

McDaniel, & Nguyen, N.T., 2001. Situational Judgement Tests: A Review of Practice and Construct Assessed. Situational Judgement Tests, 9(1/2), pp.103-13.

Patel , V.L. & Groen, G.J., 1991. The general and specific nature of medical expertise: A critical look. In K.A. Ericsson & J. Smith, eds. Toward a general theory of expertise. Cambridge, England: Cambridge University Press. pp. 93-125.

Phelps, R.H. & Shanteau, J., 1978. Livestock judges: how much information can an expert use? Organizational Behaviour and Human Performance, 21, pp.209-219.

Pusic, M.V. et al., 2012. Experience Curves as an Organizing Framework for Deliberate Practice in Emergency Medicine Learning. Society for Academic Emergency Medicine, 19(12), pp. 1476-80.

Salas, E., Wilson, K., Priest, H. & Guthrie, J., 2006. Design, delivery, and evaluation of training systems. In G. Salvendy, ed. Handbook of human factors and ergonomics. 3rd ed. Hoboken, NJ: John Wiley & Sons. pp.472-512.

Sauer, J. et al., 2008. The Effects of Heuristic Rule Training on Operator Performance in a Simulated Process Control Environment. Ergonomics, 51, pp.953–67.

Schendel, J.D., Shields, J.L. & Katz, M.S., 1978. Retention of motor skills: review. Alexandria, VA: U. S. Army Research Institute for the Behavioural and Social Sciences.

Teachout, M.S., Winston, B.J.R., Barham, B. & Phalen, W.J., 1993. Determining Intervals for Aerospace Physiology Refresher Training: An Approach for Research. In Mercier, R., ed. 35th Annual Conference of the Military Testing Association. Williamsburg, Virginia, 1993. Military Testing Association.

Vineberg, R., 1975. A study of the retention of skills and knowledge acquired in basic training. HumRRO-TR-75-10. Alexandria, Virginia: Human Resources Research Organisation Human Resources Research Organisation.

Weissbein, D.A., Huang, J.L., Ford, J.K. & Schmidt, A.M., 2011. Influencing learning states to enhance trainee motivation and improve training transfer. Journal of Business and Psychology, 26, pp.423-35.

Wetzel, S.K., Konoske, P.J. & Montague, W.E., 1983. Estimating skill degradation for aviation antisubmarine warfare operators (AWs): Loss of skill and knowledge following training. San Diego, California: Navy Personnel Research and Development Centre.

Whitehill, B.V. & Ellis, J.A., 1995. The Effect of Qualitative Explanations and Pictures on Learning, Retention, and Transfer of Procedural Tasks. NPRDC-TR-96-1. San Diego, California: NPRDC Navy Personnel Research and Development Centre.

UNSAFE ACTS AND UNSAFE CONDITIONS: DEVELOPMENT OF A PRELUDE MODEL

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Construction safety management has long utilised the concepts of unsafe acts and unsafe conditions within incident and accident reporting processes. Unsafe acts are often considered to be the greater concern; with figures of approximately 80-90% of accidents attributed to unsafe worker behaviour, although unsafe conditions remain relevant. It has also been argued that both play a part in safety, as manifest in highly complex accident causation models, yet industry often remains reliant on the simplistic categorisations of acts/conditions within accident reporting processes and safety observations undertaken in practice. This utility and common practice must be recognised, and it can be suggested that acts and conditions are firmly interlinked. Drawing on a large dataset of nearly 4,000 Safety Observation Reports from a large infrastructure construction project, investigation of the way in which incidents are categorised is explored and then, via content analysis of a purposive sample of individual reports, the reality of how the acts and conditions combine and interrelate is evaluated. Findings revealed significant inconsistency in the application of the categorisations of act or condition, and utilisation of the process to apportion individual blame through 'unsafe acts'. Grounded in the data, a conceptual model is developed that recognises the state of 'unsafety' of both acts and conditions, but also explores the preludes to both. It can be suggested that within the construction context there are relatively few precursors that produce unsafe acts or conditions in practice, and employing these in practice would provide greater insights, enhancing utility without adding significant complexity. Integration of this model within the reporting process would enable management to better use reporting data in the development and implementation of focused interventions, albeit still grounded in the familiar unsafe acts and unsafe conditions identified on their projects.

Keywords: safety observations, unsafe acts, unsafe conditions, taxonomies

INTRODUCTION

The historical development of occupational health and safety management in construction has in part dictated its lexicon. Early focus was on the identification and mitigation of physical risks within the workplace, through the provision of machine guards and controls (Lingard and Rowlinson 2005) which led to prescriptive management approaches which focused on unsafe conditions through mechanistic regulations. Subsequently, as the number of accidents decreased focus shifted onto unsafe acts, through approches such as behaviour-based safety (Lingard and Rowlinson 2005), goals and feedback programmes, and most recently notions of safety climate and culture have emerged (Choudhry et al 2007).

A consequence of this language of safety is the way it has directed thinking, particularly in the areas of safety reporting for accidents and near-misses, towards unsafe acts or unsafe conditions as an either/or situation. However, accidents are often highly complex in reality, and to use such a

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simplistic dichotomy in reporting and subsequent investigation is likely to limit the learning potential of an incident. Indeed, although acts have come to the fore in terms of management focus, evidence has shown that organisational factors are indeed critical (Lingard and Rowlinson 2005); whilst Hinze (1996) argued that it is always a combination of physical conditions and worker actions that is the true cause of safety accidents on sites.

Despite such evidence, unsafe acts and unsafe conditions often remain segregated in practice, accident and near miss reporting seeking to categorise one or the other, with no potential for overlap. Academic advances in accident analysis have led to the development of ever more complex approaches, grounded in systems thinking and organisational failure models, yet their utility has been questioned (Hovden et al 2010). Indeed they are rarely used in practice, and would be challenging to apply to near-miss reporting, which is often large scale in terms of volume, but with relatively little management time available to record, analyse and act upon them.

Drawing on a large database of nearly 4,000 safety observation reports that have been categorised as either unsafe acts or unsafe conditions, this work seeks to explore empirically the consequences of this dualistic approach, and how acts and conditions combine in practice. It reflects on the utility of this approach to practice, and how it can form the basis of a simpler 'prelude model' of safety.

CONTEXT

Unsafe Conditions and Unsafe Acts, and more Systemic Thinking

Early health and safety management was grounded in the elimination of unsafe working conditions, indeed the earliest UK safety legislation sought to address the mechanistic problems of exposed mill-gearing in the factories of the industrial revolution. Developments in technology brought new hazards and risks into workplaces, and key concerns were to "… find the technical means to safeguard machinery, to stop explosions and to prevent structures from collapsing" (Hollnagel 2014:24). Within the UK construction industry, unsafe conditions are often addressed through rigorous legislation, such as that found within Part 4 of the Construction (Design and Management) Regulations 2007, which sets out amongst other things how stability of structures must be maintained, how excavations must be managed and how good order can be kept on sites.

Alongside such unsafe conditions, relating to the work space, can be found the concept of unsafe acts, relating to the behaviour of the people who work there. As Hollnagel (2014:30) states, "the idea that human error could be used to explain the occurrence of adverse events was eagerly adopted". Application of cognitive theories also enables 'explanation' of such unsafe acts, examples including the optimism bias, that everything will go right despite risks being taken, the overconfidence barrier, and the planning fallacy, which results in optimistic predictions about how long a task will take (Baron et al 2006) which can result in cutting corners and risk taking when deadlines approach. More generally, Kletz (2001) suggested that most unsafe acts were the result of a moments forgetfulness or aberration, others the result of errors of judgement, which can also be traced back to inadequate training or supervision. Within the construction industry, Rawlinson and Farrell (2010) observe that a high tolerance to risk taking is evident, allowing intentional unsafe acts to form part of everyday site life.

A combined approach is to make technology failsafe so unsafe acts cannot not lead to an accident, rather than educate workers through training programmes (Swuste et al 2014), however this is highly problematic within the construction industry, given the nature of the work. Indeed, the continuing development of technology within the workplace has led to increasing complexity and coupling between tasks and activities, therefore interactions cannot be fully planned, understood or anticipated (Leveson 2004). This is particularly relevant when many different subcontractors and long supply chains create complex relationships on sites, and have been found to have negative effects on safety (Manu et al 2010). Although single failure prevention is often built in to processes and equipment, this means that in practice accidents have shifted to more complicated occurrences with two or more cumulative failures, which are harder to predict and therefore harder to prevent. (Hollnagel 2004:3).

These ideas of organisational failure (Hollnagel 2004; Hovden et al 2010) and systemic safety (Dekker 2006) bring together unsafe acts and conditions. Unsafe acts have become a symptom of deeper latent problems within projects or organisations, the management system creating situations, or rather unsafe conditions that can encourage or even force human errors within certain contexts (Perrow 1999; Dekker 2006). As Whittingham (2004:34) states, most violations (unsafe acts) also have a systemic underlying cause that effectively 'encourages' them. Within the construction industry competitive tendering for work winning (Morton and Ross 2008); and bonus and payment schemes that encourage speed and risk taking behaviours (Fellows et al 2002; Spanswick 2007) have both been highlighted as unsafe conditions, or latent safety defects, in industry operations. However, as Whittingam (2004) argues, organisations are often unwilling to look too closely at the system faults which caused the error, and would rather focus on the individual who caused it; emphasising the unsafe act rather than the systemic cause.

On construction sites, where the workplace is subject to continual changes, different resources, poor working conditions, tough environments and complex co-ordination of different trades and subcontractors (Pinto et al 2011), performance variability can be argued to be a necessity, therefore to isolate and label unsafe acts within such (potentially unsafe) conditions seems incongruous. However, this has not stopped continued focus on unsafe acts, embedded as they are in the historical language of safety. Indeed, both acts and conditions, independently and combined in systems thinking, still hold significant influence on the way accidents, incidents and near misses are investigated both academically and in practice.

The Influences of Accident and Incident Investigation

Statistics form one of the most prominent safety indicators of an industry, providing evidence of safety management in practice. Accident statistics are themselves lagging indicators (Hinze et al 2013), and learning from past indicators is a key process for understanding why accidents occur on sites and how future performance can be improved (Manu et al 2010). Yet investigations of accident causality have developed highly complex, and at times rather unfathomable, approaches to investigating incidents from a variety of underlying theories and approaches. Indeed, Grabowski et al noted the panoply of approaches, and that there have been " … few efforts to harmonise or synthesise the models and methods" (2009, p1187), resulting in an incoherent body of work. The accident process itself has also seen development from linear, causal models, which suggest accidents are simply the sequential result of technical factors, human error or organisational problems (Hovden et al 2010), to more complex, integrated approaches. As Grabowski et al (2009) note, whilst some accidents will be the result of immediate causes, cascading through an error chain, others are much more complex with non-linear interdependencies, drawing on systems thinking for their theoretical foundation.

One of the main goals of accident investigation has been the identification of the 'root cause', and consequently the apportioning of blame (Whittingham 2004). Accidents are seen as evidence of error or failure, through either an unsafe act or the emergence of an unsafe condition, and therefore accident investigation becomes the quest to identify the responsible individual behind the error (Dekker 2011). It can be argued that this has perpetuated 'human error' as a prominent causal factor in accidents (Whittingham 2004), as the cause becomes easily identifiable as one of Reason's (1990) rule, skill and knowledge-based errors or occasional or routine violations. Yet the quest for root causes has been challenged on a variety of levels, not least the potential for over-simplification (Grabowski et al 2009). Kletz (2001) suggested that root cause has an air of finality about it, not always helpful, given that the cause of many accidents is actually gravity. Hollnagel (2004) suggested that causes are not sought simply for learning, but from desires for certainty, and the notion we gain knowledge that can be used in future accident prevention.

Systemic, management and organisational factors have also been identified and incorporated into accident thinking. For example, Hollnagel (2004) proposed a Functional Resonance Accident Model (FRAM) based on the concepts of emergence. Ferjencik (2011) discussed the notions of singular causality, general causality, contextual factors, contributory factors and causal factors in the development of an Integrated Procedure of Incident Cause Analysis (IPICA). Leveson (2004:257) went further than organisational boundaries in suggesting a general form of a model of socio-technical control which also acknowledges the influences of legislation, regulations, certifications, and law.

From the utilitarian perspective, the shift to systemic and organisational thinking has added considerable complexity to the process of accident and incident investigation. Although it is arguable that a contextual understanding of an accident is a vital part of its investigation, in order to appreciate the social and technical systems that surrounded it (Leveson 2004) and enable the development of explanations, rather than isolated root causes (Hollngel 2004), it has been questioned whether they have seen utilisable fit with the current, existing realities of work (Hovden et al 2010). There is the potential for the level of detail and the interactions of these details to develop incoherence and impracticality, as they increase in numbers and interrelationships. Indeed, it has been suggested that this increasing complexity is incompatible within traditional linear accident models and whether new approaches are needed (Hovden et al 2010), exploring non-linear perspectives (Ferjencik 2011). This may however raise its own problems, as the representations and communication of such approaches may prove too complex to practically deliver.

Indeed, uptake of complex approaches to investigation has been limited, or only utilised when serious incidents, such as fatalities, occur. The need for investigation to support learning, the human desire for categorisation and management, and the desire to apportion blame where necessary, has arguably resulted in the reliance on two fundamental root causes; unsafe act and unsafe conditions. Therefore, rather than seek complexity, it is this basic approach that should be empirically explored to ascertain its benefits and limitations, whilst enabling consideration of the relationships between these two root causes. In taking a utilitarian perspective, and accepting of the desire to retain simplicity and ease of use on sites, it is hoped that a theoretical model can be produced which fits with the site context, yet is able to inform improvements in accident reporting and learning on sites.

METHODS

Between March 2013 and July 2014, 3956 safety observation reports were collected from a large UK infrastructure construction project (approximate value £800M). The collection of safety observations from construction personnel is common practice on large projects, and for this dataset any manager or foreman was able to enter details in to an online system for the attention of the safety department. The person entering the report categorised it initially as a type of ‘observation’, either an ‘Unsafe Act’ or an ‘Unsafe Condition’ or as an example of ‘Good Practice’, and subsequently this observation was allocated to one of 27 different work ‘categories’. A project safety advisor ‘checked’ this categorisation, and could amend it if necessary, potentially dismissing it as a non-safety issue, or authorising it for further action.

A mixed methods approach has been used with these data. Quantitative analysis was carried out to initially determine the allocation of observations, and then to establish the relative quantifications of the ascribed categories beneath them. While a full content analysis of all the safety observations would reveal more about the actual practices and nature of activities that resulted in the safety report, it is beyond the scope of this paper. Therefore a qualitative approach was made to just two categories, considered a purposive sample, which could then be examined in depth, utilising content analysis (Tonkiss 2004) to develop a taxonomy of the data. A taxonomy can reveal the principles underlying a classification, for example Garrett and Teizer (2009) provided a taxonomy for human error awareness in construction safety. Repeated passes of the data enabled the researchers to explore the data itself and also undertake a process of re-framing, exploring the potential for alternative categorisations than those originally made, through the lens of the literature.

FINDINGS AND ANALYSIS

Quantitative Analysis

Of the 3956 safety observation reports, 2128 were categorised as unsafe conditions, 697 as unsafe acts and 1131 as good practice. Here only 'unsafety' is considered and therefore the 'good practice' observations were removed from the dataset, resulting in 2825 records. With just over 75% of the observations considered to be unsafe conditions these data can be considered surprising – they imply that the majority of unsafe incidents are derived from situations that are not influenced by human actions. However, this may also be a reflection of the difficulties of observing fluid and momentary acts when compared to static and unchanging conditions.

A fuller picture of the dataset and of the range of categories to which the reports had been ascribed can be found in Figure 1, which presents graphically the range of categories as assigned beneath the observations of unsafe acts and unsafe conditions.

In almost all categories it can be seen that the number of unsafe conditions exceeds the number of unsafe acts, with the exception of 'behaviour'. The inclusion of this category in itself is interesting – it is neither a work type (such as excavations or lifting) nor an organisational function (such as permits, PPE or welfare). That there are any 'unsafe conditions' that can be attributed to behaviour is also interesting and the data overall suggests either misunderstanding in the categorisation of the safety observations, or is the manifestation of the complexities of incident reporting when limited to just categorisations.

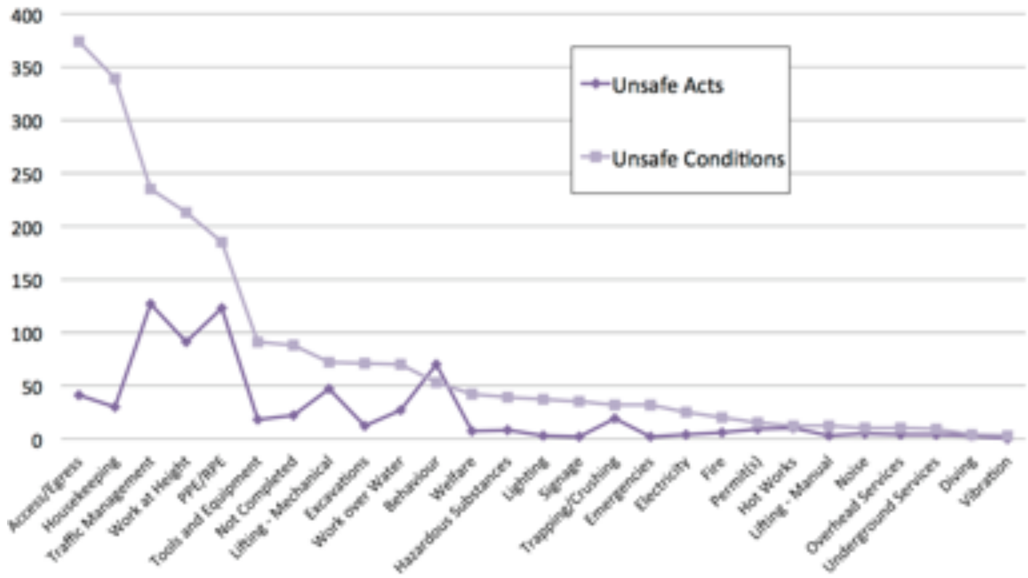

Figure 1: Categorisation of Unsafe Acts and Unsafe Conditions

Qualitative Analysis

In order to further explore the data, and these apparent inconsistencies, the cases under the 'behaviour' category for both unsafe acts and unsafe conditions, were extracted from the wider dataset, a total of n= 114 records.

The process of this analysis was revealing in itself. In the initial dataset, 48 observations were recorded as unsafe conditions but many of these did not fall under a definition of situations that were unsafe through non-immediate human means. For example, one report suggested that "Welder welding without screen in internal stair" was an unsafe condition, presumably because the correct equipment was not present, but in the researchers' interpretation the lack of a screen in a particular area should not be the immediate focus; rather the fact that the welder chose to continue welding without a screen present is itself poor human judgement and thus an unsafe act. This consideration of 'human means' was used as a 'benchmark' for classification, while at the same time acknowledging it is arguable that any classification process is inherently subject to interpretation, as demonstrated by the data explored here: overall, of the 48 initial such observations only 5 remained as such following the re-framing process; 90% were changed by the researchers. This finding illustrates the complexities involved in deciding at what point an act, or number of acts, eventually ossifies into a condition.

However, those observations that remained 'unsafe conditions' following the re-framing process were still supported by the sub-categorisation of behaviour. Here, and to further develop the previous argument, the underlying premise was that an act had initiated the condition, although the line between them had been drawn at the level of the categorisation rather than the observation. For example, the observation that "road pins for gulley setting out have no protection either place caps or remove pins", can be related to behaviour, or rather the omission of the behaviour to place caps on the pins, but it could also relate specifically to excavation works. Although this analysis arguably supports more complex, non-linear and emergent approaches to analysing safety incidents, given the reliance on acts and conditions it can be suggested that what would actually be of greater utility would be a clearly defined and shared understanding of the 'line' between acts and consequentially emergent conditions, integrating this concept of behaviour within it.

Another notable aspect of the data, revealed by the analytical process was the prominence of finger pointing or blaming individuals for their behaviour. For example "Safety rep parking vehicle in live traffic route to speak to his supervisor"; "Security guard not using walkways, challenged and re-routed to walkway" are clearly identifying individuals with some level of authority. While many unsafe act observations report simply the behaviour of an unidentified individual, 37% directly identify the individual by name or by the company they work for or by the registration number of their vehicle. Such data strongly indicates highly complex social and organisational issues at play that have seeped into the safety observation process, in part those who create and enforce the policies are readily punished by others for their violation. Even where individuals are not named, the desire to lay blame can be found within the data, a fundamental need in incident reporting as identified by Whittingham (2004) and Dekker (2011).

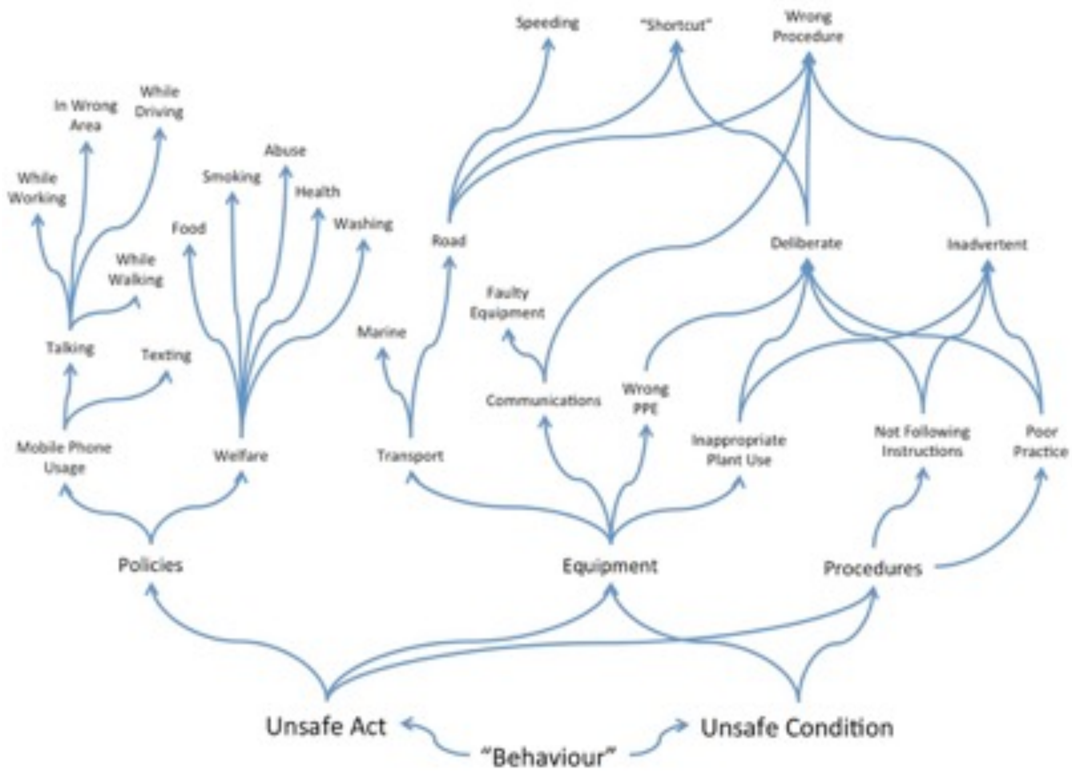

Figure 2: A taxonomy of the Behaviour category of safety observations

The prepared taxonomy itself, seen in graphical form in Figure 2, was also of interest; both behavioural acts and conditions easily assigned to either policy, procedural or equipment categorisations, suggesting that a more useful assignment could be made at a more 'detailed' level within the data, rather than the traditional act/condition dichotomy. As the taxonomy developed, 'deliberate' and 'inadvertent' also emerged as key categorisations, deliberate further supported by notions of 'shortcuts' and deliberate violations of procedure.

In order to provide a 'check' on the findings from the 'behavioural' categorisation data, a taxonomy was also prepared for the 'hot works' category. This was a much smaller sub-set of the data (n = 22 reports that were either unsafe act or unsafe condition), yet the same taxonomy categories emerged from this data. The only category present in hot works but not in behaviour was 'missing equipment'. This is itself of interest, as it could be suggested that equipment has developed beyond its inherent unsafety, the initial causes behind historical concerns around unsafe conditions (Hollnagel 2014), and rather it is unsafe acts involving this equipment that have become more relevant to practice. The taxonomy for hot works can be seen in Figure 3.

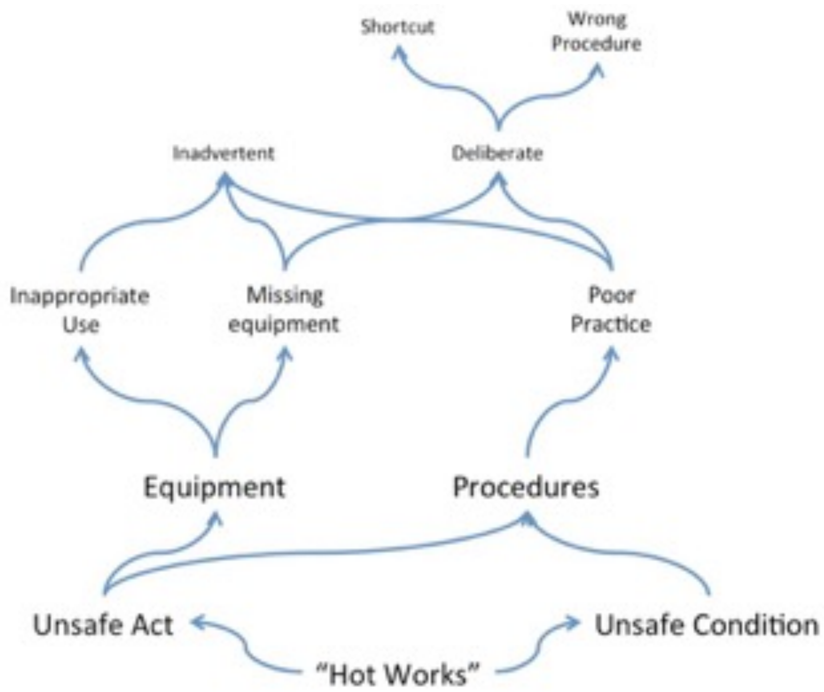

Figure 3: A taxonomy of the Hot Works category of safety observations

In the preparatory process of this second taxonomy, similar observations were made as for the behaviour category. Reports again appeared to be incorrectly categorised as unsafe condition when could be more appropriately labelled unsafe act (50% were changed) and those that identified individuals or companies and could be considered 'blame reports' (27%), though both were not to the same extent as for 'behaviour'.

THE PRELUDE MODEL

The ease with which the same levels were identified in the preparation of both taxonomies suggest there may be a common pattern to how unsafety can be understood, in terms of preludes rather than 'root causes' (Grabowski et al 2009). Generally, equipment and procedures can be identified in level 2; poor execution in level 3; inadvertent or deliberate at level 4 with either shortcuts or wrong choice of procedure at level 5. By reversing these levels, a tentative 'prelude model' of unsafety development emerges.

These ideas are explored in Figure 4, a conceptual prelude model of unsafety development between unsafe acts and unsafe conditions.

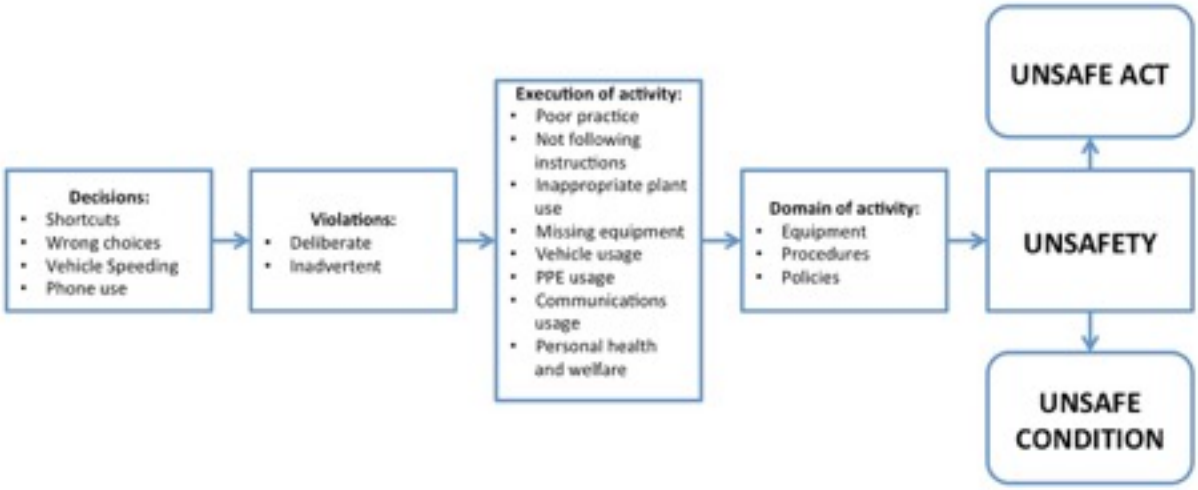

Figure 4: The development of unsafety – a conceptual model

CONCLUSIONS

Through content analysis of 136 Safety Observation Reports taken from a larger dataset of nearly 4000, a greater understanding of the nature of unsafety as perceived by those undertaking construction work emerges. The process of analysis revealed both complexities and subjectivity within the reporting process, and an underlying desire to apportion blame. This raises questions of the motivation for creating reports; to point fingers, particularly at those in authority, or to genuinely attempt to improve conditions. Projects and organisations undertaking safety reporting of this nature should seek to ensure this does not undermine the utility of the exercise.

The categorisation of unsafe act and unsafe condition was found to be highly subjective, and likely dependent first on a robust definition of what constitutes an 'act' and what a 'condition; and secondly on individuals' interpretation of this definition. Many reported unsafe conditions were deemed by the researchers to actually be unsafe acts. In some ways this is contrary to the conclusions of Whittingham (2004), who argues that organisations would rather focus on the error of the individual. Yet the contextual descriptions of each observation challenge this further – while many clearly indicate human error, most unsafe acts were categorised as systemic conditions. If such labels are to be used then clearer and objective definitions are needed for consistency of reporting, to mitigate the subjective nature of the process.

Preparation of taxonomies on two subsets of the overall data enabled the development of a conceptual prelude model of how unsafe acts and unsafe conditions may develop and form. The nature of how unsafety develops was very similar for both acts and conditions and rather than as two ends of a single spectrum, they are perhaps instead two artificial constructs superimposed on a development of unsafety, that has roots in decisions made either consciously or unconsciously; deliberately or inadvertently. It is suggested that further research explore this prelude model in practice, including the utility of its application to existing reporting processes to ensure its ability to enhance, rather than over-complicate, existing industry reporting procedures.

REFERENCES

Choudhry, R M, Fang, D and Mohamed, S (2007) Developing a Model of Construction Safety Culture. ASCE *Journal of Management in Engineering*, 23(4), 207-212.

Dekker, S. (2006) The Field Guide to Understanding Human Error, Ashgate Publishing, Farnham.

Dekker, S. (2011) The criminalisation of human error in aviation and healthcare: A review, *Safety Science* 49(2) 121-127.

Ferjencik, M. (2011) An integrated approach to the analysis of incident causes, *Safety Science*, 49(6) 886-905.

Garrett, J. and Teizer, J. (2009). Human Factors Analysis Classification System Relating to Human Error Awareness Taxonomy in Construction Safety. *Journal of Construction Engineering and Management*, 135, 8, 754-763.

Grabowski, M., Zhuyu, Y., Zhou, Z., Huawei, S., Steward, M. and Steward, B. (2009) Human and organisational error data challenges in complex, large-scale systems, *Safety Science* 47(8) 1185-1194.

Hinze, J., Thurman, S. and Wehle, A. (2013) Leading indicators of construction safety performance, *Safety Science*, 51(1) 23-28.

Hinze, J.W. (1996) *Construction Safety*. USA: Prentice Hall

Hollnagel, E. (2004) *Barriers and Accident Prevention*, Ashgate Publishing: Aldershot.

Hollnagel, E. (2014) *Safety-I and Safety-II: The Past and Future of Safety Management*, Ashgate Publishing, Aldershot

Hovden, J., Albrechtsen, E. and Herrera, I.A. (2010) Is there a need for new theories, models and approaches to occupational accident prevention? *Safety Science*, 48(8) 950-956.

Kletz, T. (2001) *Learning from Accidents*, Butterworth-Heinemann: Oxford

Leveson, N. (2004): A New Accident Model for Engineering Safer Systems. *Safety Science*, 42(4): 237-270.

Lingard, H. and Rowlinson, S. (2005) *Occupational Health and Safety in Construction Project Management*. London: Spon Press

Manu, P., Ankrah, N., Proverbs, D. and Suresh, S. (2010) An approach for determining the extent of contribution of construction project features to accident causation, *Safety Science* 48(6) 687-692

Morton, R. and Ross, A. (2008) *Construction UK: Introduction to the Industry*. 2nd ed. Oxford: Blackwell Publishing Limited

Perrow, C. (1999) *Normal Accidents – Living with High Risk Technologies*, Princeton University Press, Chichester.

Pinto, A., Nunes, I.L. and Ribeiro, R.A. (2011) Occupational risk assessment in construction industry – Overview and reflection, *Safety Science*, 49(5) 616-624.

Reason, J. (1990) *Human Error*, Cambridge University Press: Cambridge.

Rawlinson, F. and Farrell, P. (2010) But we *like* risk. *Construction Research and Innovation* 1(1), 46-50.

Swuste, P., van Gulijk, C., Zwaard, W. and Oostendorp, Y. (2014) Occupational safety theories, models and metaphors in the three decades since World War II, in the United States, Britain and the Netherlands: A literature review. *Safety Science*, 62(1) 16-27.

Tonkiss, F. (2004) *Content and Discourse Analysis*, In Seale, C. (Ed) "Researching Society and Culture", Second Edition, Sage Publications Limited, London, pp305-321.

Whittingham, R.B. (2004) *The Blame Machine – Why Human Error Causes Accidents*, Elsevier Butterworth-Heinemann: Oxford.

'CONSTRUCTION OS&H': A FREE, COMPREHENSIVE TRAINING PACKAGE IN OCCUPATIONAL SAFETY AND HEALTH FOR THE CONSTRUCTION INDUSTRY

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Construction remains one of the industries with very high rates of accidents and ill-health, and many of the 'accidents' are not accidents at all, but occupational safety and health 'incidents', because they could have been avoided by good practices, procedures and equipment, together with appropriate knowledge and responsible attitudes. This problem is at least partially related to lack of proper training. A worldwide analysis by the International Labour Office (ILO) in 2007 concluded that there was a shortage of comprehensive, internationally relevant training materials freely available in the public domain.

Construction OS&H is an international occupational safety & health (OS&H) training package, freely available to download from the ILO web site. It is designed specifically for four main groups: clients; design and project management teams; construction companies ('contractors'); and workers; but it will also be useful to other groups, such as government inspectors and company OS&H officers. It provides trainers with a substantial digital resource, rather than set of four linear programmes, so that competent trainers can adapt the contents for a specific programme. It comprises seven main components.

The package was validated in depth by bringing together 24 professionals - practicing engineers, academics, trainers, government officials, trades union officials, contractors and consultants - from four African countries, for a two-day workshop in Dar es Salaam, Tanzania, in 2009. The package was then refined and published on the ILO web site in 2011.

Evaluating the practical use of Construction OS&H is difficult because it is freely available for downloading from the ILO web site for anyone to use as they wish. The evidence that we have is that one of the authors used it extensively in a five-day course in Panamá, where it was found to be very effective. A call for feedback from ILO offices around the world reported that an independent consultant used it as the basis for a course in Paraguay, which had very favourable evaluations (summarised in the paper) and that it has been used in courses in Azerbaijan, Kenya, Tajikistan and Tanzania, although it has not been possible to obtain evaluation reports.

Keywords: construction industry, safety and health, international, training materials, free download.

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INTRODUCTION

High standards of safety should be an objective pursued in the same way and with as much vigour as other management objectives. The aim of most development projects is to improve the general well-being of the inhabitants of the country concerned. It is a reasonable humanitarian aim to ensure that the well-being of the people engaged in the project itself is preserved and perhaps enhanced. (Austen and Neale 1984: 93)

Construction OS&H is a package of training materials and guidance in its use. It was the result of an initiative by the International Labour Office (ILO) and Building and Woodworkers International (BWI). The ILO is a major specialised agency of the United Nations:

The ILO was founded in 1919, in the wake of a destructive war, to pursue a vision based on the premise that universal, lasting peace can be established only if it is based on social justice. The ILO became the first specialized agency of the UN in 1946.

The main aims of the ILO are to promote rights at work, encourage decent employment opportunities, enhance social protection and strengthen dialogue on work-related issues.

[ILO web site, www.ilo.org]

The ILO has summarised its mission in two words: "Decent Work". At a more specific level, the ILO Sectoral Activities Department (SECTOR) promotes decent work by addressing social and labour issues in specific economic sectors, both at international and national levels. The construction industry is an important sector for consideration and it was through SECTOR that this package was developed and published, in partnership with the ILO's "Programme on Safety and Health at Work and the Environment".

The ILO is a tripartite organization, the only one of its kind bringing together representatives of governments, employers and workers in its executive bodies. This facilitates (and expects) cooperation between important parties in national economies, and in the case of this training package the construction specialist in SECTOR worked with BWI.

BWI is the Global Union Federation grouping free and democratic unions with members in the Building, Building Materials, Wood, Forestry and Allied sectors. The BWI groups together around 326 trade unions representing around 12 million members in 130 countries. BWI's mission is:

To promote the development of trade unions in our sectors throughout the world and to promote and enforce workers' rights in the context of sustainable development.

[BWI web site, www.bwint.org]

The construction industry is a notoriously hazardous industry in which to work:

- *In industrialized countries, construction workers are 3-4 times more likely than other workers to die from accidents at work.*
- *In developing countries, the risks associated with construction work are estimated to be 3 to 6 times greater in comparison to developed countries.*

[ILO 2014: slide 12]

Construction OS&H was developed through a systematic process during the period 2003 to 2011. A statistical review by the ILO in 2003 found that about 250 million workers suffer accidents in the course of their work, and over 300,000 are killed every year (ILO 2003). The ILO further ascertained that: *In the construction industry, at least 60,000 people are fatally injured on building sites every year. Many hundreds of thousands more suffer serious injuries and ill health.*

Effective training is obviously a crucial element in any serious attempt to improve the occupational safety and health (OS&H) of workers in this industry and training has to be based on sound training materials. In 2007 the ILO commissioned consultants to conduct a review of the training materials readily available to potential trainers worldwide (ILO 2007). The following are extracts:

This analysis concluded that there was indeed a shortage of OSH and project management training materials to be found in the public domain and that those that could be found tended to be generic, and not focused on the construction sector. Those materials found bespoke to the construction sector themselves varied greatly in quality and were in many cases obsolete in the context of the modern construction environment, characterized by complex contractual and employment relationships, often lacking clarity in the flow of responsibilities for OSH.

The remedy …… is the production of a universally applicable compendium of OSH and Project Management training materials relevant to a global audience and applicable in a variety of legislative environments, bespoke for the construction sector and the various actors active within the sector. This compendium of training materials needs to be made available for dissemination through the public domain to provide equality of access globally and to ensure that those most at need have access to good quality and current OSH and Project Management training materials.

In response to this study, ILO developed a project proposal through its normal processes and in 2008 funds were provided to commission the authors of this paper to write a training package. The Terms of Reference (ToR) ran to 12 pages but the quotation above gives the principal requirements. A draft of the package was reviewed by the ILO officials managing the project at a meeting with the authors (which approximated to an all-day PhD viva) and the package was refined and a new draft was completed, which was validated through a two day 'Expert Workshop' in Dar es Salaam, Tanzania, in 2009. The final version was put on the ILO construction sector web site in 2011. This was obviously a protracted process but had the rigour necessary to formulate a well-researched training package to the standard required by a major UN agency.

This paper begins with an explanation of the overall educational principles and design, followed by a summary of the content and sources. A series of examples illustrates the form and content of the package, and the validation process is described. The paper concludes with a review of its practical use with case studies in Panamá and Paraguay, and some conclusions.

EDUCATIONAL PRINCIPLES OF CONSTRUCTION OS&H

The main principle on which Construction OS&H is based stems from the educational principle that an effective training programme must be designed to meet specific training objectives and give full consideration to the relevant characteristics of the intended trainees, the venues and facilities to be used, funding and time available, and other contextual factors. Thus it is unlikely that a training package offering 'standard courses' will be universally useful. Furthermore, the extensive experience of the authors of this paper had shown that trainers very rarely use standard training packages as a whole; they do not use them 'straight out of the box' but adapt them to suit specific circumstances and use parts of them in combination with other material. So, at the design stage of Construction OS&H the decision was made that it would be a flexible resource rather than a set of prescriptive course programmes. This decision led to the package being based on a number of Themes, each of which would comprise a substantial body of information. The Themes provide most of the content of Construction OS&H, and so are good bases for the documentation (handouts, manuals etc) required by training programmes. To provide a resource for the delivery of the material, a PowerPoint Presentation (PPP) was compiled for each Theme.

Although the package was designed for flexible use, the ToR also envisaged a training package of four fairly prescriptive courses, one for each of four 'actors' in the construction industry: *clients; consultants, architects, engineers, project coordinators; prime contractors and subcontractors; and workers in the various trades*. So, the material from the Themes and PPPs was assembled into four 'Model Courses' for each of these 'actors', so illustrating how the package could be used in practice.

A second important principle is that Construction OS&H considers OS&H to be an essential element of construction project management rather than a specialised subject. It is obviously the duty of all involved in a project to take OS&H seriously themselves, as individuals, rather than seeing it as a job for specialists. Thirdly, the whole subject was treated systematically and recognised national and international systems, processes and procedures.

A final principle relates to education theory. The authors hope that those who use Construction OS&H will realise that quite a lot of educational skill has gone into its creation, but at its most simple the learning aphorism of Confucius provided a guiding principle (Yang and Lau, 1979): *I hear and I forget; I see and I remember; I do and I understand.* Thus an effective training programme must have an appropriate balance of formal teaching, visual stimulation and active participation through exercises such as discussions, case-studies, site visits, etc.

CONTENT OF CONSTRUCTION OS&H

The content was obtained from wide ranging international literature searches, supplemented by the authors' own information. Many of the photos used are by the authors, some of them taken especially for the package.

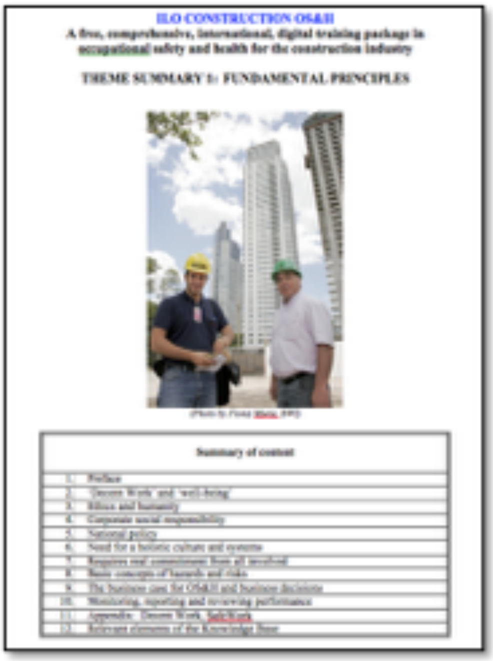
Theme summaries

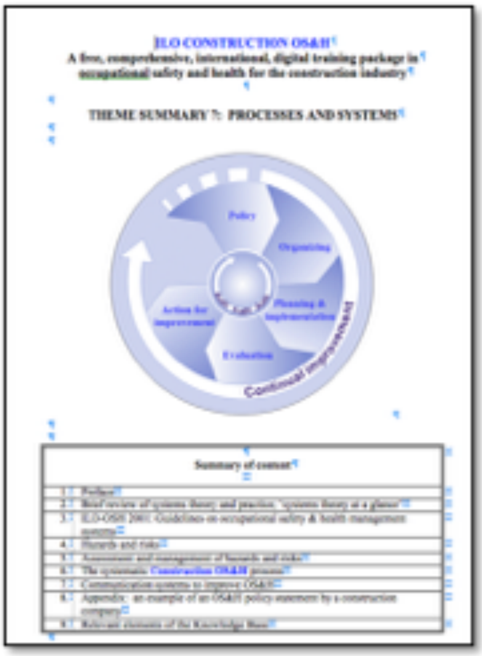
Construction OS&H is based of 15 Theme Summaries, typically 30 A4 pages each, totalling 424 pages. These provide the Tutor with an extensively illustrated, comprehensive body of information, from which training course materials can be selected and edited. Theme Summaries are numbered 1-15. The structure and content were derived from a study of legal documents, textbooks, training manuals and other published material. The headings and subheading from these documents were transcribed into a spreadsheet, which yielded a large compendium of phrases. By inspection, phrases of broadly similar meaning were grouped together in a new spreadsheet, so creating a rough thematic structure. The authors used their expertise to assess and shape this structure to produce the set of themes in Table 1. As an illustration, the title pages of two Theme Summaries are given in Figure 1, which demonstrates the visual character of Construction OS&H.

Table 1: Theme sets and titles

Fundamental themes	**Theme Number**
Fundamental principles	1
General duties	2
Safe and healthy working environment	3
Workers' perspectives	4
Project management themes	
Principles of safe project management	5
Project planning and control for OS&H	6
Processes and systems	7
Welfare and project site	8
Technical themes	
Personal protective clothing & equipment (PPE)	9
General plant and equipment	10
Vertical movement	11
Horizontal movement	12
Working at or below ground level	13
Working at height	14
Integration and conclusion	
Project, concluding case study, evaluation	15
Further technical themes for future development	
A number of more specialist Themes were suggested for future development, such as tunnelling	

Figure 1**:** Examples of the title pages of Theme Summaries





A PowerPoint presentation was derived directly from each Theme Summary, typically 50 slides each, totalling 802 slides. These can be selected and edited for specific training events to match the selection from the Theme Summaries. PowerPoint presentations are the main medium for communicating the training content, so these presentations also include exercises and instructions to the course participants. The PowerPoint Presentations are numbered 1-15, corresponding to the Theme Summaries. Figure 2 shows examples of two title slides for the PPPs and Figure 3 gives examples of slides to stimulate discussion.

Figure 2: Examples of title slides for PPPs

Figure 3: Example of slides for group discussion

Other elements of Construction OS&H

Tutors' Guide. This explains the content of the package and how to use it.

Knowledge Base. This provides the principal sources of the content of the package (61 references) and includes **Downloads** of some of the main sources.

Model Courses. Four Model Courses are provided, one each for clients, design & project management teams, construction companies and workers.

Participants' Handbooks. The content of each Model Course has been summarised in a printed Participants' Handbook.

Other materials. These include a few PPPs from other sources, a PPP based on an ILO booklet which avoids language difficulties by only uses cartoon-type illustrations (See the second example in Figure 2) and a couple of 'Toolbox Briefings' which can be used for on-site training.

Web site. All the above is available on the ILO web site, for free downloading.

VALIDATION

A complete draft was validated through a two-day workshop in Dar es Salaam, Tanzania. The participants were all senior people from a suitable range of institutions, as shown in Table 2.

The validation process began with a plenary session at which a summary of the package was presented and discussed. Each participant was given a full print out of the package plus the same content on DVD. The participants were divided into four groups and each was asked to consider the package from the point of view of one of the 'actors' for whom the package had been designed. They were asked to review the package against the ToR but also to review the technical content and to suggest on how they would use it in practice. The Workshop concluded with an afternoon of group presentations and discussions, from which a set of revisions was agreed. This was a lively, very positive and useful event. The draft of Construction OS&H came through it very well and it was then revised as agreed and put on the ILO web site in 2011.

Table 2: List of participants – validation workshop Dar es Salaam 28 & 29 October 2009

No.	INSTITUTION	Country
1.	Ministry of Infrastructure Development	Tanzania
2.	Ministry of Gender, Labour and Social Development	Uganda
3.	Uganda Building Union	Uganda
4.	Construction company	Tanzania
5.	Construction company	Tanzania
6.	Construction company	Tanzania
7.	Institution of Engineers, Tanzania	Tanzania
8.	University of Dar es Salaam	Tanzania
9.	Occupational Safety and Health Authority (OSHA)	Tanzania
10.	Association of Consulting Engineers Tanzania (ACET)	Tanzania
11.	Kenya Building Union	Kenya
12.	University of Dar es Salaam	Tanzania
13.	ILO Pretoria Office	RSA
14.	Tanzania Occupational Health Services **(**TOHS**)**	Tanzania
15.	Dar es Salaam Institute of Technology (DIT)	Tanzania
16.	Dar es Salaam Institute of Technology (DIT)	Tanzania
17.	Engineers Registration Board, (ERB) Tanzania	Tanzania
18.	Building and Wood Workers International (BWI)	Kenya
19.	Tanzania Mine and Construction Workers Union	Tanzania
20.	Tanzania Mine and Construction Workers Union	Tanzania
21.	Social Business consultancy	Tanzania
22.	Ardhi University	Tanzania
23.	Tanzania Civil Engineering Contractors Association	Tanzania
24.	Tanzania Civil Engineering Contractors Association	Tanzania

EVALUATION THROUGH TWO CASE STUDIES

Evaluating the practical use of Construction OS&H is difficult because it is freely available for downloading from the ILO web site for anyone to use as they wish. From a call for feedback from ILO offices around the world we know that Construction OS&H has been used in courses in Azerbaijan, Kenya, Tajikistan and Tanzania, but at the time of writing this paper we have not been able to obtain any information to assess its effectiveness. We do have information about its use in Panamá and Paraguay, which is summarised in the case studies below. Although the original package was entirely in the English language, the ILO had it translated into Spanish, which is one of the official languages of the UN system, which facilitated its use in these countries.

Case Study 1: Use in Panamá

This was OS&H training for construction workers through a five-day course held in Ciudad de Panamá. The lead trainer was the second author of this paper.

The course was 'made to measure' for the Panamanian Trade Union, SUNTRACS. The content was based on the training materials for the Workers' Model Course as a general foundation, but with substantial additions and adaptations. The subjects covered are summarised in Table 3.

Table 3: Summary of the content covered

Introduction
Trade Union Approach
Welfare & Project Site
Personal Protective Equipment
Organising for Health and Safety Workplace
General Plant and Equipment
Vertical Movement
Horizontal Movement
Working at or Below Ground
Working at Height
Getting Management to Make Improvements
Site visit

This course demonstrated how Construction OS&H was intended to be used; that is, as a substantial resource adapted in partnership with those involved in providing the training to serve specific training needs.

The course participants had all received previous training on OS&H and were all experienced trade union OS&H representatives on large infrastructure projects, and four were full time organisers and trainers for the Union. SUNTRACS represents over 100,000 members in the construction industry in Panama and has a national industry Collective Bargaining Agreement with CAPAC, the Construction Contractors Association of Panamá, which covers OS&H arrangements for the sector in some detail.

In order to meet the specific needs of the SUNTRACS union, the course took account of the current situation in the construction industry in Panamá City. This allowed participants to focus on the most relevant hazards and prevention issues, also key speakers on construction OS&H were invited to come each day to give talks and to engage in discussions. These included OS&H specialists from the Panamá Canal Authority (ACP), the Consortium for the Canal Expansion (GUCP), the company building the Panamá Metro (FCC), the Ministry of Labour Inspectors, and the Construction Contractors Association (CAPAC), as well as short inputs from speakers from the ILO offices in Panamá and Costa Rica.

The Union had requested special emphasis to be placed on the training modules covering work below ground and horizontal movement. This is of particular relevance because of large new infrastructure works in Panama. Firstly, the Panama Canal Expansion Project, which began last July, currently employs almost 3,000 workers, and is due to reach 7,000 workers this year (2014). The characteristics of this project created a particular need for training on working with and around heavy plant and equipment, horizontal movement and site planning and provision of welfare facilities. Furthermore, at the end of February 2011, a new agreement on OS&H was reached between SUNTRACS and the consortium Grupo Unidos Por el Canal (GUPC). The agreement establishes a new OS&H system, with Trade Union OS&H representatives, OS&H Committees, daily joint inspections and weekly meetings on OS&H. Therefore the Trade Union was keen to receive specific training to support the OS&H representatives from the site.

The participants concluded that the training course had provided the union with valuable information resources, which they intend to communicate and use with local branches and with OS&H representatives around the country. It was felt that the technical information was of high quality, very well presented and (above all) timely and relevant to the current needs of the Trade Union.

From the point of view of the trainer, the materials are sufficiently comprehensive and flexible so as to be readily adaptable to different country contexts and levels of development. In the case of Panama, the construction industry is quite sophisticated, and the materials worked well, with use of pertinent country information and drawing on the participation and first hand knowledge of industry partners.

Case study 2: Evaluation report from Paraguay

Construction OS&H was used by an independent consultant for a training course in Paraguay. A statistical summary of the participants' evaluation is given in Table 4.

It is clear from the numerical data that this was a successful event. Obviously the course was conducted by a competent trainer, but the data demonstrate that the training package can be used successfully quite independently of its authors. Question 10 refers directly to the training materials, and the responses to question 13 would have been influenced by them, so these are very pleasing results. Questions 4 (objectives), 6 (gender) and 7 (methodology) would have been derived – at least in part – from the package so these results are also very pleasing. In terms of the overall effectiveness of the package, questions 14 and 15 very important, so the average scores (>4) are very satisfactory.

Table 4: Evaluation of a training course in Paraguay (translated from Spanish)

Questions		**Average (scale 1-5)**	**% 4 & 5**	**Estimated deviation**	**No. of replies**
1	Before the course, did you know its objectives, content and methodology?	3.33	37%	1.15	27
2	After completing the course, are the training objectives clear?	4.68	100%	0.47	28
3	Have the training objectives been achieved?	4.50	89%	0.68	28
4	Did the content meet the objectives?	4.61	96%	0.56	28
5	Were the contents tailored to take account of previous knowledge?	4.15	78%	0.85	27
6	How do you rate the gender balance in the content, methodology and materials?	4.33	88%	0.69	24
7	Do you think the teaching methodology was appropriate?	4.39	89%	1.08	28
8	How do you rate the contribution of the course tutors and specialists?	4.74	100%	0.44	27
9	Do you feel the group of course participants facilitated you learning?	4.07	85%	0.72	27
10	Do you feel that the materials used were appropriate?	4.74	96%	0.52	27
11	Do you feel the course was well organised?	4.56	96%	0.68	27
12	Do you feel the course secretariat was efficient?	4.65	96%	0.55	26
13	Are you satisfied with the quality of the training course?	4.63	96%	0.55	27
14	Do you think it is probable that your institution/ employer will benefit from your participation in this training?	4.07	74%	0.86	27
15	Do you think it is probable that your career will benefit from your participation in this training?	4.19	81%	0.72	27
Average		4.38	87%		

CONCLUSIONS AND RECOMENDATIONS

Construction OS&H is a substantial training resource. It was developed in a systematic way over a period of a few years. The final output was a very flexible set of training materials *intended to be useful for a worldwide audience and to be universally applicable for different countries and contexts*. It was carefully validated through an 'Expert Workshop' and the two case studies show that it has been used successfully in Panamá and Paraguay. It has also been used in courses in Azerbaijan, Kenya, Tajikistan and Tanzania.

It is free to download from the ILO web site:

In English: http://www.ilo.org/sector/Resources/training-materials/WCMS_161706/lang--en/index.htm

In Spanish: http://www.oitcinterfor.org/es/re curso-did%C3%A1ctico/seguridad-salud-trabajo-industria-construcci%C3%B3n-programa-formaci%C3%B3n-oit

Any further formal developments of the package will require the ILO to initiate a follow-up project and this will depend on user feedback, demand from member states and funding priorities. More realistically, the whole package is free to download and edit, so future developments are largely in the hands of users. The authors wrote this paper for this conference in the hope that it would be of interest to an international group of scholars who have a commitment to this subject, so perhaps some of you will develop it further. The authors would be pleased to engage in discussions on possibilities, although we have no funding at present.

REFERENCES

Austen, A D and Neale, R H (1984) "Managing construction projects: A guide to processes and procedures". International Labour Office, Geneva.

International Labour Office (2007) "Training material on occupational safety and health and project management for different actors in the construction sector". Internal report, International Labour Office, Geneva.

International Labour Office (2014) "Safety and Health in the Construction Sector: Overcoming the Challenges". ILO/UN Global Compact Webinar, 7 November. Available from Dr Edmundo Werna, ILO SECTOR, werna@ilo.org

International Labour Organisation (2003) "Safety in Numbers: Pointers for Global Safety Culture at Work". International Labour Office, Geneva.

Yang, Bojun and Lau, D C (1979) "Confucius: The Analects". Penguin Classics, London.

EXPLORING SAFETY COMMUNICATION PATTERNS IN SMALL WORK GROUPS IN THE CONSTRUCTION INDUSTRY - A THEORETICAL FRAMEWORK

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The short term and transitory nature of the construction industry is one of the factors that have been correlated to the poor safety performance of the industry. Effective safety communication between all parties is an essential part of safety performance. The construction industry is highly regulated due to its high incidence of work-place accidents. This is especially true of smaller building companies/enterprises where the burden of compliance to safety regulations is most onerous. The majority of current research in this topic area has focused on identifying the high risk components or the causes of increased risks. The literature on safety communication network patterns and its relation to safety performance is nevertheless minimal. Thus, this study is aimed at exploring the safety communication issue in the construction industry by analysing the communications patterns in small workgroups. It is proposed that modern analytical techniques such as social network analysis be utilised to identify patterns of safety communications. Data are designed to be collected through surveys with construction crews and their members that are contributing to active construction projects. This paper, based on a literature review, reports on a theoretical framework of the relation between communication network patterns and safety performance.

Keywords: Safety, communication, social networks, construction projects.

INTRODUCTION

The construction industry is one of the most injury prone industries worldwide (Kines *et al.*, 2010). As of 2011-12 the construction industry constituted about 9% of the Australian workforce (1.01 million people). The industry however accounted for about 11% of all of the serious workers' compensation claims. Additionally over 5 years from 2007-08 to 2011-12 there were 211 fatalities of construction workers resulting from work-related injuries. This corresponds to a fatality rate of 4.34 fatalities per 100,000 workers, nearly twice the national rate of 2.29 for all industries (Safe Work Australia, 2012). Furthermore, in 2010 56.3% of the construction fatalities, within the US occurred in

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establishments that employ less than 20 employees, and yet they only employed 41.4% of the wage-salary workforce in construction (CCRT, 2013). This indicates that small work groups within the construction industry have exceptionally poor incident rates. There is also evidence that small businesses struggle to understand their obligations under principle-based Occupational Health and Safety (OHS) legislation. This is significant in the construction industry as the majority of the construction businesses employ 5 or less people (Loosemore and Andonakis, 2007). Safe workplace practice is also compromised due to Work Health and Safety (WHS) not always being a high priority in the planning of a project. It is often seen as an additional cost on their already thin profit margin (Wadick, 2010).

The construction industry is a project based industry that incorporates many trades and practices into a complex and interdependent system. A project based interdependent industry is heavily reliant on communications between the groups and individuals. The communications enable people, tasks, processes, and systems to interact with each other in a purposeful and co-operative way. A large part of this communication involves the exchange of information related to safety. Effective and constructive safety communication can help prevent at-risk behaviours and promote safe work practices (Vecchio-Sadus, 2007).

The construction industry requires greater attention to communication and safety than most other industries due to its short term and transitory nature, and the complexity and diversity of the projects (Sawacha *et al.*, 1999). These factors have contributed to the construction industry being over represented in the workplace injury and death statistics. The majority of incidents that occur on construction sites are related to the field level employees.

Communications can be used within a safety context to advise, inform, assist, train, learn, direct, warn, seek help, reassure, motivate, question and complain. When the communication involves a threat or a benefit to the member it is commonly absorbed better (Vecchio-Sadus, 2007). As such, to improve the achievement of safety standards and abiding safety policies, such as the OHS policies, the transfer of information and communication between the management and employees should be improved in order to increase its effectiveness (Teo *et al.*, 2005). Safety communications and discussions can help to promote the essence of safety (Sawacha *et al.*, 1999).

An effective method to analyse a group for their effective safety communication network patterns is through the use of Social Network Analysis (SNA). SNA creates a communication network that can provide an understanding of the supportive framework for the interactions that if improved along with safety communications, can help to prevent at-risk behaviours and enhance safety culture (Vecchio-Sadus, 2007). This method of analysis employs a set of techniques that involve representing the relationships between a set of nodes or actors, as well as its structural characteristics (Pryke, 2012). Thus through SNA it is possible to identify ‘strong’ and ‘poor’ safety communication network structures and apply these findings to the Safety performance findings.

Work Health and Safety (WHS) within a workplace has been a topical area for industries as a whole and specifically in the construction industry. The previous literature tended to focus on identifying the high risk components of the industries or the causes of increased risks within an industry (Wang *et al.*, 2013; Zhou *et al.*, 2014). There are fewer studies on safety communication network patterns within a workplace and its relationship to workplace safety performance (Alsamadani *et al.*, 2013; Kines *et al.*, 2010), and these studies have not been performed for the Australian construction industry. This gap of safety communications within the Australian on-site construction workplace and its relationship to workplace safety has been identified as the focus of this thesis.

It is widely recognised that safety within the construction industry workplace is quite poor in relation to incident frequencies (Biggs and Biggs, 2013; Biggs *et al.*, 2013; Bust *et al.*, 2008; Knowledge Management Branch, 2010; Le *et al.*, 2014; Loosemore and Andonakis, 2007; Safe Work Australia, 2012; Wadick, 2010). Due to this, some of the focus should be moved from identifying the risk features, to how to reduce the risks within the industry. As stated previously, the high incident frequency is related to the field level employees within the construction industry and, thus it is important to study these groups.

This study is therefore aimed at determining whether there is a relationship between safety communication network patterns (e.g. interconnections and member dominance) and safety performance within small groups of the Australian construction industry. The reason this study is focused on smaller construction groups is due to the size being a major contributing factor to the OHS performance (Lin and Mills, 2001). Loosemore and Andonakis (2007) pointed out that there is substantial evidence showing that small businesses are struggling to comprehend their responsibilities under the principle-based OHS legislations. They also mention that over 90% of a project's value is accounted by small trade-subcontractors that often lack any resources, culture and skills to implement new reforms. Since the proportion of small groups are so large that an improvement in their safety would disproportionately improve the industries standards for the better.

LITERATURE REVIEW

Occupational Health and Safety

The introduction of the Occupational Health and Safety (OHS) regulations, in 2001, and the introduction of the Work Health and Safety (WHS), in 2011, in Australia were meant to help facilitate improvement in the construction industry's poor health and safety performance (Loosemore and Andonakis, 2007). The regulations are based on the belief that the identification and measurement of risks is what will improve safety performance. It implies that the employers must be the primary wardens of their employees' safety; that those who create risks must take responsibility for identifying and mitigating those. The regulations place much need for training, certification and consultation between those in control and the workers who could be affected by workplace activities (Loosemore and Andonakis, 2007).

WHS is a vitally important topic within the construction industry. This is because of every employee should have the right to a healthy and safe working environment (Construction, 2012), however the incident rate and fatality rate within the construction industry are markedly higher than that of most other industries (Knowledge Management Branch, 2010). A portion of the blame for this is attributed to the short term transitory nature and the complexity and diversity of the projects (Sawacha *et al.*, 1999).

While the policies within the Australian community which help to shape Health and Safety within the workplace are predominately obtained from OHS legislations, there is also pressure on the companies to produce effective policies that also addresses health and safety factors as well as to adequately train and commit management to the issues of health and safety to improve worker attitudes and safety practices (Teo *et al.*, 2005). The improvement of health and safety management systems are expected to be held by companies as a smart financial decision and held as a part of the cost conscious culture of companies who are committed to profitability and efficiency (Baxendale and Jones, 2000).

Communication and Occupational Health and Safety

Handling health and safety necessitates good skills in communication (Holt, 2005). The use of effective methods of communication and information transfer between employees and management has been shown to return an increase in the safety standards as well as improving the achievement of safety policies (Teo *et al.*, 2005).

The manner in which safety is communicated will have an influence on whether or not the safety processes are partaken or understood (Vecchio-Sadus, 2007). This is shown in a study performed by Loosemore and Andonakis (2007) which indicates that under the principle-based OHS legislations the responsibilities given to the small businesses are often misunderstood. This particular challenge is of significant importance in relation to the construction industry, as the majority of its businesses consist of 5 or less people being employed. Furthermore, the main contractors of the project may transfer over all of the safety responsibilities to the sub-contractors without ensuring that they have the capacity to maintain these and keep a safe working environment (Teo *et al.*, 2005).

The purpose of safety communications are in their most general sense intended to improve safety to eliminate or at least reduce occurrences that result in injury or illness (Wogalter *et al.*, 1999). Vecchio-Sadus (2007) stated that effective communication skills are able to decrease the probability of an injury as well as promote safe behaviours. Safety communication can also be seen as a means of shifting safety responsibility to others where hazards cannot be adequately guarded. This is not then the limitation of their responsibility, however. The second argument for maintaining constant effective safety communications is the workers' rights to know of the hazards within their workplace (Wogalter *et al.*, 1999).

Vecchio-Sadus (2007) stated that it is not as simple as training people to partake in safety processes and to work safely. It is sometimes necessary to provide some motivation to partake in safe working. It is of importance that an atmosphere promoting safe behaviour is introduced which reinforces the benefits for the organisation and for the employees.

Safety Communications in the Construction Industry

Construction sites are still one of the most accident prone and hazardous workplaces to be a part of. Developing a safety culture and improving the safety performance is a current challenge for the Australian construction industry. This is of particular importance in Australia in part due to Australia's largely diverse and multicultural workforce that is represented (Biggs and Biggs, 2013). Groups with greater diversity of culture and language have an increased need of consistent and effective safety communication as these can form 'barriers' to achieving a safe work environment (Alsamadani *et al.*, 2013).

It has been found that accidents on construction sites have an increased probability of occurring if there are insufficient company policies, poor attitudes presented by the construction personnel, unsafe practices, workers with inadequate safety knowledge and training, and a poor management commitment (Sawacha *et al.*, 1999). This is further shown throughout the construction industry, by workers characterised as frequently utilising the principle that the benefits of operating safely are not as palpable as the benefits of meeting production outputs and time/cost charts (Biggs *et al.*, 2013), or that of maximum expected utility, where the benefits of safe behaviour often get outweighed by the benefits of unsafe behaviour. This is often due to a fear that the slower paced work or safe behaviour may lead to lower wages and/or penalties (Kines *et al.*, 2010). An increasing amount of the reliance for the liability of the compensation claims, for contractors within the construction industry, has been shifting over from the companies themselves to insurance companies. This shift may lead to inadequate site safety training and supervision for the workers and instead obtaining insurance (Teo *et al.*, 2005).

Communications are important in forming a safe work environment at the workplace through the exchange of information about hazards and risk control methods. Safety communications are also essential to aid in influencing attitudes and behaviours within the workplace (Vecchio-Sadus, 2007). Engaging staff in safety activities to gain cooperation and support towards the safety culture of the group is critical and effective safety communications are essential for this (Vecchio-Sadus, 2007).

A study showed, however, that only 6-16% of the verbal exchanges between foremen and the workers were related to safety (Kines *et al.*, 2010). Other studies have stated that employees will be more comfortable with engaging in safety communications when a framework for communication and consultation has been created that encourages individuals to report hazards, incidents and near misses. The studies also ratify that in order to acquire a better safety performance and a better physical safety level there should be regular talks on site, between site managers or supervisors and the on-site workers (Kines *et al.*, 2010). They also point out, that training workers appropriately also leads to improved safety performance. Organisations that exhibit positive safety cultures are often characterised by having a solid base for their communications. This base is usually trust and shared perceptions of the importance of safety. A study by Vecchio-Sadus (2007) noted that one of the drivers of safety communication is shifting safety responsibilities to others when the hazard cannot be adequately guarded. As a basis he states that in order to decrease the probability of any workplace injuries it is beneficial to have effective communication skills.

Construction Projects contain large amounts of sub-contractors on their sites at any given time. This large quantity of sub-contractors raises a concern for the construction management group in managing the process factors, in order to effectively maintain control and communication over these large numbers. It has been seen that as larger numbers of sub-contractors are presented so too are the chances of an accident occurrence (Teo *et al.*, 2005). This problem stems from the difficulty to maintain an effective communication network to and from the various sub-contractors, as there may be many levels of them, thus reducing coordination and control (Teo *et al.*, 2005).

Studies on the subject of exchanges between leaders and workers found that these interactions inspired employees to raise safety issues. Supervisory feedback and recognition were seen as one of the most influential incentives for job performance. Thus daily feedback from supervisors in relation to safety and unsafe behaviour exposed the priorities between production and safety (Kines *et al.*, 2010). Kines et al. (2010) concluded that by coaching construction foremen to include safety communications in their daily verbal exchanges with the workers that they had a positive and lasting effect on the safety levels, and thus for their safety performances.

Safety Communications Networks

This study includes some research into the communication network patterns that are present in each of the studied groups. Safety communication networks are the communication structures of a system or network (Sonquist, 1984). Communication networks identify the relationships or ties within the groups' network. This is to gain an understanding of human behaviour (Feld, 1982) with the process of mutual information exchange (Sonquist, 1984). This feature works by utilising tools, such as social network analysis (SNA), to obtain measures about the groups communicative interactions.

Social network analysis (SNA) provides a method of analysis of these safety communication network patterns. The analyses of these features vary greatly from what a traditional individualistic, variable-based approach can achieve. This is due to the traditional method of analysis calculations take into account only the individual characteristics of the subjects and ignores the broader context of interactions with the social networks connecting them to other subjects (Knoke and Yang, 2008; Sonquist, 1984). This means that the subjects are assumed to act without regard to the behaviour of the connected actors. However the connecting actors are known to influence each other through their connections (Knoke and Yang, 2008). Using SNA as a tool for the study of communication network patterns has grown considerably in the past decades (Knoke and Yang, 2008).

A notable article relating to the study of safety communication networks in the construction industry used SNA to identify the network characteristics (Alsamadani *et al.*, 2013), which have also been in this study. Another study, by Pryke (2004), studied the application of SNA with a focus on construction. This study found many benefits to the use of SNA in the appropriate study, such as the graphical representation of the analysis and also a detailed representation of the relationships that exist between actors. These studies show that SNA can be successfully implemented into the study of groups' communication network patterns within the construction industry.

The safety communication network patterns that are studied in this thesis are analysed in relation to the interconnections and the member dominance within the groups. These features are analysed using SNA as a tool to aid in the understanding of the effectiveness of these communication network patterns. All of these features have been included in a previous similar study about safety communication networks in small work crews and their safety performances (Alsamadani et al., 2013).

THEORETICAL FRAMEWORK

The construction of a theoretical framework is an important part of this study. The theoretical framework is established from the preliminary findings based on the literature review. Figure 1 illustrates the theoretical framework, which acts as the general conceptualisation and backbone for this study. It graphically depicts the constructs that are analysed within the study. These constructs are measured in order to establish the performance of these variables and enable an evaluation of their relationships (Fellows and Liu, 2008).

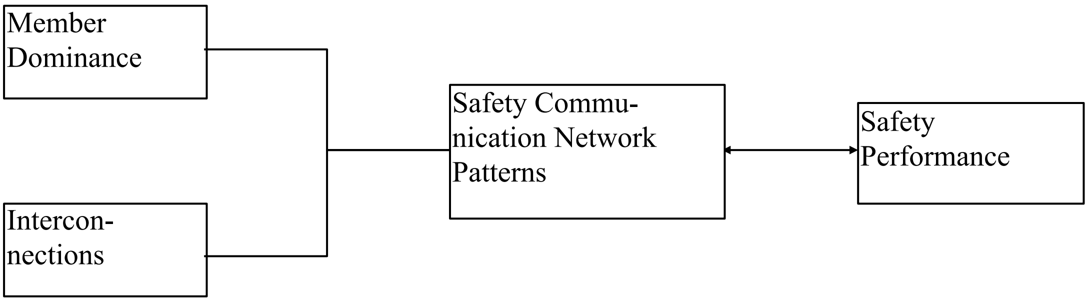

Figure 1. Theoretical Framework of relationships between safety performance and communication network patterns

The theoretical framework was developed based on a review of relevant literature, in particular, a similar study that was performed by Alsamadani et al. (2013). The framework shows the hypothetic correlative relationship between safety performance and safety communication network patterns. It also specifies that there are two types of network patterns that are useful in demonstrate such relationship: (1) there is a trend between the safety performance of a group and the interconnections of the groups' safety communication network; and (2) The safety performance of a group also displays a relationship with the member dominance of the groups' safety communication network. These trends have been the focus of Alsamadani et al.'s (2013) study, in which they identified communication network factors as important differentiators between project teams with high or low incidence rates in the US.

In the proposed framework the main connection is between safety performances and safety communication network patterns. The theory behind this proposition was given in many supporting studies (Alsamadani *et al.*, 2013; Kines *et al.*, 2010; Le *et al.*, 2014; Sawacha *et al.*, 1999; Teo *et al.*, 2005; Vecchio-Sadus, 2007; Wong *et al.*, 1999) that noted the importance of safety communications on a work group's safety performance.

RESEARCH DESIGN

The research is divided into three parts. A base knowledge around the research is compiled and constructed into a review. Data will be collected via a questionnaire survey conducted for the purpose of this study. Methods of analysis will then interpret the data. The information will then be used as evidence as to the results that are obtained with references to other studies. In this study it is proposed to use the measures of lost time injury frequency rate (LTIFR), network density, betweenness centrality, and degree centrality to measure the factors to be used in SNA and statistical analysis.

Surveys are methodical observations or interviews that ask the questions that the research wants answered. The survey that is designed for this research will be undertaken through the use of questionnaires. The questionnaires are aimed at uncovering the safety communication network patterns of the groups. To address the various methods of safety communications that can arise in the construction industry, both formal and informal communication types are considered. The formal communications model involves any safety knowledge that is shared through any pre-determined mediums. These mediums often involve written communications, formal presentations, toolbox talks, and training. The informal communications are modelled to incorporate any ad hoc communications between individual group members on site. These communications include notifying another member of a hazard while in passing without any pre-defined necessity.

The survey questionnaires for this study will be administered in person to the participants. This method of administering questionnaires is chosen to ensure that all participants of the groups complete the survey. This is important for everyone from the crew to participate. Otherwise critical participants may be missing from the data set. The survey research will be limited in this study to field-level groups consisting of field-level employees and field-level managers. Furthermore, each eligible group must work for the same employer (including contractors), in the same physical location, and working on the same project. In order to narrow the focus of the research and to avoid conflicts of interest, the research will not include the managers and or directors that are not part of the daily building team.

The questionnaire that will be used in this study has two sections. The first section of the questionnaire requests for the respondents' personal profile. Such data will be used to further determine the respondents' suitability for participation in this study. These questions involve the name of the project that the respondents are working on and their project role. The second section of the questionnaire addresses the safety communications between group members. The data will be utilised for analysing the safety communication network patterns. The data analysis will be conducted using Social Network Analysis software and techniques. This section focuses on how the individual members communicate or are communicated with and with whom. The respondents will be asked to fill in the names of the other group members and then denote the methods of safety communication with these members and the frequencies of those.

This study focuses on two types of network patterns in order to identify the relationships between safety communication network patterns of a group and their safety performance. The first type concerns the interconnections of the networks and their relevance to the safety performances of those groups. The second type relates to the trends between member dominance in the groups and their safety performances. Both of these two types of network patterns will be examined using social network analysis techniques. Correlation statistical analysis will then be conducted to reveal any significant correlative relationship between safety communication network patterns of a group and their safety performance. The proposed metrics associated with network patterns include centrality (both degree and betweenness) (associated with member dominance) and density (associated with interconnections). These metrics represent the heart of the constructs when modelling communication patterns (Alsamadani *et al.*, 2013).

Social network analysis is an analytical method that has been the topic of and used in many studies (Chinowsky *et al.*, 2008; Chinowsky *et al.*, 2010; Hartmann and Fischer, 2009; Park *et al.*, 2011; Pryke, 2012; Pryke, 2004; Ruan *et al.*, 2013; Tatlonghari *et al.*, 2012). However there have only been a few articles that have attempted to incorporate SNA into their studies of assessing the effectiveness of safety communication networks in the construction industry (Alsamadani et al., 2013; Le et al., 2014). These studies, however, where performed within the United States (US) and have not been performed to address the unique characteristics of the Australian construction industry.

CONCLUSION

The construction industry is highly regulated due to its high incidence of work-place accidents. This is especially true of smaller building companies/enterprises. This study takes the opportunity to explore the issue by proposing to analyse the communications patterns in small workgroups. It is evident through a literature review that the occupational health and safety of the members within the construction industry are considerably bad in comparison to other industries and that safety performance is often held as a lower priority on construction sites. The literature review also showed that safety communications are an important aspect to achieving a safe workplace. Safety communication network patterns have been identified as features of communication that can be assessed in terms of interconnections and member dominance. The literature on safety communication network patterns and its relation to safety performance is nevertheless minimal. Therefore, this study is aimed at determining whether there is a relationship between the safety performance of a group and the patterns of the groups' safety communication network under different communication modes. A theoretical framework is thus established and explained. A questionnaire survey will be conducted and the collected data will be analysed using Social Network Analysis techniques. The data collection and analysis is underway and will be reported separately.

REFERENCES

Alsamadani, R., Hallowell, M. and Javernick-Will, A.N. (2013) Measuring and Modelling safety Communication in Small Work Crews in the US using Social Network Analysis. Construction Management and Economics, 31(6), pp. 568-579.

Baxendale, T. and Jones, O. (2000) Construction design and management safety regulations in practice-progress on implementation. International Journal of Project Management, 18(1), pp. 33-40.

Biggs, H.C. and Biggs, S.E. (2013) Interlocked projects in safety competency and safety effectiveness indicators in the construction sector. Safety Science, 52(6), pp. 37-42.

Biggs, S.E., Banks, T.D., Davey, J.D. and Freeman, J.E. (2013) Safety leaders' perceptions of safety culture in a large Australasian construction organisation. Safety Science, 52(3), pp. 3-12.

Bust, P.D., Gibb, A.G.F. and Pink, S. (2008) Managing construction health and safety: Migrant workers and communicating safety messages. Safety Science, 46(4), pp. 585-602.

CCRT (2013) The Construction Chart Book: The U.S. Construction Industry and Its Workers, The Center for Construction Research and Training (CCRT). [Available online from http://www.cpwr.com/sites/default/files/publications/5th%20Edition%20Chart%20Book%20Final.pdf.]

Chinowsky, P., Diekmann, J. and Galotti, V. (2008) Social network model of construction. Journal of Construction Engineering and Management, 134(10), pp. 804-812.

Chinowsky, P.S., Diekmann, J. and O'Brien, J. (2010) Project Organizations as Social Networks. Journal of Construction Engineering and Management, 136(4), pp. 452-458.

Construction, F.W.B.a. (2012) Work Health and Safety. [Available online from http://www.fwbc.gov.au/work-health-and-safety-2.], accessed in 2 May 2014.

Feld, S.L. (1982) Communication Networks: Toward a New Paradigm for Research (Book Review). Contemporary Sociology, 11(2), pp. 203.

Fellows, R. and Liu, A. (2008) Research Methods for Construction, 3 Ed., Oxford: Wiley-Blackwell.

Hartmann, T. and Fischer, M. (2009) An ethnographc method to collect input data for formal social network analyses of project teams, In Proceedings of Specialty conference on governance of global project organizations, pp. 10, LEAD.

Holt, A.S.J. (2005) Principles of Construction Safety, Oxford: Blackwell Science.

Kines, P., Andersen, L.P.S., Spangenberg, S., Mikkelsen, K.L., Dyreborg, J. and Zohar, D. (2010) Improving construction site safety through leader-based verbal safety communication. Journal of Safety Research, 41(5), pp. 399-406.

Knoke, D. and Yang, S. (2008) Social Network Analysis, 2 Ed., California: Sage Publications.

Knowledge Management Branch (2010) (Ed, Wales, W. N. S.) WorkCover New South Wales, pp. 163.

Le, Q.T., Lee, D.Y. and Park, C.S. (2014) A social network system for sharing construction safety and health knowledge. Automation in Construction.

Lin, J. and Mills, A. (2001) Measuring the occupational health and safety performance of construction companies in Australia. Facilities, 19(3/4), pp. 131-139.

Loosemore, M. and Andonakis, N. (2007) Barriers to implementing OHS reforms – The experiences of small subcontractors in the Australian Construction Industry. International Journal of Project Management, 25(6), pp. 579-588.

Park, H., Han, S.H., Rojas, E.M., Son, J. and Jung, W. (2011) Social Network Analysis of Collaborative Ventures for Overseas Construction Projects. Journal of Construction Engineering and Management, 137(5), pp. 344-355.

Pryke, S. (2012) Social Network Analysis in Construction, Chinchester, West Sussex: Wiley-Blackwell.

Pryke, S.D. (2004) Analysing construction project coalitions: exploring the application of social network analysis. Construction Management and Economics, 22(8), pp. 787-797.

Ruan, X., Ochieng, E., Price, A. and Egbu, C. (2013) Time for a real shift to relations: appraisal of Social Network Analysis applications in the UK construction industry. Australasian Journal of Construction Economics and Building, 13(1), pp. 92-105.

Safe Work Australia (2012) (Ed, Australia, S. W.) Safe Work Australia.

Sawacha, E., Naoum, S. and Fong, D. (1999) Factors affecting safety performance on construction sites. International Journal of Project Management, 17(5), pp. 309-315.

Sonquist, J.A. (1984) Communication Networks: Toward a New Paradigm for Research (Book Review). American Journal of Sociology, 89(4), pp. 986-988.

Tatlonghari, G., Paris, T., Pede, V., Siliphouthone, I. and Suhaeti, R. (2012) Seed and Information Exchange through Social Networks: The Case of Rice Farmers of Indonesia and Lao PDR. Sociology Mind, 2(2), pp. 169-176.

Teo, E.A.L., Ling, F.Y.Y. and Chong, A.F.W. (2005) Framework for project managers to manage construction safety. International Journal of Project Management, 23(4), pp. 329-341.

Vecchio-Sadus, A.M. (2007) Enhancing safety culture through effective communication. Safety Science Monitor, 11(3).

Wadick, P. (2010) Safety culture among subcontractors in the domestic housing construction industry. Structural Survey, 28(2), pp. 108-120.

Wang, X., Wu, X., Abdel-Aty, M. and Tremont, P.J. (2013) Investigation of road network features and safety performance. Accident Analysis and Prevention, 56, pp. 22-31.

Wogalter, M.S., Dejoy, D.M. and Laughery, K.R. (1999) Warnings and Risk Communication, London: Taylor & Francis.

Wong, K.W., Chan, P.C. and Lo, K.K. (1999) Factors affecting the safety performance of contractors and construction sites. Implementation of Safety and Health on Construction Sites, pp. 19-24.

Zhou, Z., Irizarry, J. and Li, Q. (2014) Using network theory to explore the complexity of subway construction accident network (SCAN) for promoting safety management. Safety Science, 64, pp. 127-136.

PARTICIPATED TRAINING AS A MEASURE OF GENERAL PROTECTION AND PREVENTION OF ACCIDENTS

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The protection of workers' health has long been the subject of attention from institutions and companies. The common goal is to implement the necessary measures to minimize the risk of accidents and the spread of diseases during the course of their employment. In the Italian Consolidated Safety issued in 2008, and subsequently amended, provides companies with a complete picture of the steps necessary to ensure that workers have the best conditions of health and safety in the workplace. Is confirmed and improved the safety model in a participatory manner already in the previous legislation of 1994. The general safety measures are targeted prevention activities with the aim to intervene at the base. Among them are particularly important training, information and training of workers. The worker becomes an active, conscious and responsible in the conduct of their work in safety. The inappropriate behaviour of the employee are always the real cause of accidents in the workplace and often the training received has proved inadequate.
It presents a study conducted as part of the Master on Management of Safety in Construction Sites, held at the Mediterranean University, which allowed highlighting that the training could not be limited, as often happens, in a didactic activity. It requires the integration of dynamic phases with exercises in use of safety systems, simulation of situations of danger and emergency, etc.

Keywords: education, training, protection, prevention.

INTRODUCTION

In recent years we have had the chance to address issues about education and training of those people involved with Health and Safety in the building process.

The importance of training was addressed with the management of training processes for Safety Managers (Gottfried, 2000).

Then researches carried out in universities and in other organizations allowed us to test the educational approach directly (Laganà, Barbato, 2011).

More recently, the experience in a post-graduate master's degree for architects and engineers, in cooperation with INAIL, the Italian National Institute for the prevention of accidents at work, gave us an outlook of the new topics and guidelines for an in-depth analysis about Health and Safety at work, putting an emphasis on the multidisciplinary approach (Laganà, 2014).

The process of information begun during the university course enabled to acquire the technical know-how on occupational H&S together with the gradual acquisition of technical and cultural issues that characterise education of architects and engineers.

From physical management of H&S in building sites over the last years we learnt the need to measure with the other players involved in the project (workers, managers, etc.) whose training is set forth in the most recent national laws.

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Knowing the training pathways aiming at the involvement of workers is an important step needed to improve their lives.

My paper today features the subject of a graduation thesis on the effectiveness of training on H&S as a mean to prevent accidents at work written by arch. Simona Maio for the post-graduate masters' degree on Health & Safety in the building sites.

METHODOLOGICAL GUIDELINES

The methodological approach follows the legal provisions about training of workers in the building sector in order to spot the training pathways for each worker. Starting from the legal provisions we analysed the role played by each worker, then we highlighted the identified deficiencies by means of surveys that had been carried out in important building sites. Data collected and our remarks were updated and compared with the outcomes of the Italian national Prevention Plan.

THE PROVISIONS OF ITALIAN LAW AND TRAINING ON SAFETY

The new law (Legislative decree n. 81/2008 and its subsequent additions) clarifies immediately that information, education and training of workers are compulsory. They must be carried out in compliance with the Italian law on occupational Health and Safety that applies to all workers employed, whatever the sector.

Owing to their momentum, information, education and training must be targeted to their recipients, according to their learning skills and their cultural level. Every worker has to be enabled to acquire the know-how and the experience needed to work safely, with full awareness of his/her role and responsibilities. Workers must be trained in order to prevent accidents by adopting the right behaviours and contribute to make their workplace a safe working environment. This principle also applies to those involved in the management and enforcement of health and Safety norms in building sites.

The Italian law devotes a whole section (Sinardi, 2009) to information, education and training (Title I, Chapter III, Section IV); in art. 36 and 37 it sets forth the employer's obligations, which can be summarised as follows:

- **Worker information,** i.e. *"those activities aiming to provide the know-how useful to identify, reduce and manage risks at work"*.

- **Education of workers and their representatives,** i.e. *"the educational process whose purpose is to convey workers those know-how and procedures useful to acquire skills to carry out safely their tasks and to identify, reduce and manage risks"*.

- **Training**, i.e. *"those activities aiming to teach workers how to safely use equipment, machineries, plants, substances, devices, PPEs and working procedures"*.

Worker information must provide workers with the proper know-how about:

- Risks for occupational health and safety arising from the company operations

- Specific risks arising from his/her exposure to dangerous substances ore the use of equipment or machines

- First aid procedures, firefighting, and evacuation of workplaces

- The names of those workers charged with the enforcement of measures for emergency management

- The names of Safety Officers and of the company physician

- Safety regulations and corporate health and safety policy

The content of information has to be readily understandable so that workers can learn without difficulties. A particular attention must be paid to migrant workers, who can receive information after having ascertained their fluency in the language used in the information process.

Education of workers and their representatives must provide them with know-how about:

a) Concepts of risk, damage, prevention, protection, organization of prevention at corporate level, rights and duties of workers, supervisory bodies;
b) Risks arising from tasks and the resulting damages and the consequent preventative measures pertaining to the sector in which the company operates.

In order to be effective, the training process must:

-Analyse the original context and the educational needs on safety in order to set the goals we want to achieve
-Ask experts who know the company and the education methods available to plan the intervention
-Provide the training according to the ways set forth by the training project
-Evaluate the learning outcome paying particular attention to the behavioural changes of attendees.

Because of its practical character, training must be provided by an expert and on site. It aims at teaching the proper use of equipment, machines, plants etc. It must also foresee a practice session about the specific equipment the worker will use in his/her daily activity. Training is conceived as a path in which workers do simulate operational situations they will face at work.

It is made up of several tests that bring workers closer to the real operational conditions and enable him/her to cope safely even with the unexpected situations.

As far as technicians are concerned, namely the coordinator for safety and health matters at the project preparations stage and the coordinator for safety and health matters at the project execution stage, the training course is shaped in four modules:

- 1) Legal aspects (28 hours)

  Fundamentals of occupational safety and hygiene, legislation on contracts concerning occupational health and safety, legislation on insurance against accidents at work and occupational diseases, EU regulations and their enforcement, code of practice, product directives, the Consolidated law on health and safety at work, the corporate prevention system, its task, its duties and its civil and criminal liabilities; methods to identify, analyse and assess risks; the specific regulations concerning health and safety in temporary or rolling building sites and in work at a height; people involved in the construction work: tasks, duties, civil and criminal liabilities; the framework act on public works and the main decrees implementing the laws; penalty rules and inspection procedures.

- 2) Technical aspects (52 hours)

Risks of fall from height; scaffolding and temporary structures; organisation of safety in the building site; time schedule of works; documentation rules applying to developers, contractors, coordinators for safety; occupational diseases and first aid; the different kinds of risks in the building site; PPEs and safety signs.

3) Methodological and organisational aspects (16 hours)

The minimum content of the safety plan, the substitutive safety plan and of the operational safety plan; the methodological criteria for drawing the safety plan and its integration with the operational safety plans and the safety case; the drawing of the safety case; the drawing of the operational safety plan, the drawing of scaffolding assembly, use and dismantling plan; the estimate of safety-related costs; communication techniques aiming at problem-solving and cooperation; theories for group management and leadership; relationships with developer, planners, works management, workers' safety representatives.

4) Practical aspects (24 hours)

Examples of Safety and Coordination Plan; presenting the project, discussion about the analysis of area-related risks or those arising from the organisation of the building site, its operations and their interference; drawing Safety and Coordination plans making reference to the risks related to the area, the organisation of the building site, its operations and their interference; examples of Operational safety plans and substitutive safety plans; examples and drawing of the safety case based on the same examples used for the safety plans risks; role-play as coordinator for safety and health matters at the project execution stage.

TRAINING: GOALS, CONTENTS AND METHODS

The Italian Consolidated Law on Safety entrusts the *Conferenza permanente per i rapporti tra lo Stato-Regioni*, a body composed by representatives of Ministry of Labour and Social Policy, Ministry of Health and Ministry Of Regions and Autonomous Provinces, the task to set the duration, the minimum contents and the methods of training.

On December 21, 2011 it approved the agreements on training courses to be carried directly carried out by employers, in particular those concerning risks prevention and protection and workers training. On February 22, 2012 it approved the agreement concerning those work equipment for which workers need a specific qualification. Innovation in training courses was the outcome of the guidelines derived from the National Prevention Plan for the Building Sector 2008-2010, prepared by the Coordination body for regions and implemented in cooperation with INAIL, the Ministry of Labour and Social Affairs. In the contents of the Plan there were indications that training about safety was often abstract and far from the daily working lives. It aimed at showing that it did teaching work but more than having brought and assessed the learning it conveyed.

The two agreements of December 21, 2011, which norm the contents and the methods concerning one of the main employer obligations on safety (i.e. training) must determine the general concept of *"suitable and sufficient training"* (Meggiato, Spiazzi, 2012).

AGREEMENTS SIGNED BETWEEN THE ITALIAN GOVERNMENT AND THE REGIONS OF ITALY	INDIVIDUALS TO BE TRAINED	ENTRY INTO FORCE
December 21, 2011	Workers, supervisors and managers	January 26, 2012
December 21, 2011	Employer who carries directly out the task of Officer for prevention and protection.	January 26, 2012
February 22, 2012	Workers using work equipment requiring a suitable qualification (e.g. platforms, lift trucks, cranes, excavators, etc.)	March 12, 2013

Table 1 - Minimum length of training

Agreement between the Italian government and the Regions of Italy signed on December 21, 2011

Training under this Agreement is the one set forth in Title I of the Legislative Decree n. 81/2008.

The Agreement stipulates that:

- Training can occur in classroom or on site or via e-Learning platforms;
- Training courses for workers must be carried out in cooperation with bilateral bodies and paritarian institutions, if any, to be found in the communities and in the sector in which the company operates

The training course includes two different modules:

• A **general training module**, provided to all workers, which lasts at least 4 hours and is devoted to a general introduction to topics concerning prevention and safety at work, id est:

- Concepts of risk
- Damage
- Prevention
- Protection
- Organization of prevention at corporate level
- Rights, duties and penalties for the different corporate positions
- Supervisory bodies

This module is a permanent training credit.

• A **specific training module**, which deals with the specific tasks and whose length varies according to the risks related to the operations, the resulting damages and the consequent preventative measures in force in the sector in which the company operates, as defined in ATECO 2002 and 2007 classification in the tables of Annex II:

- 4 hours for the sectors listed in low-risk category
- 8 hours for the sectors listed in medium-risk category
- 12 hours for the sectors listed in high-risk category

All workers, in spite of the risk category, must attend every five years a six-hours refresher course.

RISK LEVEL	GENERAL TRAINING	SPECIFIC TRAINING	TOTALE
LOW risk	4 hours	4 hours	8 hours
MEDIUM risk	4 hours	8 hours	12 hours
HIGH risk	4 hours	12 hours	16 hours

Table 2 - Minimum length of training

The contents, the risks dealt with and the length of the training courses must be planned on the basis of the risks assessment made by the employer. Therefore training courses must be planned keeping in mind the risks you can run in the sector in which the company operates and according to the activities each worker carries out.

The agreement aims at favouring an interactive approach in providing training courses, which puts workers with their skills and competences at the heart of the training pathway. Moreover it proposes some learning methods based on problem solving, by means of demonstrations, simulations, practical session and teamwork. Frontal lectures must alternate with practical sessions within the set amount of hours.

As far as the building sector is concerned, for new entries in this industry training carried out within the framework of the structural project "16 ore-MICS" as set forth by FORMEDIL, the Italian national body for vocational education and training in the building sector, is acknow-howd as corresponding to the general training as stated in the Agreement (Carapella, 2012).

Agreement between the Italian government and the Regions of Italy signed on February 22, 2012

It concerns the training of workers about the specific risks that can be found in the company operations, related to particular tasks or equipment, for which the Legislative Decree n. 81/2008 in its art. 37 point 3, expressly foresees additional and targeted training pathways. Education and training about particular risks are going to supplement the general training governed by that agreement.

Therefore the additional training will deal with:

- the use of specific work equipment;
- the use of equipment for work at a height, scaffoldings assembly and dismantling;
- workers exposed to asbestos dust.

This agreement aims at training workers using dangerous work equipment, as identified in the Annex A. This specific training is not included in the amount of hours of compulsory training as required by art. 37.

The equipment covered by the agreement is:

a) mobile elevating work platforms;

b) cranes;

c) lift trucks with driver on board;

d) agricultural or forestry tractors;

e) heavy equipment;

f) concrete pumps

The different training pathways are aiming at learning suitable operating techniques in order to use work equipment safely. They are organised in theoretical and practical modules whose contents, length and intermediate or final checks are identified in Annex III of the agreement according to the kind of equipment.

Demonstrations and practical tests are very important as well as simulations and autonomous management of equipment carried out in safe areas. The maximum number of participant per course is 24; every 6 attendees there's s trainer available.

Additional specific training for supervisors and managers.

Employers must provide supervisors and managers with a suitable and specific training and regular refresher courses related to their responsibilities as far as occupational health and safety are concerned.

Supervisors, who according to the Consolidated law are "*those supervising the work and ensuring the implementation of the instructions received, by controlling the proper execution by the workers and exercise his/her right of initiative"* must attend an additional training as well as the 8-hours training for common workers. It deals with the identification of risk factors, communication and awareness-raising techniques, the performance of duties involving the control of compliance with legal provisions on health and safety at work.

The Agreement sets forth that managers must attend a 16-hours training course, which is structured in four modules:

- legal and regulatory aspects
- safety organisation and management
- risks identification and assessment
- Communication, workers training and consultation

At the end of both training courses, which workers must attend for at least 90% of the hours amount, there's an interview to test learning. The certificate of attendance is a permanent training credit, unless the holder moves to another sector.

TRAINING COURSES IN BUILDING SECTOR

Basic training course for workers: 16 ore prima

"*16ore prima*" is an important innovation introduced in collective work agreements (Edili Industria, Edili Artigiani, Edili PMI, Edili Cooperative) signed in June-July 2008 (Calzoni M., Tombari C) and confirmed on December 16, 2011. All workers who enter for the first time in the building sector they propose a training course on safety aiming at a quality work. It offers support and coaching services for professional development, and identifies training as a strategic resource to improve safeguard of workers in one of the most risky sectors.

Introductory vocational training for building sector is intended to learn how to move in the building site in a rational and proper way and the good work procedures, i.e. work safely. This project aims at linking vocational training to training on safety issues, staring from the awareness that the adoption of safe and careful behaviours is one of the essential components of productive work. As a matter of fact, capacity building is the starting point and the real core of this course that lasts 16 hours.

The course teaches practically how to work well and safely those activities entrusted to each worker upon the first employment in the building site. Beside that, it conveys the basic contents of the prevention of risks for health and safety at work. A stiff training on safety is not suited to the needs of somebody working in a building site. It is important to foster his/her problem solving skills so that they become a rooted habit aimed at embed prevention and personal attention to a safe way of working.

Thus we are looking for a new approach to training on safety, which stems from the awareness that training courses carried out in the last years were not so effective. Often it was a formal training, more careful to the transfer of legal notions (laws, technical standards, etc.) than to the adoption of safe behaviours. Often what had been taught did not translate in a real learning.

According to the contractual innovation, starting from January 1, 2009:

a) Construction companies committed to communicate well in advance the hiring of each worker entering in this sector for the first time, at least 3 days before his/her arrival at the building site. This communication must be sent to the local branch of construction workers' social security fund, which on its turn will forward it to the local building craftsmen school.

b) The local building craftsmen school will summon the worker to attend a 16-hours training course concerning the fundamentals of construction work and safety training.

The training course *16oreprima* allows complying with the obligations set forth in art. 37 of the Legislative Decree 81/08 and its successive additions, in a qualified way and free of charge. Introductory training is provided before the beginning of employment therefore it's not an economic or organisational burden for the company. At the end of the training course the worker gets a training certificate showing that he/she complied with the legal provision concerning training.

The attendance of the 16-hours course includes also the 8 hours required by art. 87 and 110 of the Collective work agreement related to the first employment in the sector.

It does not include the compulsory training expected in case of a change of position, or the use of new equipment, technologies, and dangerous substances. In this case applies the contractual provision of an 8-hours training course during working hours, which can be provided by the company or the building craftsmen school.

Qualification courses for the use of specific machines or equipment

Among the employer obligations, the Legislative Decree 81/2008 in its art. 71 clarifies that if the work equipment needs particular know-how or responsibilities related to their specific risks, they must be used only by qualified workers who must have been previously provided with suitable and specific information, education and training related to the safe use of the equipment.

In the meeting of the State-regions conference on February 22, 2012 they laid down an agreement on training about work equipment or better the identification of that equipment requiring a specific qualification of its operator as well as the methods to acknow-how that qualification, the trainers, the length of the training course, the guidelines and the minimum requirements of its validity under art. *73, point 5* of the Legislative Decree n. 81/08.

a) This agreement aims at training workers using dangerous work equipment, as identified in the Annex A in which you find a list of equipment covered by the agreement (mobile elevating work platforms, cranes, lift trucks with driver on board, agricultural or forestry tractors, heavy equipment, concrete pumps). The different training pathways are aiming at learning suitable operating techniques in order to use work equipment safely. They are organised in theoretical and practical modules whose contents, length and intermediate or final checks are identified in Annex III of the agreement according to the kind of equipment. Demonstrations and practical tests are very important as well as simulations and autonomous management of equipment carried out in safe areas. The maximum number of participant per course is 24; every 6 attendees there's s trainer available. Teachers must have a proven experience in training and in health and safety at work as well as a documented practical experience in the use of the equipment.

The training credit and the acquired qualification for having attended the course have a five-years validity. Then workers are compelled to attend the 4-hours refresher course.

Training courses for safety trainers

With the Interministerial Decree on March 6, 2013 published on the Gazzetta Ufficiale della Repubblica Italiana n. 65 on March 18, 2013 were reflected the criteria for the health and safety trainers' qualification identified by "Standing Advisory Commission on Health and Safety at Work" under art. 6, point 8, lett. m-bis) of Legislative Decree 81/08 and its subsequent additions.

This course is intended to develop professional skills enabling its attendees to work on the Italian scene since they got in-depth know-how to work as occupational safety trainer. The course aims at creating professionals who can enter the job market and deliver what required by the Consolidated Law on safety.

QUALITY AND EFFECTIVENESS OF SAFETY TRAINING

The provision of training courses to workers, besides being compulsory, it's something important although it does not guarantee that they are completely safe and that risks of accidents have been eliminated. A trained worker is influenced in his/her behaviours at work by several factors that are more crucial than what he/she learnt in classroom. These crucial factors are; the working environment, the behaviours of his/her managers or colleagues, corporate habits and the overall organisation of work.

We know - how the importance of workers at work in their individual aspects (skills, physical features, attitudes, capabilities) as well as in their social aspects (atmosphere in working groups, relationship among workers, organisational culture, etc.). Training is without any doubt important but alone it is not enough to bring a change in behaviours.

It is useful for the sake of know-how, to know methods, procedures, regulations, but alone it does not spur workers to act according to the messages they have got. It is not crucial for a change of workers behaviour that, instead, is influenced by the working environment and the behaviours of his/her managers and colleagues. The more rooted safety culture is in managers, the easier the promotion of safe behaviours within the company. Workers and partners assess the importance the company gives to the protection of health according to the coherence and the seriousness it implements and complies with safety provisions. Everybody in the company and in the building site must adopt suitable behaviours, being careful to their own safety while protecting others' safety. During their activity workers must work following the suitable procedures, above all when dealing with machines, use PPEs and cooperate for the management of corporate safety by means of their skills and their character.

CONCLUSIONS

The role of training in safety management must aim at modifying those unsafe behaviours and enhancing the good ones. Training must embed in technical and organisational provisions. Training activities have to convey know-how and information; in addition they must succeed in impacting on some determinants such as risk perception and risk awareness, risk management and safety obligations. In doing so, safety training will not only improve professional skills related to the different tasks but it will develop cross-functional skills (how-how vs. self-management). This will cover the ability to learn from situations, communicate, make a decision, know one's limits, and share one's know-how and skills. It is therefore imperative to identify and strengthen cross-functional skills since they favour the ability to pick up danger signs and spot dangerous situations, thus facing critical situations in the most suitable way.

Training therefore cannot just be confined in frontal lectures but needs to be supplemented by experience. It must be related to one's own risk perception, by means of practice on the use of safety systems, simulations of dangerous situations at work, teamwork and debates.

These aspects must be taken into account in planning and implementing training courses.

Only then safety culture can be considered a skill built on social principles, originating working and organisational procedures that protect health of an individual and the benefits to society.

REFERENCES

Gottfried, A. (2000) Education and training in the building process and integration of safety disciplines: The Italian experience, "Designing for Safety and Health Proceedings", London.

Calzoni, M., and Tombari, C. (2008) Sicurezza in cantiere. L'innovazione contrattuale a tutela di tutti i nuovi accessi. Prima dell'ingresso in cantiere 16 ore di formazione, www.ambientesicurezza.ilsole 24ore.com.

Di Giuda, G. M. (2011) Progettazione e Gestione della Sicurezza nei Cantieri Edili, Milano.

Laganà, R. and Barbato, M. (2011) University Experiences in the Training of Safety Managers, "Prevention - Means to the End of Construction Injuries, Illnesses and Fatalities", Proceedings of CIB W099, Washington DC.

Laganà, R. and Barbato, M. (2011) Training as first step towards prevention: our experiences in training workers employed in road constructions in South Italy, "Prevention - Means to the End of Construction Injuries, Illnesses and Fatalities", Proceedings of CIB W099, Washington DC.

Meggiato, C. and Spiazzi M. (2012) Sicurezza sul lavoro: la formazione dei lavoratori, dei preposti, dei dirigenti e dei datori di lavoro, w.ww.unindustria.treviso.it.

Strazzeri, C. (2012) Guida completa alla Formazione per la Sicurezza sul Lavoro, www.asso231.i.

Sinardi, G. (2009) I piani formativi in materia di sicurezza e salute nei luoghi di lavoro.

CPT Bergamo (2011) Special issue dedicated to Training, Newsletter n° 07, www.cptbergamo.it

Carapella, G. (2012) I progetti di Formedil sul tema della Prevenzione per gli organismi bilaterali, in "Piano di Prevenzione in Edilizia. Un programma di azioni per costruire cantieri sicuri". Suppl. Ambiente e Sicurezza, 19 dicembre.

Tombari, C. (2011) Il progetto 16 ore – MICS. Nuovi criteri e metodologie per una adeguata formazione, in “Piano di Prevenzione in Edilizia. Un programma di azioni per costruire cantieri sicuri”. Suppl. Ambiente e Sicurezza, 19 dicembre.

Soeiro, A. and Silva B. & Barkokebas B (2014) Prevention guide for designers based on analysis of about 2000 accident - Proceedings of CIB W099 International Conference “Achieving Sustainable Construction Health and Safety” 2-3 June Lund University, Sweden.

Laganà, R. (2014) Professional University Training For The Safety Engineer, in “Sustainable Solutions in Structural Engineering and Construction” Edited by Chantawarangul, K., Suanpaga, W., Yazdani, S., Vimonsatit, V., and Singh, A., ISEC Press.

AN IMAGE-BASED TOOL FOR WORK HEALTH AND SAFETY (WHS) RISK PERCEPTION COMMUNICATION

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Risk perception is an antecedent to the conceptualisation of a risk control strategy. If project stakeholders do not perceive risks in a similar way, it is likely that they will have disagreement about how risks should be controlled and /or the adequacy of strategies developed to control these risks. If the disagreement is not understood and remains unresolved, the effectiveness of the strategies implemented for work health and safety (WHS) risk management would be hindered. It is important that WHS experiences and perceptions of all relevant project stakeholders be communicated and considered in decision-making. This would give rise to more comprehensive and accurate assessments of WHS risks. This paper introduces a practical image-based tool that can be used in a workshop to engage relevant project stakeholder groups to discuss WHS risks inherent in design and construction processes, and bring to light the different ways that project stakeholders think about WHS risks. The communication process would enable project stakeholders to understand WHS risks from other project participants' perspectives and inform the development of more equitable and effective risk management strategies in a construction project. This paper demonstrates the timing and procedures to use the image-based tool, the techniques to effectively engage project stakeholders into a consultative process and the approaches to document the discussion outcomes.

Keywords: risk perception, communication, image-based, tool, project stakeholders

INTRODUCTION

The role of risk perception in risk management

The concept of risk perception is theoretically grounded in social science approaches to risk, which claim that the understanding of risk is subjective in nature and is shaped by various psychological, social and cultural factors (Renn, 1998). Social science approaches to risk challenge the conventional technical approaches to risk, which suggest that risks associated with an activity or a system can be objectively assessed by technical experts using scientific methods (e.g. mathematic modelling). The outcome of the technical risk assessment normally is a statistical index or values in terms of probability and magnitude. However, researchers argue that technical approaches to risk analysis can never be entirely objective (Lingard and Rowlinson, 2005). This is because the assumption underlying

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the technical approaches is that all causal paths to an event can be identified and statistically modelled, which is unlikely to eventuate due to the complexity inherent in the interplay of social and technical systems (Lingard and Rowlinson, 2005). Also, risk assessment activity cannot be totally value-free (Pidgeon, 1998; Renn, 1998). The way technical experts characterise, measure and interpret risks is a reflection their own values (Renn, 1998). The risk judgements of technical experts are also subject to various explicit or implicit assumptions associated with membership of the social group that the technical experts belong to (Lingard and Rowlinson, 2005). For example, Zhang et al. (2014) found safety professionals rated the levels of WHS risks associated with constructing various façade systems higher than other professional groups due to their high risk sensitivity developed from their professional training and on-site role.

Social science approaches to risks maintain that risk perceptions are the outcome of the interplay between '*people's beliefs, attitudes, judgements and feelings, as well as the wider cultural and social dispositions they adopt towards threats to things that we value*' (Pidgeon, 1998; p. 5). Social science approaches to risk are characterised by descriptive analyses (Lingard and Rowlinson, 2005). Two main schools of thought are adopted by social science researchers to study people's risk perceptions:

- The psychological approach, which examines individual perceptions of risks and identifies perceived qualities of riskiness to explain individual risk judgements (Holmes et al. 1998). Researchers use psychometric procedures to measure people's attitudes toward risks and associated risk qualities (see for example, Fischhoff et al. 1978, Slovic 1987). Examples of risk qualities that shape the way people think about risk include *knowledge about risk*, *immediacy of effect*, *control over risk*, *newness*, *chronic-catastrophic*, etc. (Fischhoff et al. 1978).The underlying assumption is that the risk judgements are initiated by qualitative decisions made in relation to those risk qualities.
- The social approach, which assumes that meanings of risk are socially constructed within social groups, and people's risk perceptions are deeply influenced by wider social and cultural contexts (Holmes et al. 1998). Therefore, conflicting risk perceptions between individuals may not necessarily arise as a result of different individual psychological processes, but reflect more fundamental value commitments associated with particular groups (Pidgeon 1998). A social approach can be adopted to examine similarities and differences between social groups' understandings of risk and explore how social contexts determine and construct meanings of risk.

The understanding of social science approaches to risk indicates that technical risk analysis only represents part of what individuals and society experience as risk, and only provides a narrow framework which should not be regarded as the only criterion for risk identification, evaluation and management (Renn, 1998). It is important to complement technical risk analysis with social science approaches to reveal the risk concerns and experiences that may be otherwise dismissed or ignored by technical risks analysis. This is not a critique that technical risk analysis is not useful. Technical risk analysis provides the most available knowledge about the damage empirically associated with a possible action (Renn, 1998). However, the investigation of people's risk perceptions helps to identify the areas of concerns for technical risk estimates, which ultimately improve risk communication among technical experts, relevant stakeholder groups and decision makers. Considering risk perceptions in risk management provides an opportunity to link professional accuracy with the criteria of social adequacy and fairness (Renn, 1998).

The need for risk perceptions in construction WHS

There has been increasing awareness of the role of risk perception in construction WHS management. For example, through qualitative interviews, MacDonald (2006) found that site managers rarely rely on written risk assessment to make safety decisions. They respond to risks largely through their risk perceptions. MacDonald (2006) appealed that there should be more research into how risk perception and safety management processes actually affect construction project safety.

The construction industry is complex with multiple stakeholders involved. Given that the way people perceive risks is shaped by various technical, psychological, social and cultural factors, different project stakeholders may use different criteria to judge WHS risks and develop different understandings of WHS risks (Zhang et al. 2014). The construction industry is also highly fragmented. Project decision makers are usually organisationally and spatially distal from site-based production. They are also expected to make decisions about the implementation of WHS risk management strategies based on their WHS risk assessment before the commencement of the construction stage. In a fragmented project environment, decision makers are likely to make WHS-related decisions without considering the WHS perspectives of other relevant stakeholder groups (e.g. those involved in the construction or subsequent stages). It is possible that the nature and magnitude of WHS risks perceived by project decision makers are different from what is perceived by other stakeholder groups.

Risk perception is the antecedent to the conceptualisation of a risk control strategy, i.e. risk perceptions provide sensory cues to individuals, who then cognitively process the sensory cures, and decide the response to the cues by applying decision-making rules (Surry, 1979). The discrepancy between project stakeholders' perceptions of WHS risks therefore may lead to subsequent disagreement about how WHS risks should be controlled and/or the adequacy of strategies implemented to control these risks. If the disagreement is not understood or remains unresolved, the effectiveness the strategies implemented for WHS risk management would be hindered. For example, Hallowell (2010) found that managers and workers of construction companies have vastly different perceptions about what is an acceptable WHS risk. The safety rules and policies of the companies only reflect managers' WHS visions without addressing workers' WHS risk concerns. This leads to the outcome that workers constantly violate the safety rules and policies which they do not trust. It is important that WHS risk perceptions of different stakeholders be integrated into construction WHS risk management to achieve equitable and satisfactory WHS risk control outcomes.

A multidisciplinary approach to WHS management

The importance of risk perception suggests that a multidisciplinary approach be used to manage WHS risks in the construction project environment. All relevant stakeholders, who could impact WHS or whose WHS could be impacted by decision-making, should be involved in a consultative process to identify the various criteria for WHS risk judgement. As noted above, the failure to address important parties' risk concerns may lead to the ineffectiveness of risk control strategies. All relevant parties' WHS risk perspectives and experiences need to be communicated and considered in the risk evaluation process to achieve equitable and satisfactory WHS risk control outcomes. To identify those perspectives and experiences and address them in project decision-making, a risk perception communication process facilitated by a platform where all relevant stakeholders can be involved in intensive dialogue and mutual social learning is arguably needed (Renn, 1998). This paper will introduce an image-based tool that is being developed to engage project stakeholders in a consultative process to identify and communicate their WHS risk concerns and experiences.

THE IMAGE-BASED TOOL

Images are effective and straightforward in representing a construction scenario, yet can maintain the richness of information needed to assess WHS risks (Zhang et al. 2013). A workshop facilitated by the image-based tool presents an opportunity to engage relevant project stakeholders to discuss the criteria they use to judge WHS risks inherent in design and construction process, and bring to light the different ways that stakeholders think about WHS risks. The communication process would help stakeholders to understand WHS risks from other project participants' perspectives and help to integrate WHS considerations into upstream project activities in the design and planning stages. The communication process would also inform the development of more effective WHS risk management strategies, which address the WHS risk concerns and WHS risk experiences of all project participants.

A workshop facilitated by the image-based tool can be conducted by the following procedures:

- develop an image-based tool and related instructions,
- identify relevant project stakeholder groups for the workshop,
- instruct the stakeholders to make risk judgements according to relevant instructions,
- engage the stakeholders in a consultative process to discuss their risk judgements and evaluation criteria,
- document the discussion arising from the workshop, and
- discuss the implications of the different WHS risk perceptions for achieving effective and equitable risk control.

The workshop would have the highest impact if it is conducted in early project stages, including:

- The conceptual design review stage, during which fundamental changes can be made
- The detailed design review stage, during which risks could be reduced/eliminated through design changes

The workshop would also be beneficial in circumstances where there is a design change. Relevant stakeholder groups can be identified and engaged to discuss the corresponding changes in WHS risk control strategies.

APPLICATION OF THE IMAGE-BASED TOOL – AN EXAMPLE

The development of an image-based tool and instruction

The image-based tool comprises images depicting a wide range of construction methods, which by implication present WHS risks of different natures and magnitudes. In the example, eight photographs depicting commonly used construction methods for façade systems were developed. Each photograph shows the façade panel as well as its installation method (see examples in Figure 1). The description of the eight photographs is provided in Table 1.

The nature of the images could and should be tailored to suit specific construction contexts or purposes. For example, images can be selected to represent:

- alternative conceptual designs for buildings,
- alternative construction processes for a building system,
- different construction methodologies for building elements (e.g. roof, façade, structure), or
- different construction methodologies for infrastructure projects (e.g. bridge, tunnel).

Although this paper has focused on photographs, the tool could work equally well with sketches, animations, 3D models or any other visual medium.

Figure 1: Examples of photographs in the prototype image-based tool

Table 1: Photograph codes and descriptions

ID	Descriptions
F01	Precast concrete panel system for housing
F02	Precast concrete panel system for car park
F03	Concrete and window panel façade system
F04	Full storey prefabricated façade system
F05	Glazed panel façade system
F06	Mixed glass and concrete panel façade system. Note: concrete sections covered by glass panels
F09	In-situ RC walling
F10	Concrete block wall façade system

The tool also comprises a grid with a rating scale to facilitate project stakeholders' WHS risk judgements. Project stakeholders would be instructed to 'sort' the images into the grid according to their judgements of how safe the construction processes of the depicted façade systems would be. Table 2 illustrates the grid, which consists of five columns ranging from 'Safest' to 'Least safe'.

Table 2: Example of sorting grid

Safest	Safe	Moderate	Unsafe	Least safe

Other methods of rating the images can also be used in specific contexts. For example, stakeholder groups could be requested to make judgements about:

- the likelihood of accidental injury arising during the course of the construction process depicted in each image,
- the severity of consequence should an accident occur, and
- the duration of exposure to WHS risks.

Identify relevant stakeholders

Relevant stakeholders, who could impact WHS or whose WHS could be impacted by project decision-making, should be engaged in the workshop. The potential stakeholder groups involved in the workshop would include clients, architects, design engineers, work health and safety professionals, construction managers, facility managers, construction engineers, sub-contractors/ trades, and suppliers.

In the example, four groups of stakeholders were identified, i.e. architects, design engineers, occupational health and safety (OHS) professionals, and constructors. The four groups have the most impact on or are most influenced by WHS risks implicit in the project decision-making.

Instruct the stakeholders to make WHS risk judgements

WHS risk judgements can be assessed on an individual or a group basis, which depends on the number of participants attending the workshop. In the example, participants were presented with images, and were requested to sort the images into a printed grid on an individual basis. The participants were asked to get familiar with the images first and then sort the images. Figure 2 shows an example of the sorting pattern illustrating the judgement of WHS risks associated with constructing the depicted façade systems.

Table 3 illustrates the examples of WHS risk judgements made by four participants representing four stakeholder groups. The examples are from the data set collected for the second phase of a five-year bench marking research project, which aimed to compare the risk perceptions of different construction project stakeholder groups. The sorting patterns indicate that the participants sorted some images similarly (e.g. F09) but rated some images differently (e.g. F10).

Figure 2: An example of an image sorting pattern

Table 3: WHS risk judgements of four participants

Participants	WHS Risk Judgements				
	Safest	Safe	Moderate	Unsafe	Least safe
Design engineer		F02	F06	F09	
		F01	F05	F10	
		F04	F03		
Architect		F01	F09	F04	
		F10	F02	F06	
				F03	
				F05	
OHS professional			F02	F10	
			F01	F09	
			F04	F03	
			F05	F06	
Constructor		F10	F03	F09	
		F05	F06		
		F04	F02		
			F01		

Engage stakeholders into a consultative discussion process

The workshop facilitator would then use open-ended questions to explore what WHS risks participants perceive to be represented in the images and what evaluation criteria that participants use to make risk judgements. Sample open questions could include:

- Could you please explain what WHS risks you see in these images?
- Why do you think the systems depicted in these images are safer than the systems depicted in other images?
- Why are these images rated safest?
- Why are these images rated least safe?

The questions may be subject to change to suit different contexts and purposes. The workshop facilitator could also use probing questions to elicit the underlying reasons.

Table 4 lists the evaluation criteria used by the participants, who sorted photographs as shown in Table 3, to judge the level of safety associated with constructing the façade systems. There is much variation in the WHS risk evaluation criteria used by participants of different stakeholder groups. The variation is useful to understand so that different perspectives or factor affecting WHS can be understood by all parties.

Table 4: Summary of participants' explanation

Participant	WHS risk evaluation criteria	Example quotation
Design Engineer	Construction method in terms of process (off-site manufacture reduces on-site processes versus in-situ construction involves many processes)	*'F09/F10 lots of things happening, material and elements might fall over'*
	Work level (at low level versus high level)	*'F05 Mainly height'*
	Complexity of construction methodology (Single or multiple systems/trades)	*'F06 The fixing might go wrong, element might fall'*
	Location of installation (inside versus outside)	*'F04 They do it from inside, there is minimal risk'*
	Component handling method (machinery handling versus manual handling)	*'F02/F01: Everything is done by crane, there is less handling involved'*
	Distance (separation) between plant/load and workers/ working platform	*'F03 Crane and scissor lift used'*
Architect	Density of installation process (Repetitive processes with small panel size versus less processes with large panel size)	*'F09 large formwork frames put in place and pour concrete from top instead of installing small panel by panel'*
	Work level (at low level versus high level)	*'F01 F10, small scale work, and less high involved'*
OHS professional	Density of installation process (Repetitive processes with small panel size versus less processes with large panel size)	*'F10 and F09 Manual intensive process with small components'*
	Construction method in terms of process (off-site manufacture reduces on-site processes versus in-situ construction involves many processes)	*'F01, F02: Prefabricated system, less manually intensive; better systems of working at height in terms of falls '*
	Construction method in terms of work at height (off-site prefabrication reduces work at height while in-situ construction involves long duration of work at height)	
	Complexity of construction methodology (single or multiple systems/trades)	*'F04 and F05: one system, simply just involve one contractor, less people involved'*
Constructor	Work platform (scaffolding versus mechanical elevated work platform)	*'F10 Good coverage with scaffolding, reduce the likelihood'*
	Location of installation (install from inside versus from outside)	*'F05 F04 Work inside the building'*
	Types of building construction (domestic versus commercial)	*'F01 Precast, domestic industry less experienced with precast, less trained people'*
	Interaction of manual handling and machinery lifting	*'Trip hazards, sharp objectives, manual handling would be difficult as well'*

Document the discussion results

It is likely that similarities and differences in WHS risk perceptions and judgements will be observed in multi-disciplinary project teams. The discussion outcomes could be aggregated across each stakeholder group and documented in a way to help participants to understand:

- what are the salient evaluation criteria used by each stakeholder group to judge WHS risks,
- whether the stakeholder groups use any similar criteria to judge WHS risk,
- how different are the criteria used by different stakeholder groups to judge WHS risks.

Discuss the implication of the different WHS risk perceptions on integrating WHS considerations in design and planning stage

The workshop facilitator could then use a brain-storming session to engage participants to openly discuss the implication of the different WHS risk perceptions on integrating WHS considerations in design and planning decision-making. The workshop facilitator could lead the participants to discuss issues such as:

- what WHS risks could be reduced/eliminated if the different risk perspectives are acknowledged in design and planning activities?
- how WHS risks could be reduced/eliminated by various design chances or options?
- what would be the most effective risk control measures should some risks not be eliminated?

The discussion process could potentially be very useful in design review meetings for a construction project because the discussion outcome would inform the development of a more comprehensive WHS risk assessment and the selection of related effective risk control strategies.

CONCLUSIONS

A workshop facilitated by the image-based tool provides a good opportunity to elicit the differences in ways of perceiving WHS risks between stakeholder groups. These differences can help to identify biases, misperceptions and different experiences or concerns in relation to WHS risks. It is recommended that all stakeholder groups who could impact WHS, or whose WHS could be impacted by project decision-making, are engaged in a consultative process to explore each other's and their own WHS risk judgements and evaluation criteria early in the construction project life cycle. Through communication and rational discourse about the magnitude of and best ways to control WHS risks, it is anticipated the WHS experiences and perceptions of all project stakeholders can be considered more effectively in decision-making. This is likely to lead to more comprehensive and accurate assessments of WHS risk, as well as more equitable and effective WHS risk control measures.

REFERENCES

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S. and Combs, B (1978) How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. "Policy Sciences", 9(2), 127-152.

Hallowell, M. (2010). Safety risk perception in construction companies in the Pacific Northwest of the USA. "Construction Management & Economics", 28(4), 403 - 413.

Holmes, N., Gifford, S. M., and Triggs, T. J (1998) Meanings of risk control in occupational health and safety among employers and employees. "Safety Science", 28(3), 141-154.

Lingard, H. and Rowlinson, S (2005) "Occupational health and safety in construction project management". London and New York: Spon Press, Taylor & Francis.

MacDonald, G. (2006) Risk perception and construction safety. "Proceedings of the Institution of Civil Engineers: Civil Engineering", 159(6), 51-56.

Pidgeon, N. (1998) Risk assessment, risk values and the social science programme: why we do need risk perception research. "Reliability Engineering & System Safety", 59(1), 5-15.

Renn, O. (1998) The role of risk perception for risk management. "Reliability Engineering & System Safety", 59(1), 49-62.

Slovic, P. (1987) Perception of risk. "Science", 236(4799), 280-285.

Surry, J. (1979) "Industrial Accident Research: A Human Engineering Appraisal", Ontario Labor Safety Council, Toronto.

Zhang, P, Lingard, H, Blismas, N, Wakefield, R and Kleiner, B. (2013) Application of Q-methodology in studying construction stakeholders' perceptions of OSH risks - An introduction to the preliminary stage. In: John V McCarthy AO, Stephen Kajewski, Karen Manley, Keith Hampson (Ed.), "Proceedings of the 19th Triennial CIB World Building Congress", 5-9 May 2013, Brisbane, Queensland.

Zhang, P., Lingard, H., Blismas, N., Wakefield, R. and Kleiner, B. (2014) Work-Health and Safety-Risk Perceptions of Construction-Industry Stakeholders Using Photograph-Based Q Methodology. "ASCE Journal of Construction Engineering and Management", DOI: 10.1061/(ASCE)CO.1943-7862.0000954.

INCLUSION OF HIV/AIDS AWARENESS INTO THIRD YEAR COMMUNICATION COURSES FOR STUDENTS OF ENGINEERING AND THE BUILT ENVIRONMENT

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University graduates enter the workplace having immediate influence and, frequently, progress rapidly to powerful managerial positions (approximately 60% of the group in the study). The knowledge-sharing space a university allows can go beyond set curricula to ensure these graduates acquire information on and develop appropriate attitudes to health and social problems into the workplace. Five streams of engineers and construction students were asked to volunteer for a six-month pilot study as part of their Professional Communication Studies course. The study was aligned with the aims of the National Department of Health (2012–2016) National Strategic Plan for HIV, STIs and TB), which addresses the structural, social, economic and behavioural factors driving the HIV and TB epidemics. The study sample consisted of 41 students, out of a group of 56, who voluntarily attended a weekend workshop and presented on their research into the topic. Results indicated that while the majority of students were knowledgeable about the infection, transmission and treatment options, there was lack of or incorrect knowledge concerning other issues such as stigma and workplace discrimination. Conclusions described the experience as positive and that the debates in the focus groups on social and public issues were valued. The group's recommendation was that this theme and the assignment should be included in the core course and not be a voluntary additional item.

Keywords: H&S education; HIV/AIDS, graduateness, construction.

INTRODUCTION

HIV/Aids has deepened the poverty crisis in Africa. Medical care and loss of productivity are direct costs, and South Africa has a critical number of infections (Bowen et al, 2014). Because of its nature being associated with migrant and out-sourced labour, construction work has had, and continues to have, a particularly high incidence of HIV/Aids (English et al. 2006; English and Bowen 2012; Bowen et al. 2014). This paper explores the work undertaken in a South African university to enable students graduating from the Faculty of Engineering and the Built Environment (EBE) have knowledge and awareness of HIV/Aids. The context of the study is given through a description of the higher education drivers; of literature pertaining to HIV/Aids in South African education and in the construction industry; of the departments within the university; of the courses through which the study was conducted and of the outcomes of the study and conclusions drawn from them. The drivers were the Higher Education HIV and AIDS Programme (HEAIDS), which was established by the Department of Higher Education and Training (DHET) to assist universities in their programmatic

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responses to HIV and the University of Cape Town (UCT). In addition to sourcing funding for low resourced campuses, HEAIDS provides frameworks for policy and intervention for use by the universities to upgrade or develop the university's HIV programmes (HEAIDS, 2006).

The HIV/AIDS, Inclusivity & Change Unit (HAICU), works within the Transformation Office at UCT. HAICU's mandate is to create platforms for student engagement on areas aligned with the universities strategic initiatives, namely: climate change, safety and violence, transformation and poverty. Under the framework of engaged scholarship, discursive lecture and co-curricula spaces are created for students to discuss the inter-sectionality of public health and social justice issues within their discipline. HAICU reports annually to the UCT Council and to HEAIDS. (HIV/Aids Report to Council, March 2014.)

Background to the HAICU programme

In 2012, approximately 6.5 million people were considered to be HIV positive in South Africa, with the prevalence being highest among people in their twenties. Given this is the age group of students, it makes sense for awareness education and intervention to take place at tertiary institutions. This view was formalised at a South African Universities Vice-Chancellors Association (SAUVCA) workshop in 2000 (HEAIDS 2010b). Note that in 2005, SAUVCA was incorporated into Higher Education of South Africa (HESA).

One of the outcomes of the SAUVCA resolution was the decision to look at programmes and management practices in tertiary education. Chetty's research (2001) described leadership capacity and resources as being important for higher education programmes. Findings presented at the workshop illustrated the impact that stigma can have. Persistent stigma makes it crucially important that students be educated and made aware of how to manage HIV and Aids in their environment.

A further outcome of this research was that learning within a learner-centred environment is more effective than within a teacher-centred environment. This applies particularly to social issues (Mkize et al. 2010). In its policy on the subject, UCT describes curriculum integration of HIV/Aids as a commitment to combat the disease through its curriculum, thereby enhancing awareness and preparing students for a career. In the HEAIDS report (HEAIDS 2010b), a description of a senior manager with a background in engineering emphasises the importance of graduates having empathy for HIV positive employees. A further finding was that new graduates appeared particularly ill-equipped to deal with HIV/Aids, despite many believing they are well versed in the subject. This, however, was found not to be the case by HAICU (Volks 2013) as described by HEAIDS (2010b) in the quotation below. Given the likelihood of graduates being managers of employees with the condition, the need to ensure they have the appropriate knowledge is paramount.

"Everybody believes that because they have heard so much about HIV/Aids in the mass media and in the printed media they are competent in dealing with HIV/Aids. Information on HIV/Aids has become boring. Yet as soon as the new graduates are exposed to the company's HIV/Aids Champions program, the overwhelming feedback has been: 'My God, I didn't realize..' so, there's a lot of assumed knowledge which is probably at best half baked, at worst there is total ignorance." (HEAIDS 2010b:36)

HEAIDS (2010b) concluded that higher education institutions need to deliver HIV/Aids education and awareness programmes. The HEAIDS report (2010b) described the need for a clear mandate to address HIV/Aids within curricula so that it does not remain an unexamined and thus weak part of the course. It noted that while many faculties and departments are including aspects of such training, it is too diffuse to be effective.

Wood (2014), in her desktop review of HIV and Aids curricular responses in the higher education sector, concluded that HIV and Aids education needs to be discipline specific. This cannot be achieved by cross-department, independent courses, only by integration into core curricula. She also found that lectures without debate do not have a profound impact: lectures need to be backed up by the student being practically involved. Furthermore, core curricular academics found it too demanding to incorporate an area not in their field, into their courses. Therefore, a different model was needed, which was sought through designated units within universities. At UCT, HAICU’s work includes development of curricula and co-curricula, education and evaluation, and development of policy.

In terms of managing curricula including HIV/Aids, leadership by the appropriate body at the development level is important to ensure all relevant material is included. Particularly important is that material addressing stigma be included, such as stereotyping and personal biases. Such input should lead to graduates having increased empathy towards HIV positive employees and generally to the reduction of the stigma around it. Finally, Woods found that including a module of self-study and research is effective in integrating the subject.

At UCT, Volks (2012) showed that including HIV/Aids education in core curricula was effective. A programme run in the Faculties of Health Sciences and Science had positive outcomes. The programme showed, in particular, that a compulsory module on HIV/Aids was not information-overload but rather contributed to students’ knowledge and led to a change in attitudes. HAICU had, at this stage, also done work in the Faculties of Law and Commerce although not in the Faculty of Engineering and the Built Environment. A study by the UCT Alumni office showed that 60% of students from engineering and the built environment and commerce go into management positions and thus would have the decision-making role and responsibility to drive this area of health and safety. Thus, inclusion of the Faculty of EBE was desirable. Nonetheless, that meant overcoming certain immediate challenges: finding space in an already-packed curriculum and integrating it into core course material in these technical degrees.

Background to Professional Communication Studies

Students in UCT's EBE faculty take degrees in either Engineering (Chemical, Electrical, Mechanical and Civil) or the Built Environment (Architecture, Town Planning, Construction and Property Studies). It is an accepted part of university curricula now that formerly entirely technical degrees, such as construction and engineering, include communication courses (Reave 2004; Jennings & Ferguson 1995). As part of their degrees, all EBE students take a course in the Professional Communication Studies (PCS) department. PCS courses develop graduate skills by improving students’ oral, written and interpersonal communication skills. While the focus is to aid them in their future careers, it also assists them perform more effectively while at the university (Sulcas & English, 2010). The PCS curriculum thus reflects increasing international recognition of the need to have communication competence in virtually all fields of industry. To meet industry’s needs, there is growing emphasis, in particular, on communication in engineering curricula (Dannels 2002). Many tertiary institutions across the world now offer communication courses as part of engineering and built environment degrees. For example, in a 2004 study on technical communication instruction in engineering schools, Reave determined that of the 73 top-ranked US and Canadian engineering schools, about 50% of the US schools and 80% of the Canadian schools required that students complete a course in technical communication (Reave 2004: 452).

Some of the universities in Reave’s study, which acknowledged that students should be exposed to communication skills, chose to hand over the responsibility of these courses to departments of psychology, sociology and the humanities (Reave 2004). The components of effective communication differ from discipline to discipline and from profession to profession and thus who delivering body must be aware of the different disciplines’ needs, be it professional or social (HIV/Aids).

The HEAIDS report (2010b) describes how communication is important in managing HIV/Aids. Important too was that the HIV/Aids intervention be housed with a sympathetic subject (Campbell & Cornish 2010). UCT has a designated Professional Communication Studies (PCS) unit which teaches written, spoken, and interpersonal skills, and ethics. PCS was selected as the department to work with HAICU as all EBE students take a one-semester course in PCS in their third year. Competency in negotiation skills, effective listening, decision-making skills forms part of the Professional Communication course, thus further making it an appropriate platform for an Aids awareness programme. These findings were supported by the results from an engineering task force study which rated "effectiveness in communicating ideas" as being of importance (Dannels 2002: 256). Communication skills are a core requirement in the effective management of HIV/Aids – as reflected both in the literature and in this study.

Working threshold concepts across disciplines, and thus across the departments of HAICU and PCS, reinforced that team teaching is effective because more information is provided to the students without the course lecturers in either team being loaded with all the additional work (Meyer and Land, 2003). Furthermore, this approach allows for the relevant expert to give the information. Team teaching also allays core course lecturer concerns about being uncomfortable with the subject and not delivering the correct information. Teamwork further means that core course lecturers (in this case PCS lecturers) are linked to the subject (HIV/Aids) though not expert in it. However, they are the ones with the direct link to the student and are more likely to have the student's trust.

'Graduateness'

Recent policy strategy at UCT has emphasised 'graduateness' as encapsulating attributes and skills that students require in preparation for the challenges of professional life (Conradie at al. 2010). There are significant areas of overlap between UCT's conception of 'graduateness' and the requirements of the professional in engineering and built environment industries. With this analysis comes an increasing focus on ethics including social justice as a key area of 'graduateness'.

The particular strengths of PCS in presenting classes in a relaxed environment, in a workshop which encourages engagement (Stuart, 2007), have meant that PCS is recognised as being well positioned to teach and facilitate the development of these professional skills (Gwynne-Evans & English 2014). In this regard, UCT adopted the term 'graduateness' to address and respond to these challenges. Out of this came six international graduate attributes:

- providing inclusive curricula and engagement with African voices;
- bringing research into teaching;
- preparing graduates for a global workplace;
- providing opportunities for more breadth within our undergraduate curriculum;
- ensuring graduates are critical thinkers and interested in post-graduate research;
- embracing the concept of graduateness which is seen to incorporate the 'skills, demeanour and values UCT hopes students will ... acquire by the time they leave UCT' (CHED 2010: 4).

Aims

The aim of the intervention and research study in the University of Cape Town's (UCT) Engineering and the Built Environment (EBE) faculty by the HIV/Aids Inclusivity and Change Unit (HAICU), a support division for students at UCT, was to provide knowledge and information; to engage staff and students at a personal and professional level; and to change staff and student attitudes and behaviours. The study was aligned with the aims of the National Department of Health (2012−2016 National Strategic Plan for HIV, STIs and TB), which addresses the structural, social, economic and behavioural factors driving the HIV and TB epidemics. The study aimed to answer questions raised by the HEAIDS 2010a report as to the steps professional bodies in engineering could take to contribute to curriculum development concerning HIV/Aids in South Africa (HEAIDS 2010a). The mode of delivery also aimed to respond to UCT's drive for cross-discipline research as it involved integration between the two departments, HAICU and PCS, and it was presented through workshops.

Finally, the intervention was also to meet UCT's drive to ensure all students have the qualities of 'graduateness' to take into their working lives.

METHOD

The research study was conducted to pilot a training programme and was based on a mixed methodology of the following: an informative lecture to staff, pre-assessment questionnaires to students, voluntary workshops for students participating, oral assignment competition and post-assessment comprising focus-group discussion. An incentive was added for the students to take part in the HIV/Aids module. The incentive was a persuasive presentation competition, which carried a prize for the two best speakers from each discipline.

Commitment to a topic is required for teachers to respond positively to teaching it. While the members of staff were not required to teach this topic, they rehearsed the students and were on the assessment team and so it was important for them to be able to connect with the topic and the students, and so create an atmosphere of trust to enable the students to speak freely. To do this, HAICU gave PCS staff an informative lecture. Pre-assessment of the students' knowledge and attitudes was carried out via on on-line questionnaire − the challenge in effective administration of questionnaires being to ensure that they reach the appropriate person, anonymous or known, and that they are completed. For this study, convenience and purposive sampling were applied and a sufficient sample was deemed as having been accessed. Thus, of the full cohort of 502, 56 students volunteered to select a topic relating to HIV/Aids to enter the competition and be part of the programme. UCT's ethics' requirements were met in that these students signed permission granting the researchers the right to use the data in papers or presentations.

Of the 56 students who completed the questionnaire, 41 students attended the mandatory 4-hour workshop given by HAICU and therefore comprised the number who took part in the final study. The workshop included input on gender-based violence and its management in the workplace, as well as the management of HIV/Aids in the workplace. Care Works and the Power Group, a large Civil Engineering company working throughout Africa, also gave presentations. Care Works is private company (social enterprise) operating nationally in SA focussing on HIV/Aids; it provides the following to companies (for example, to the Power Group): awareness-to-action training, counselling and testing; peer education training; on-going counselling and support for those testing HIV positive, and on-going treatment for HIV positive employees.

The workshop, with the involvement of these guest speakers from industry, focused on the students' roles and responsibilities as future managers. Thus the emphasis on HIV/Aids was less on personal experience and more on how it might affect their peer-group and future employees. This objectivity took personal pressure away from the participants. The next stage of the programme was for student to give, in pairs, an oral presentation in answer to this question: "HIV/Aids: How does this affect the Engineering and the Built Environment Industry?" The criteria included giving a 10-minute presentation that used PowerPoint and meeting both PCS requirements in terms of delivery and HAICU requirements in terms of content. The final part of the programme was for the students to attend a focus group for post-assessment.

OUTCOMES AND RESULTS

Staff Involvement

The first outcome was education of PCS staff involved. The staff profile is part-time teachers of communication; all are women. The involvement of PCS staff in HAICU's work reflected the changing role of teachers to include becoming caring about social issues affecting their students. The staff had considered themselves well versed in the subject but found they had much to learn, particularly in current industry practices.

Pre-Assessment

The responses to the questions indicated that students had an accurate understanding of infection, transmission and treatment of HIV. It was, however, also evident, from the pre-assessment, that there were misconceptions and indicators of discrimination and stigma. Examples of this were various views that being HIV/Aids positive would have a negative impact on their functioning as effective managers, that is, on their ‘graduateness’ as engineers. Comments from the survey illustrating this negativity are the following which show discriminatory attitudes:

“People with HIV and their loved ones fight for their rights; they are an unnecessary burden on the country. Instead of fighting poverty, the government must waste time and money on promiscuous peoples' bad decisions and their consequences.”

The survey also indicated a lack of knowledge about management and treatment of the condition: “HIV can be treated by the segregation of the infected.”

The survey highlighted the importance of HAICU providing the appropriate information and conducting a workshop with the students to engage in issues such as cultural influences, treatment and identity.

Presentations

For the PCS component, the students were required to research and present a talk. The brief given to the students was to select a topic focused on the work environment with an HIV/AIDS theme. It had to be aimed at a realistic, mixed work-place audience (ie including specialist and non-specialist members) with a specific need for this information. The talk was to persuade an audience to change its attitude or to act on the information given − that is, for it to be more than a merely informative talk. The final presentation was marked for professional presentation skills by the PCS lecturer and judged for HIV/Aids content by adjudicators working in the HIV/Aids field.

A sample of topics given by the students is as follows:

- HIV/Aids and Transparency in the Engineering Workplace
- A Brighter Future for those working with HIV/AIDS…
- Sexual Violence and HIV
- The Importance of Awareness of HIV/AIDS in the Workplace: its Effect on the Labour Force
- CareWorks and HIV management

All the talks passed categories set by PCS and HAICU, with the winning pair achieving 80%. The focus group that followed analysed the generative learning (research, reflection, presentation) which had taken place. It was found that the workshop connected with the students' discipline, career path and 'graduateness'.

Focus Groups

The focus group, meeting a month after the presentations, had an 11% attendance. The poor attendance was attributed to the session falling in the examination period. The first question was on the ease of assimilation of the HIV/Aids module into the PCS core course. The following conversation is evidence of the generative learning that had taken place and the role of the presentation exercise:

“Student 5: It was a very good experiment to put it into professional communication because you (PCS) were making us research on it and present back to you, so that was a very good setting.

PCS Facilitator: Integrating it, and not just being talked at.

Student 5: Yes, having conversations about it.

Student 6: Yes, and it was persuasive, so you had to believe what you were saying and really get into it and convince everybody you were talking to. So, it was really good.

A wider assessment of the integration followed. One student observed: “…especially about the stigma, a lot of people actually used that in their presentation, which was quite good.” The students found the presentations by the independent companies enlightening, with an example comment being, "I honestly did not know much about like you know [sic] how maybe industry is dealing with, companies are dealing with, HIV and all that, but these guys gave you a starting point."

The second topic was whether the students found a link between the theory described by the Power Group and Care Works, and practical outcomes. Comments were that this was the first time the students had seen a work place study around HIV/Aids programmes. Given the diverse backgrounds of UCT students, one commented on applying the theory to what has happened in Botswana, where he could access data, and another related it to Nigeria.

The third topic was stigma and victimization and there was agreement that the workshop had been informative on discrimination and the stigma that people experience while living with HIV/Aids. Students commented on the value of education and of voluntary counselling: "…when we become managers, we are in top positions in companies, then we won't be discriminating against those with Aids. It's kind of a progressive thing, so instead of going straight to industry, you need to teach the people who will be in industry, so that at some point it's, like, common knowledge."

The fourth topic was whether they felt their HIV presentation had influenced their peers who had not volunteered to be part of the programme. Predictably, responses were given around their friends having held misconceptions, as indeed they themselves had held, and now having the knowledge to change them. One student had the following to say:

"Well, I must say, for me, like half my class was like why would you do that when you can present about cool engineering stuff? Like: that's what everyone was saying: 'You chose to do an HIV thing, really?' It was like guys were not keen about doing it, because they were like no, I'd rather do it about some cool gadget or whatever. …I spoke to one of my friends who was really interested in what we did, and she was like you know, I had no idea this is what they meant when they were saying doing the HIV thing. I think she had a misconception about it, because she really enjoyed my presentation. She was asking, she was like 'this is really cool and it's really informative'. But initially they weren't keen, so I don't know what you have to do. "

Another student made this comment on the learning experience:

"I think the thing with most people is because they get a bit of information about HIV and Aids, especially in first year, they think they know all there is to know about HIV and Aids, so later on they are not so keen on progressing and learning more about it. Even me, I thought okay, there's no harm in knowing more, then I realised that actually, there isn't much that I knew before. So most people tend to think that they already know all there is to know about HIV and Aids, but they are unaware that they still have got lots to learn about the topic."

The following quotations from the students' feedback are an indicator of its success:

Student 1: "The workplace focus stood out for me specifically, you couldn't force people to get tested and yet some were victimised because of their status. These guys probably want to get tested but didn't want to share that information with the company."

Student 2: "When you get to industry you become oblivious to it [HIV/Aids] and so it needs to be implemented into curriculum and related it to the discipline."

CONCLUSIONS

The conclusions were that overall collaboration between HAICU and PCS over including HIV/Aids input into the core curricula of the professional communication courses was effective and contributed to 'graduateness'. The exercise met the aspirations of the HEADSa and HEADSb reports needing HIV/Aids awareness training integrated into core curricula. Through this successful response it also responded to the National Department of Health's strategic aims for management of HIV/Aids. The decision to locate this intervention in the PCS course meant that the full spectrum of Faculty of EBE students were reached, albeit on a voluntary basis.

At no stage did the inclusion of the topic have a negative effect on the PCS course, and its course objectives were achieved. The HAICU objectives on developing workplace skills and competency in social and public health discourse were also achieved. And finally, perhaps most importantly, the students valued the integration of social and public health discourse. As it had been a first attempt, the course was voluntary. However, given its success for all role players, the final assessment of the the study was to make the topic mandatory within a PCS course. This will mean every student and not only volunteers would be exposed to input on the topic and would participate in its assimilation. Thus the aims of the research study to set up a pilot study for mandatory inclusion were met. This was pursued in 2014.

REFERENCES

Bowen, P., Allen, Y., Edwards, P., Cattell, K. and Simbayi, L. (2014) Guidelinds for effective workplace HIV/AIDS intervention management by construction firms. “Construction Management and Economics” DOI:10.1080/01446193.2014.883080

Campbell, C & Cornish, F (2010) “Towards a “fourth generation” of approaches to HIV/AIDS management: creating contexts for effective community mobilisation” http://www.tandfonline.com/doi/abs/10.1080/09540121.2010.525812 (accessed 10.05.2015)

CHED (2010) “Teaching and learning at UCT: A report on the 2009 academic year”. Council on Higher Education and Institutional Planning Department.

Chetty, D. (2001). South African universities and HIV/AIDS: Developing a sector-wide response to the HIV epidemic. “South African Vice Chancellors Association (SAUVCA) resource documents”.

Conradie, B., Paxton, M. and Skelly, L. (2010) What do graduate attributes mean for the classroom? The case of academic literacy in 3rd year economics. “Presentation by Commerce Education Group, University of Cape Town,” 11 May. Available at: http://www.commerce.uct.ac.za/Organisations/CEG/Documents/2010/Academic literacy & graduateness II - CEG 11 May 2010.pptx (accessed 27.07.2013).

Dannels, D. (2002) Communication Across the Curriculum and in the Disciplines: Speaking in Engineering. “Communication Education” 51(3) 254−268.

English, J. and Bowen, P. (2012) Overcoming Potential Risks to Females Employed in the South African Construction Industry**. “**The International Journal of Construction Management: Special Edition – Corporate Social Responsibility within Construction” 12(1) 37-49 www.cibworld.nl/site/about_cib/encouraged_journals

English, J., Haupt, T.C. and Smallwood, J. (2006) Women, Construction, and Health and Safety in South Africa: South African and Tanzanian Perspectives, “Journal of Engineering, Design and Technology”, 4(1) 18−29, ISBN: 0-620-33919-5

Gwynne-Evans, A. and English, J. (2014) Changes in teaching Graduate Skills, including ethics, since 2010. “South African Journal of Higher Education” 28, (1) 110−127. ISSN 1011−3487

HAICU (2014) HIV/AIDS Report to Council: Responses to HIV/AIDS teaching and support services at UCT. March, 201

Haupt, T.C. & Smallwood, J. (2005) The need for construction health and safety (H&S) and the construction regulations: engineers’ perceptions. “Journal of the South African Institution of Civil Engineering” 47 (2) 2−8

HEAIDS (2010b) HIV prevalence and related factors – Higher Education sector study, South Africa, 2008−2009. Pretoria: HESA.

HEAIDSa (2010a) Creating space for HIV and AIDS in the curriculum – A Rapid Assessment of curricular responses in South African Higher Education Institutions. Pretoria: HEAIDS Programme Report, 2002–2004.

http://www.hsrcpress.ac.za/product.php?productid=2282&cat=1&page=2&freedownload=1Bowen, P.A., Cattell, K.S., Edwards, P.J. and Marks, J. (2010) Perceptions of HIV/AIDS policies and treatment programmes by Western Cape construction firms, “Construction Management and Economics”, 28 (9), 997−1006

Jennings. A. and Ferguson, J.D. 1995. Focusing on Communication Skills in Engineering Education. “Studies in Higher Education”. 20 (3) 305−31

Jones, M. (2003) The renaissance engineer: a reality for the 21st century? “European Journal of Engineering Education”. 28(2) 169−178

Meyer, J.H.F. and Land, R. (2003) ‘Threshold concepts and troublesome knowledge: Linkages to ways of thinking and practising within the disciplines’, in Rust, C. (ed.), “Improving Student Learning: Improving Student Learning Theory and Practice – Ten Years On”. Oxford: Oxford Centre for Staff and Learning Development.

Mkhize, N, Bennett, J, Reddy, V. and Moletsane, R. (2010) “The country we want to live in: hate crimes and homophobia in the lives of black lesbian South Africans” http://www.hsrcpress.ac.za/product.php?productid=2282&cat=1&page=2&freedownload=1 (accessed 15.03.2015)

National Department of Health (2012−2016 National Strategic Plan for HIV, STIs and TB) http://www.sahivsoc.org/upload/documents/National_Strategic_Plan_2012.pdff (accessed 15.03.2015)

Reave, L. (2004) Communication Instruction in Engineering Schools: A Survey of Top-Ranked U.S. and Canadian Programs. “Journal of Business and Technical Communication”. 18 452−490

Stuart, J. D. (2007). From our frames: Exploring visual arts-based approaches for addressing HIV and AIDS with pre-service teachers. “Unpublished doctoral thesis”, University of KwaZulu-Natal, Durban.

Sulcas, G. and English, J. (2010) A Case for Focus on Professional Communication Skills at Senior Undergraduate Level in Engineering and the Built Environment, “Southern African Linguistics and Applied Language Studies” on “Language and Communication in Technical fields” 28 (3) 219−227 ISSN 1607-3614.

Ugwu, O. O. and Haupt, T. C. (2005). Key Performance Indicators and Assessment Methods for Infrastructure Sustainability − a South African Construction Industry Perspective. “Building and Environment”. DOI: 10.1016/j.buildenv.2005.10.018

Volks, C. (2012) “Third Degree: AIDS review”. Pretoria: Centre for the Study of AIDS.

ETHICS IN CONSTRUCTION HEALTH AND SAFETY RESEARCH: REFLECTIONS FROM A PHD PROJECT

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Construction health and safety researchers need to be aware of the various aspects associated with the ethical conduct of research. Most journals now require researchers to make some reference to some aspects of informed consent and confidentiality of informants as a way of addressing ethical conduct of research. Universities and research institutions also expect all researchers to follow established rules and guidelines as prescribed by institutional ethics research boards and/or committees, through an approval process prior to the conduct of research. However, ethical issues permeate the entire research process, yet there is little in terms of published literature that discusses how this important issue is actually addressed by the researchers during the actual conduct of research. This is a significant gap which this paper seeks to redress by reflecting on how and what ethical issues were addressed during planning, purpose and research questions, data collection, analysis and interpretation stages of the authors PhD project.

Keywords: empirical health and safety research, institutional human research ethics committee, informed consent, reflexivity.

INTRODUCTION

Research, by its very nature, involves collecting, analysing and writing about information and data on a range of issues. When the issue is as important as health and safety, this inevitably means sourcing, gaining access to and speaking with people. Hence the ethical conduct of health and safety research becomes very important. Researchers not only need to protect their research participants but also develop a trust with them, ensure integrity of their research, and cope with any new, challenging problems (Israel & Hay, 2006). It does not whether the research method involves qualitative or quantitative studies, since ethical issues are present in any kind of research (Orb, Eisenhauer, & Wynaden, 2000; Panter & Sterba, 2011), although the issues may be different. Ethical issues are therefore becoming an increasing focus for research, with a number of academic journals specifically devoted to this. Most research, however, has been published from domains such as medicine, nursing or social work; with very limited from industries such as construction, or from health and safety research. Moreover, there is very little published on the actual practice of ethics in research (Gillam, Guillemin, Bolitho, & Rosenthal, 2009), including the experiences of researchers during the conduct of research. This creates a false impression that following the guidelines and rules lay down by the institutional research ethics committees and 'approved' at the project proposal stages by itself is sufficient to warrant the ethical conduct of research! This raises the question of whether ethical challenges are understood and addressed appropriately in construction health and safety projects, since ethical issues permeate the entire research process. This is an important question to consider not only for maintaining the integrity of research, but also to ensure researchers (novice, as well as those experienced in one methodology seeking to employ different methods compared to what they may have been used to in the past) are adequately prepared for dealing with new and emerging ethical

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challenges that arise during the research process. The aim of this paper is to start the conversation on this important topic, by reflecting on how the issues of ethics were addressed as part of the researcher's PhD journey. It is limited to those issues addressed during planning, purpose, research questions, data collection, analysis and interpretation stages of a construction health and safety research project.

RESEARCH APPROACH

Any piece of academic research involves connecting the layers of basic assumptions from the ontological, epistemological and theoretical positions to inform the research methods and techniques used in the research process. This research is based on an interpretive ontology and epistemology of constructionism, both of which sees knowledge being constructed instead of being discovered (Crotty, 1998). The theoretical perspective involves symbolic interactionism (SI), which surmises that people act towards things on the basis of meanings for them, with the meaning derived and modified through social interactions (Charon, 2010) . The knowledge involves the ethical conduct of research, and for maintaining the integrity of the research process. The research method is based on reflective practice, more specifically 'reflection-on-action' which involves reviewing, describing, and evaluating past practice with the aim of improving it in future (Schön, 1994). Reflexivity and reflections are integral for maintaining the quality of any qualitative research (Malterud, 2001). The data for the paper is based on the author's collection of papers on the topic of research ethics before and after the research process, and a research journal maintained during the four-year period of the PhD project. Maintaining such a journal is an integral part of doing qualitative research and maintaining rigour (Creswell, 2009; Tracy, 2010).

LITERATURE REVIEW

Ethics and ethical standards

Ethics, in its broadest sense, is about examining and understanding morals (Israel & Hay, 2006), rule-driven principles, obligations, imperatives, rights and duties, as applied in a social context to Castaneda (2006). It can be traced to the Nuremberg Code, first developed in 1947, by American judges presiding over the cases of Nazi doctors accused of conducting lethal and torturous human experiments in concentration camps (Shuster, 1997). Since then, most professional associations, educational and research institutes have developed standards or guides to prevent similar forms of experimentations, with many making these freely available on their websites. Examples of these include:

American Medical Association Principles of Medical Ethics, adopted in 1957 and revised in 2001 (available at http://www.ama-assn.org/ama/pub/physician-resources/medical-ethics/code-medical-ethics/principles-medical-ethics.page);

Australian Code for the Responsible Conduct of Research (available at https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/r39_australian_code_responsible_conduct_research_150107.pdf);

The Royal Academy of Engineering Statement of Ethical Principles (available at www.raeng.org.uk/publications/reports/statement-of-ethical-principles); and

United Kingdom Research Integrity Office Code of Practice for Research (available at http://www.ukrio.org/publications/code-of-practice-for-research/).

Previous research on ethics in research

Ethics has been the subject of ongoing research for over a decade. In 2001 the National Bioethics Advisory Commission commissioned a research project on ethical and policy issues involving humans in research. This research investigated research ethics in a number of countries, problems of status of the National Institute of Health as an independent authority, privacy and confidentiality, unifying and expanding federal oversight of human subject research, institutional review boards and ethics research committees at local and national levels, vulnerability of research subjects, protection of human subjects, survey of policies and procedures for protecting humans, role of the state in oversighting human research, privacy and confidentiality, and beneficence of human research (National Bioethics Advisory Commission (NBAC), 2001). Since then, a number of reviews covering different aspects of research ethics in a number of fields have been published.

Singer and Vinson (2002) reviewed ethics in software engineering studies and identified informed consent, scientific value; beneficence and confidentiality were deemed most important. Shaw (2003) identified informed consent, confidentiality, privacy, and social justice was important at the design stage; power differentials, reciprocity and contextual relevance during fieldwork; and narration, outcomes, justice and the utilization during analysis and dissemination. Grant and Sugarman (2004) found out that incentives caused problems when the subjects were in a dependent relationship with researchers, when risks were particularly high, the research was degrading or when the incentives were relatively large. Dubois, Volpe, and Rangel (2008) identified informed consent, respect for subjects, value, scientific validity, fair selection of subjects, favourable risk-benefit ratios being the most important aspects published in non-ethical related health journals. Suri (2008) identified that multiple layers of interpretation influenced the selection and representation of 'voice' in research publications at the synthesis stage. White and Drew (2011) revealed authenticity of data, integrity of the analysis process and representations of voice were important at data collection and analysis. A special issue published in 2013 examined ethics of longitudinal research, theories and moral questioning, online research, visual materials and techniques (Wiles & Boddy, 2013). Redman (2014) reviewed instruments for measuring ethics in biomedical sciences; while Saunders, Kitzinger, and Kitzenger (2014) examined the challenges of maintaining anonymity of interview data. And more recent reviews by have examined deception (Liong, 2015); voluntary participation and informed consent (Mamotte & Wassenaar, 2015); and the communication of findings (MacKenzie, Christensen, & Turner, 2015). While these reviews continue to add to the body of work on different aspects of ethical conduct of research, none of these focussed on (i) building or construction settings, (ii) health and safety research, or (iii) the actual experiences of researchers. This is a significant gap in the literature, and the aim of this paper is start a conversation towards addressing this important gap.

The following sections reflect on ethical issues in conducting health and safety research in construction. While most of the issues identified here will be relevant for both quantitative and qualitative researchers, this paper draws on a qualitative case study the author completed as part of his PhD research.

PROJECT

This research draws on a project which explored the application of a set of rules, safe work method statements, in the construction industry, using the framework of resilience engineering (herein called the 'SWIMS' project). This involved a multi-level analysis (Rasmussen, 1997) of the residential construction sector using a case study methodology (Stake, 1995), with data collected through interviews, documents and field observations. Ethical approval was sought and received from the IHREC before the data collection, based on a process which met the ethical standards established jointly by the National Health and Medical Research Council / Australian Research Council / Universities Australia (2007).The key instruments used included a plain language information statement (PLIS), consent forms, and protocols for semi-structured interviews and field observations.

ETHICAL ISSUES

Ethical issues is research can arise at any, or all, stages of a research process, including planning, data collection, data analysis and interpretation, and writing and dissemination (Creswell, 2009).

Ethics in Planning

The considerations surrounding ethics starts during the planning stages (Sieber, 2000), not only during data collection. Some of the things that need to be considered here include the need and the benefits of the proposed research. In seeking to justify the need for research, it is important to identify a significant issue, concern or problem; one that benefits and is meaningful to others, not only the researcher (Creswell, 2009).

In as far as the benefits are concerned, factors such as the market share of the construction industry, its contribution in terms of Gross Domestic Product (GDP) or value-add (VA), and employment numbers are generally used to make the case for research in any industry; while statistics associated with number and/or costs of injuries and are used to strengthen the case for health and safety research. In this project the value-add of construction, estimated at that time to be around $US3 trillion, employing over 180 million workers; against 100 000 deaths and a fatality rate being five times greater than the average workforce was used to justify the need for research. Upon reflection, however, the researcher faced a moral dilemma of whether presenting an argument based on statistics alone pointed towards quantitative research! This ethical conundrum is one of conflicting rationalities (Watson, 2003), in other words is it ethical to (predominantly) rely on quantitative data to justify the need for research that has been planned to be done qualitatively? Or should this argument be dealt with in at some other part of the research process? There were no guidelines or rules to follow at this stage, but quoting and citing these types of statistics made sense, it also meant something to others other than the researchers (Creswell, 2009). More importantly, nearly all articles and publications scrutinised seemed to use it, so the overriding criteria used by the researcher was one of consistency i.e. if other researchers used it, then it was okay to use.

Ethics in Purpose and Research Questions

The purpose (or intent statement), goals and questions for research needs to be made clear to the participants involved in research, and (any) sponsors need to be identified (Creswell, 2009). A number of ethical questions arose here. For example, what, if any, 'goals' was this research trying to achieve? A common problem with most research involves 'hyperclaiming', or telling prospective participants the research is likely to achieve goals which are likely to benefit them in some way (Rosenthall, 1994). Strictly speaking, the SWIMS project did not do this entirely, for it was an attempt at seeking to understand the meaning ascribed to SWIMS. The strategy the researcher relied on here was to remain silent over this issue. Upon reflection, it can be questioned whether this represented some level of deception in the manner suggested by Liong (2015).

A related ethical question that arose at this stage was how should the purpose of research and the research questions be presented in simple, 'layman terms' so that the different players in the construction industry heard the same message? In this project the purpose statement submitted for approval by the IHREC was phrased 'to develop an understanding of whether safe work method statements (SWMS) enhance or impede resilience engineering (RE) as a health and safety management strategy in construction organisations.' It seemed to make sense, at least academically; but how would one with no (or limited) understanding of RE, or those who had not worked with SWIMS, interpret this? In hindsight, most of this information can be deemed redundant, if not confusing (Walkup & Bock, 2009). This became evident when, during one of the first of five pilot interviews, an informant asked the question "are you checking out whether I follow SWIMS or not?" Since this was not the intention, the purpose statement written in the PLIS was simplified to 'we are researching how safe work method statements (SWIMS) are interpreted and applied to control health and safety risks in the Australian construction industry!' This still sounded a bit academic, but the researchers felt this could be better explained to the participants than the earlier version.

Ethics in Data Collection

A number of ethical issues need to be considered during data collection; the three most important ones being (i) protection of informants, (ii) informed consent, and (iii) confidentiality (Creswell, 2009).

The confrontational nature of the construction industry can also pose additional ethical challenges (Loosemore, 1998), as can issues of low English-language literacies (Trajkovski & Loosemore, 2006).

Protecting participants from harm

Irrespective of the methods used for collecting data, qualitative research inevitably involves probing into the lived experiences of participants and placing these in the public arena (Mauthner, Birch, Jessop, & Miller, 2002), and this interaction affect informants because of the power differentials that exist between researchers and informants(Karnielli-Miller, Strier, & Pessach, 2009). Ways of managing this needs to be considered alongside any other physical, psychological, social, financial or legal risks (Israel & Hay, 2006). Participants can feel vulnerable, experience additional anxiety and/or distress if they are questioned, and their anxiety levels can rise if they have issues with literacy (Labott, Johnson, Fendrich, & Feeney, 2013; Roth, 2005). Some may even feel exploited, especially if the study entails methods such as ethnography or insider research. In addition to the participants, researchers also need to ensure any work areas used as research sites are not disturbed or impacted negatively in any way (Creswell, 2009).

In this project a deliberate choice was taken to ensure only those who were (i) educated to at least year 9, and (ii) predominantly born or migrated to Australia were included as key informants. This purposeful sampling strategy (Coyne, 1997) was one way of ensuring informants had a minimum language capabilities in English. In addition, as part of the data collection strategy the researcher spent a period of time getting familiar with the sites and the specific range of occupational cultures involved, completing an industry-based induction training course, becoming a member of the local union, and spending over a month at each of the research sites and the different projects (over six months in all). Some of these strategies are consistent with ethnography (Creswell, 2009), although the study design itself involved case studies. As part of data - collection, the researcher became a quasi- assistant to a range of construction crews. This, together with getting membership to the local union, was key to developing and maintaining the necessarily level of trust to be developed between the informants and the researcher. These steps were adopted from Gherardi and Nicolini (2002). The voluntary nature of participation was emphasized as part of the recruitment process, and a point of referral to the national helpline was provided to allay the concerns and fears of any potential participants. Aspects of some of these practices are what authors such as Buchanan and Bryman (2007) refer to as 'contextualization of choice in methods.' Authors such as McDonald et al (2008), however, suggest that, from the perspective of human subjects, trust is a more dynamic concept characterised by reciprocity and negotiation. Upon reflection, however, the issue of reciprocity did not play much of a role in this stage of the project.

Informed consent

Informed consent concerns the respect and right of participants to be involved in the research process, access to their data, and the ability to withdraw from the research (Miller & Boulton, 2007). A written consent form is the most commonly used instrument for gaining such consent, with textbook guidance suggesting the need to include information on things such as (i) researcher(s) and sponsor(s), (ii) purpose and scope of research, (iii) an indication of how the participants were selected, (iv) benefits of participating, (v) level and type of participant involvement, (vi) risks to participants, (vii) types of questions which will be asked, (viii) the use to which the results will be put to, (ix) how confidentiality and anonymity will be maintained, (x) right of participants to withdraw at any time, and (xi) contact details for persons (other than the researcher(s)) for any questions, clarifications or issues (Creswell, 2009). Providing the information is only half of the process; the other half is about getting the consent itself. Getting construction workers to sign something can be problematic as they generally have lower levels of literacy compared to other trades such as mechanics or fitters (Bates & Holton III, 2004; Trajkovski & Loosemore, 2006), so informed consent becomes a process of negotiating and re-negotiating, not the mere act of getting informants to sign forms.

In this project both verbal and written forms of consent were obtained from the participants. This involved giving each participant a plain language information statement (PLIS) which covered the points above, going over these at the beginning of any interviews and at the end, and giving them the right to withdraw. However, as the research progressed two issues became apparent.

The first was that a number of informants were more than happy to withdraw given that particular choice. The ethical problem however, was that if this was allowed to continue uncontrolled, it could impact on the final outcome in terms of number of informants and seeking new informants to make up. The second was that most of the workers were contractors, and they were taking out valuable time to speak with the researcher and show him how things were actually done. While all did this in good faith, the ethical issue that arose here was whether theses participants should have received some form of monetary compensation? If so, how were these likely to impact on the results? These questions have also concerned authors such as Grant and Sugarman (2004) and Ripley (2006). To account for people's time's chocolates were provided as a compromise, in line with the suggestion by Grant and Sugarman (2004) that this should neither act an incentive nor as a disincentive for participating. Due to long delays in getting access to research sites and key informants, the researcher discouraged the withdrawal of informants by maintaining a level of silence around it i.e. including this information in the consent form but not explaining it in any detail during, before and after the interviews. Whether this was ethical practice or not remains questionable.

Confidentiality

Qualitative research invariable involves collecting some level of personal information regarding the informants. While many try to conceal as much of these, such sources of contextual data are useful for analysis. Commonly used strategies for maintaining confidentiality include pseudonyms, initials or some accepted form of coding (Creswell, 2009). However, it is possible that some participants may not want to remain anonymous; and permitting this means he/she holds ownership of voice and exerts their independence in decisions, in such instances the risks of non-confidentiality need to be made clear (Creswell, 2009). Moreover, the confidentiality can be breached on legal grounds, in spite of the best assurances provided (Lowman & Palys, 2014).

In this research pseudonyms to replace any personal identifiers from protocols of interviews and observations were used for maintaining confidentiality during data collection. Most of the informants did not wish to be identified, while a few suggesting they were not overly concerned whether they were identified or not. A statement in the PLIS provided generic advice that all data collected would remain anonymous and confidential, unless required otherwise by law. Prior to the interviews this was explained to the informants, with the understanding that no such cases involving health and safety research had been the subject of such court action in Australia at the time the time research was conducted.

Ethics in Data Analysis and Interpretation

Ethical issues can also arise during analysis and interpretation. Common examples include maintaining the anonymity and confidentiality of participants, safe storage of data, using the data beyond the project for which it was collected for, and the ownership of data collected (Creswell, 2009). Dissociating names from responses during coding and recording, and using aliases and pseudonyms to protect the identity of individuals and organisations are some of the most common practices in this regard. Data collected can be stored in locked folders or through password protection for between 5-10 years, and personal agreements can be negotiated for maintenance and access to the data collected. At the interpretation stage, it is important to provide an accurate account of the information; and this may require briefing and debriefing between the researcher and the participants (Creswell, 2009). At the data transcription stage standardised responses can become the norm and lead to some level of fabrication and/or falsification (Tilley, 2003).

In this project, research sites were given aliases as orgs A, B, C, D and E. The participants were simply coded as numbers and linked with organisations. All data collected was stored electronically, and the consent form included a statement informing the participants that the data collected would be maintained for a period beyond 5 years and used in other publications. The PLIS also stipulated that some of expressions used by the participants could be cited and used in the thesis and publications, and these would be linked with a code such as A1 or A2 to protect the identity of the informants. The transcription of most of the interviews was outsourced to an external agency. Two attempts at de-briefing were made by contacting the respective informants by telephone. However, the workers and some groups of supervisors, who were employed as sub-contractors, had moved on to other sites, so this process could not be completed in its entirety. A sample of the transcripts was discussed with the supervisory panel once they were coded and themed. This was one way of maintaining reflexivity in the process.

CONCLUDING REMARKS

As this reflection has revealed, there are a number of issues that are involved in the ethical conduct of research in construction health and safety, only a few of which have been included in this article. For example, issues of 'voice', 'representation' at the data writing and dissemination stage, plus the quality of the research process are also important considerations. While these, and other related issues will be the subject of future articles, it is hoped this paper acts as an incentive to other researchers to share their experience and wisdom in enhancing the ethical conduct of health and safety research in construction settings.

Acknowledgments

The author is grateful to the editors and the two anonymous referees for their insight and critical comments on earlier versions of this paper.

REFERENCES

Bates, R., & Holton III, E. F. (2004). Linking workplace literacy skills and transfer system perceptions. Human Resource Development Quarterly, 15(2), 153-170

Buchanan, D. A., & Bryman, A. (2007). Contextualizing methods choice in organizational research. Organizational Research Methods, 10(3), 483-501

Castaneda, Q. E. (2006). Ethnography in the forest: an analysis of ethics in the morals of anthropology. Cultural Anthropology, 21(1), 121-145

Charon, J. M. (2010). Symbolic Interactionism an Introduction, an Interpretation, an Integration (10 ed.). Sydney: Prentice Hall

Coyne, I. T. (1997). Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? Journal of Advanced Nursing, 26, 623-630

Creswell, J. W. (2009). Research design: qualitative, quantitative and mixed methods (3rd Ed.). Thousand Oaks: Sage Publications

Crotty, M. (1998). The Foundations of Social Research: Meaning and Perspective in the Research Process. Crows Nest: Allen & Unwin

Dubois, J. M., Volpe, R. L., & Rangel, E. K. (2008). Hidden empirical research ethics: A review of three journals from 2005 through 2006. Journal of Empirical Research on Human Research Ethics, 3(3), 7-18

Gherardi, S., & Nicolini, D. (2002). Learning the trade: a culture of safety in practice. Organization, 9(2), 191-223

Gillam, L., Guillemin, M., Bolitho, A., & Rosenthal, D. (2009). Human research ethics in practice. Monash Bioethics Review, 28(1), 7.1-7.17

Grant, R. W., & Sugarman, J. (2004). Ethics in human subjects research: do incentives matter? Journal of Medicine and Philosophy, 29(6), 717-738

Israel, M., & Hay, I. (2006). Research ethics for social scientists. London: Sage Publications Ltd

Karnielli-Miller, O., Strier, R., & Pessach, L. (2009). Power relations in qualitative research. Qualitative Health Research, 19(2), 279-289

Labott, S. M., Johnson, T. P., Fendrich, M., & Feeney, N. (2013). Emotional risks to respondents in survey research: some empirical evidence. Journal of Empirical Research on Human Research Ethics, 8(4), 53-66

Liong, M. (2015). In the shadow of deception. Qualitative Research Journal, 15(1), 61-73

Loosemore, M. (1998). The methodological challenges posed by the confrontational nature of the construction industry. Engineering Construction and Architectural Management, 5(3), 285-293

Lowman, J., & Palys, T. (2014). The betrayal of research confidentiality in British sociology. Research Ethics, 10(2), 97-118

MacKenzie, C. A., Christensen, J., & Turner, S. (2015). Advocating beyond the academy: dilemmas of communicating relevant research results. Qualitative Research, 15(1), 105-121

Malterud, K. (2001). Qualitative research: standards, challenges, and guidelines. The LANCET, 358, 483-488.

Mamotte, N., & Wassenaar, D. (2015). Measuring voluntariness of consent to research: An instrument review. Journal of Empirical Research on Human Research Ethics, 10(2), 121-131

Mauthner, M., Birch, M., Jessop, J., & Miller, T. (2002). Ethics in Qualitative Research. Thousand Oaks: Sage Publications Ltd.

McDonald, M., Townsend, A., Cox, S. M., Paterson, N. D., & Lafreniere, D. (2008). Trust in research relationships: accounts of human subjects. Journal of Empirical Research on Human Research Ethics, 3(4), 35-47

Miller, T., & Boulton, M. (2007). Changing constructions of informed consent: qualitative research and complex social worlds. Social Science & Medicine, 21, 2199-2211

Murphy, E., & Dingwall, R. (2007). Informed consent, anticipatory regulation and ethnographic practice. Social Science & Medicine, 65, 2223-2234

National Bioethics Advisory Commission (NBAC). (2001). Ethical and policy issues in research involving human participants (Vol. II). Bethesda, Maryland: NBAC.

National Health and Medical Research Council / Australian research Council / Universities Australia. (2007). Australian code for the responsible conduct of research. https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/r39_australian_code_responsible_conduct_research_150107.pdf

Orb, A., Eisenhauer, L., & Wynaden, D. (2000). Ethics in qualitative research. Journal of Nursing Scholarship, 33(1), 93-96

Panter, A. T., & Sterba, S. K. (2011). Handbook of ethics in quantitative methodology. New York: Taylor & Francis.

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. Safety Science, 27(2-3), 183-213

Redman, B. K. (2014). Review of measurement instruments in research ethics in the biomedical sciences, 2008-2012. Research Ethics, 10(3), 141-150

Ripley, E. B. D. (2006). A review of paying research participants: It's time to move beyond the ethical debate. Journal of Empirical Research on Human Research Ethics, 1(4), 9-19

Rosenthall, R. (1994). Science and ethics in conducting, analyzing and reporting psychological research. Psychological Science, 5(3), 127-134

Roth, W.-M. (2005). Ethics as social practice: debating ethics in qualitative research. Historical Social Research, 30(1), 157-167

Saunders, B., Kitzinger, J., & Kitzenger, C. (2014). Anonymising interview data: challenges and compromise in practice. Qualitative Research, September 23, 1-17

Schön, D. A. (1994). The reflective practitioner: how professionals think in action. New York: Basic Books.

Sieber, J. E. (2000). Planning research: basic ethical decision-making. In B. D. Sales & S. Folkman (Eds.), Ethics in Human Research With Human Participants (pp. 13-26). Washington, DC: American Psychological Association

Singer, J., & Vinson, N. J. (2002). Ethical issues in empirical studies of software engineering. IEEE Transactions on Software Engineering, 28, 1171-1180

Shaw, I. (2003). Ethics in qualitative research and evaluation. Journal of Social Work, 3(1), 19-29. doi: 10.1177/1468017303003001002

Shuster, E. (1997). Fifty years later: The significance of the Nuremberg Code. The New England Journal of Medicine, 337(20), 1436-1440

Stake, R. E. (1995). The art of case study research. Thousand Oaks: Sage.

Suri, H. (2008). Ethical considerations in synthesising research: whose representation? Qualitative Research Journal, 8(1), 62-73

Tilley, S. A. (2003). “Challenging” research practices: Turning a critical lens on the work of transcription. Qualitative Inquiry, 9(5), 750-773.

Tracy, S. J. (2010). Qualitative quality: eight "big tent" criteria for excellent qualitative research. Qualitative Inquiry, 16(10), 837-851

Trajkovski, S., & Loosemore, M. (2006). Safety implications of low-English proficiency among migrant construction site operatives. International Journal of Project Management, 5(24), 446-452

Walkup, J., & Bock, E. (2009). What do prospective research participants want to know? what do they assume they know already? Journal of Empirical Research on Human Research Ethics, 4(2), 59-63

Watson, V. (2003). Conflicting rationalities: implications for planning theory and ethics. Planning Theory & Practice, 4(4), 395-407

White, J., & Drew, S. (2011). Collecting data or creating meaning? Qualitative Research Journal, 11(1), 3-12

Wiles, R., & Boddy, J. (2013). Introduction to the special issue: research ethics in challenging contexts. Methodological Innovations Online, 8(2), 1-5

EVALUATING THE EFFECTIVENESS OF MODERN BUILDING ENGINEERING STUDIOS TO DELIVER DESIGN FOR SAFETY (DFS)

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Whilst research into Design for Safety (DfS) has been undertaken in the past, little of this work has focused on how DfS is being impacted by the changing environment of engineering design studios. Following the advent of digital technologies, it is now common place for graduates and engineers to utilise complex 3D analysis suites of software which are linked to parametric BIM models. During this period the requirement of site experience to become chartered has also reduced. Final year Civil Engineering undergraduate students at a UK university and a second group of practising engineers were tested to determine their ability to identify hazards within the structural design of an office development utilizing 2 and 3D mediums. Additionally, a series of interviews were undertaken with a purposeful sample of practitioners who have witnessed the evolution of design studios. The students were typically able to identify some generic hazards but struggled to distinguish hazards generated by construction processes with only a small percentage able to suggest safer alternative forms of construction. The practitioners were better able to identify process hazards but noticeably highlighted some errors in the design. The test results are cross-referenced with the outputs of the interviews to provide a synopsis of the developing environment within design studios. The findings of the research identify that with the increasing emphasis on technology and less on practical site experience, the principles of DfS are becoming difficult to actualize in the modern design studios. This phenomena is intensified as inexperienced engineers with only 2 or 3 years' experience are making significant input into the early stages of design.

Keywords: design for safety, hazard identification, site experience, training.

INTRODUCTION

Existing research has shown a link between construction accidents and design. The aim of Design for Safety (DfS) is to eliminate or reduce construction and operational hazards early in the design phase of a project. The ability to identify hazards within designs is pivotal in the DfS process and is often reliant upon tacit knowledge (Haslam et al, 2005; Behm, 2005; Gangolells et al, 2010) acquired through experience (Hadikusumo and Rowlinson, 2004).

By undertaking hazards perception tests on final year engineering students and a second group of practising engineers; this research aims to establish if the ability to identify hazards, and therefore deliver DfS, is linked to the students experiencing extended periods of site practice.

The empirical research is supported by interviews with experienced engineers who have witnessed major changes in the industry. This coincides with a period when the reliance on digital technologies has increased and the opportunities to gain practical site experience have decreased.

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BACKGROUND

The causes of construction accidents are often complex with many factors contributing to an accident (Gibb et al., 2006; Martínez et al., 2010; Gambatese et al., 2008). Several research teams have investigated the relationship between design and construction accidents with Haslam et al., (2005) reporting that up to half of the accidents in the UK that they analysed had a connection to the design. This is a disturbingly high figure and close to that noted in the European Union directive 92/57/EEC 13 years earlier and 11 years after the introduction of the CDM regulations which were aimed to improve this situation.

Gambatese and Hinze (1999) undertook a study in the USA where they identified that designers are unaware of their impact on site safety and lack the knowledge and ability to modify their designs to improve safety. It should also be noted that unlike the UK, American designers do not have a legal, contractual or regulatory requirement to consider safety within their designs (Behm, 2005).

The fundamental principle of DfS is for "Improved safety, health and environment outcomes through better design…" (Trethewy and Atkinson, 2003, p187). Such a process should identify and where possible eliminate or minimise risks to construction workers (Behm, 2005; Toole and Gambatese, 2008). This should also be extended to include the operation/maintenance phase (Trethewy and Atkinson, 2003) as well as the demolition of the facility, a principle that is covered by the CDM regulations in the UK.

The Construction (Design and Management) Regulations 1994 (HMSO, 1994), updated in 2007 (HMSO, 2007) and again in 2015 (HSE,2015), were introduced by the UK Government as a specific response to the European Union directive 92/57/EEC which attributed a significant responsibility to designers for causes of construction accidents."…unsatisfactory architectural and/or organizational options or poor planning of the works at the project preparation stage have played a role in more than half of the occupational accidents occurring on construction sites in the Community" (EEC, 1992).

Baxendale and Jones (2000) cited in Cameron & Hare (2008) noted that the perception of many within the industry was that the regulations were failing in their objectives and simply creating another level of bureaucracy and superfluous amounts of paperwork.

The negative view of the effectiveness of the CDM regulations is further echoed by John Anderson, a former HSE Senior Inspector who stated the following in Howarth et al., 2000, p 434); “It is not just that the CDM Regulations have had no effect, they have had the wrong effect. They have cost the construction industry hundreds of millions of pounds in pointless filing and there has been no measurable improvement in the accident records.”

This suggests that few UK designers embrace the principle of DfS despite the CDM regulations being in force for almost two decades. The majority fail even to recognise the impact on safety that they, as designers, can make (Haslam et al, 2005). Several reasons have been identified as being barriers to designers; lack of resources and time, cost, client requirements and a lack of tacit knowledge gained through experience (Haslam et al, 2005; Behm, 2005).

One issue is that drawings and models produced by design teams represent the completed artefact with little or no reference to the construction processes required to construct the facility (Hadikusumo and Rowlinson, 2004; Hadikusumo and Rowlinson) 2002;). The fulcrum of DfS is the identification of hazards and if these hazards are associated with processes not included within the design information; their identification relies upon tacit knowledge of the designer which has been gained through experience (Gangolells et al, 2010; Hadikusumo and Rowlinson, 2004).

Gaining the tacit knowledge for identification of construction process hazards could be acquired on construction sites where designers can observe construction activities and talk to the operatives and tradesmen (Hayne et al, 2014). However, it should be noted that in the UK, both the Institution of Civil Engineers and the Institution of Structural Engineers no longer require graduate engineers en-route to becoming chartered to spend prolonged periods on site as part of their training requirements

(Hayne et al, 2015). Worryingly, both the Institution of Civil Engineers, (2013) and Institution of Structural Engineers, (2014) believe that the prescribed site experience can now be gained through an aggregation of short visits for meetings or inspections. This coincides with an increase in academic qualifications required to gain chartered engineer status

Nevertheless, a different perspective and arguably one that is equally valid, has been proposed by Toole and Gambatese (2008, p 225) who suggest that many site hazards are the result of "… forces, stresses, dynamic motion, and electricity …" which require a high level of education in order to make appropriate safety decisions.

The discussion above suggests that there is a lack of research into the relationship between hazard perception in designs and site experience. Therefore, interviews were carried out with practising engineers and a series of tests were undertaken to establish if an association exists and if so to identify the significance of such an association.

Research Methods

Interviews with practitioners

The primary focus of the interviews was to determine the engineers' views on the impact of the changing requirement of site experience and increased qualifications required to achieve chartered status. A purposive sample of structural engineers representing five different organisations was selected who all began their careers before these changes came into force. Interviews were undertaken until saturation was reached with the final sample consisting of six engineers and a steel fabricator as set out in table 1.

Table 1. Details of interview sample

Alias	Background	Years in industry	Route into industry
John	Experience in Consulting Engineering in UK, North America and Gulf states.	25	HND in Civil Engineering, BSc Civil Engineering
Alan	Experience in Consulting Engineering in the UK but with some time in Gulf States.	40	BSc Civil Engineering
Phil	Experience in Consulting Engineering in the UK prior to last 3 years in China	27	BSc Civil Engineering
Paul	Experience in Consulting Engineering in the UK.	27	BSc Civil Engineering
Adam	Experience in Consulting Engineering in the UK with some time in KSA and USA.	33	BSc Civil Engineering
Tom	Experience in Consulting Engineering in the UK.	29	BSc Civil Engineering
Glen	All work experience in steel fabricators in the UK	30	Practice based apprenticeship and ONC

Hazard perception tests

Two sets of hazard perception tests were conducted. The first test was carried out on a group of final year, undergraduate, Civil Engineering students at an English University with a large cohort. The second test was conducted on a vertical cross section of structural engineers working for a leading firm of multidisciplinary consulting engineers.

A 3D Revit model of a four storey insitu concrete framed office block was created as a base for the test. The model had 60 known hazards and examples of bad practice incorporated within the design. 2D elevations, plans, sections and details were cut from the model along with sheets that contained 3D images of the model.

The test participants were provided with the 2D drawings and asked to identify as many hazardous processes, operations or forms of construction as possible from the information provided. They were asked to give details of the specific hazard that had been caused and alternatives that could reduce or eliminate the hazard. When they had identified all the hazards they could, they were given the 3D images of the model and asked to repeat the process.

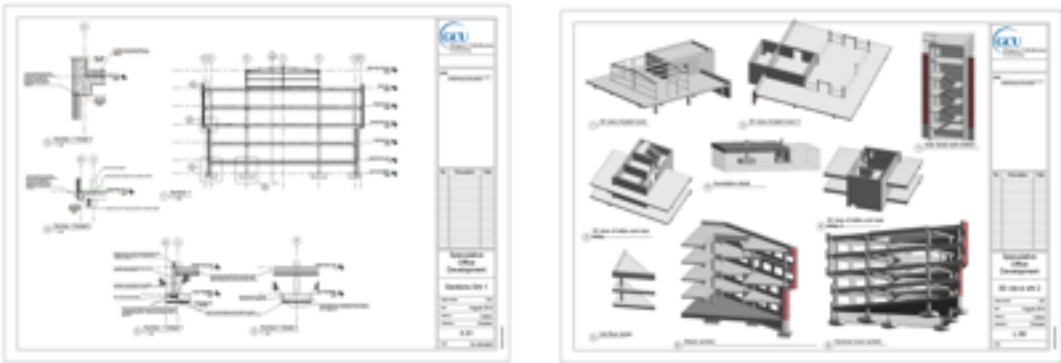

Figure 1, Example of the layout of the 2 and 3D drawings used in the hazard tests

RESEARCH RESULTS

Interviews with practitioners

It is evident that site experience is considered as an integral part of the development of design engineers. All of the interviewees extolled the virtues of a significant period of site experience. "I think going out on site is vitally important" (Paul).

Likewise, all the engineers expressed concern that the Institutions of Civil and Structural Engineers were now accepting an accumulation of separate visits to attend site meetings or inspections in lieu of prolonged periods of continuous site experience. "People are now cobbling together through site meetings enough days to qualify" (Alan). "Well, it's a cop out really isn't it? Because it's easy to visit site, look at things, write a report and go home" (Phil). "… attending site meetings and doing an inspection and a walk round site just doesn't do it. You don't learn the same things and you're not as equipped as if you've done that fuller experience" (John). These views are particularly concerning bearing in mind that all the statements are from engineers who, or have previously, acted as Supervising Engineers guiding and managing graduate trainees on company approved training schemes.

Concern exists that undertaking brief site visits would not immerse the engineer in the atmosphere of a site. They would not be party to witnessing many of the problems, which are often different in character to office problems. In a visiting role the engineer would not be involved in solving many of these problems. "If you have got a bit of steel and it does not fit you have to work out what to do with it" (Phil).

Although these concerns were universally expressed by the engineers, one interviewee raised the issue of what type of experience could be gained on site (Adam). He suggests that "site experience is good but it's got to be the right sort of site experience". He argues that if all the engineer's time was spent in the site office valuable experience would not be gained.

There was a common belief that being resident on site enabled younger engineers to witness potential hazards "If you are on site there are so many safety hazards that come up during the course of the working day and things that you can not necessarily plan for. To see the contractor's approach to safety and to understand that is key" (John). The engineers interviewed, without exception, found their site experiences to be of great value "When I look back at my site experience and how valuable that was I still use stuff that I learnt from site all those years ago" (Tom) "you gain a good understanding and experience of what happens, that will inevitably inform you not only about the safety aspect but also about the time things take" (Adam). The practical and tacit knowledge that can be gained on site was also raised "…you used to learn how these guys are going to build this thing" (Tom). Specific examples were also provided "It can be easy to say just weld a plate in there but it turns out that access isn't that great and you think we might be better off using a bolted bracket" (Glen).

Considering the increased academic requirements of an MSc to become chartered with the ICE and the IStructE, the professional diversity of engineering offices was discussed. "Everyone is now going for the degree route…we are becoming too academic" (Alan). The result of the academic focus was vocalised as potentially leading to the demise of the traditional draughtsman/technician, who had the practical experience and "would really understand how buildings were put together and what was needed" (John). The experience that these technicians bring to the profession "is important, to know how a building goes together … and [they] are invaluable to spot issues" (Adam).

The interviewees were asked if the teams needed a spread of experiences and backgrounds encompassing academic engineers, practical engineers and traditionally trained technicians. The overwhelming response was that "There are benefits to both, to have a mixed team" (Adam) "It has to be balanced" (Alan).

Hazard test results

Student tests

The entire cohort of 47 final year students took part in the hazard perception test in November 2014. 28 of the students had gained site experience during their industrial placement in the third year of their studies.

The results indicated a wide range of responses with no patterns developing during the early analysis. The maximum number of hazards identified was twenty five and the minimum was four. The split between the number of hazards identified in the 2 or 3D mediums also appeared to be random.

Further analysis was then undertaken and the identified hazards were categorised as either specific or generic. Specific hazards related to information contained on the drawings, for example, the requirement to carryout site welding. Generic hazards related to generalised hazards such as concrete burns, etc. For the ongoing analysis the generic hazards were excluded.

The 473 specific hazards were categorised further to identify if they related to spatial issues (194 No.) such as trip hazards, poor access etc., or construction processes (258 No.) such as excavation, welding etc., or design issues such as stability (6 No.).

The hazards associated with construction processes were then graded in line with the recommendations of the 'Management of risk when planning work' (HSE, 2011). The document sets out an ideal order for mitigation on a scale of 1 to 5 aligning with elimination, substitution, engineering controls, administrative controls and finally PPE. 22 students identified and mitigated 29 hazards that were categorised as level 1. The full results are shown in figure 2.

Cat.1 Elimination

Cat.2 Substitution

Cat.3 Engineering controls

Cat.4 Administration controls

Cat. 5 Personal protective equipment

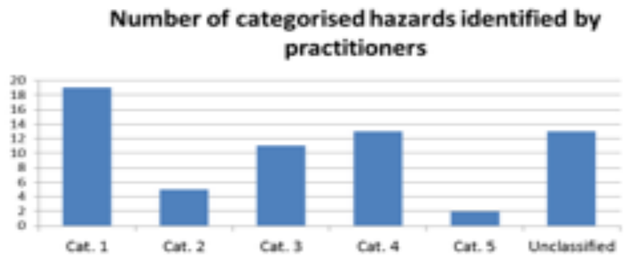

Figure 2, Number of hazards identified by students categorised 1 to 5 and ungraded

The process hazards were also analysed to identify which exhibited a clear understanding of the construction processes / operations or a sound vocabulary of the actions that could be taken to mitigate a risk eg. a permit to work system or safe lifting plan. Within this category 53 hazards were identified by 22 students.

The final analysis was to establish if site experience had any effect on the ability to mitigate hazards or the acquisition of good knowledge or vocabulary. The results of this test showed that, in both cases, site experience appeared to contribute to the ability to mitigate hazards or exhibit good understanding of the construction processes. The results are shown in Figure 3.

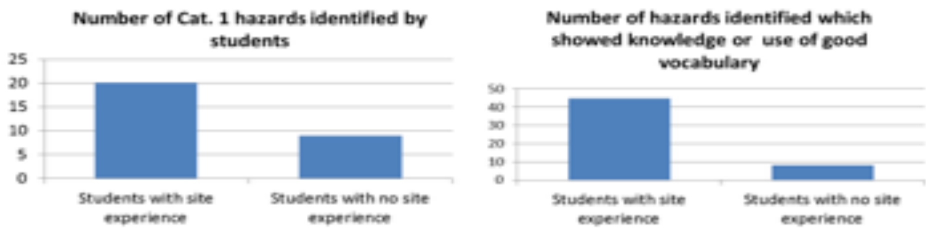

Figure 3. Effect of site experience on Cat.1 hazards identified and understanding/good vocabulary

Practitioner tests

The practitioner tests were carried out on a cross-section of structural engineering staff in a regional office of a leading firm of multidisciplinary consulting engineers. The sample comprised of 12 staff members; 2 senior technicians and a technician (15, 18 and 9 years' experience), 2 graduate engineers (1 and 0 years' experience) and 7 engineers (between 8 and 20 years' experience).

One technician and five engineers had acquired site experience on a full time basis at some period during their careers. The technician had spent three months on a project in the Middle East working for the designers. The five engineers had all acquired their experience in the UK being based on site for between three months and one year. The remaining four engineers and two technicians had either no site experience or experience gained during visits for meetings or inspections.

A total of 154 hazards were identified comprising of 14 generic and 140 specific hazards which comprised of 48 spatial, 63 process and 29 design issues. As before the process hazards were categorised according to the management of risk when planning work (HSE, 2011) with 30% being category 1. It is noted that a much greater proportion of the hazards identified by the practitioners were categorised as category 1 where the hazard was eliminated. Full results are shown in figure 4.

Cat.1 Elimination

Cat.2 Substitution

Cat.3 Engineering controls

Cat.4 Administration controls

Cat. 5 Personal protective equipment

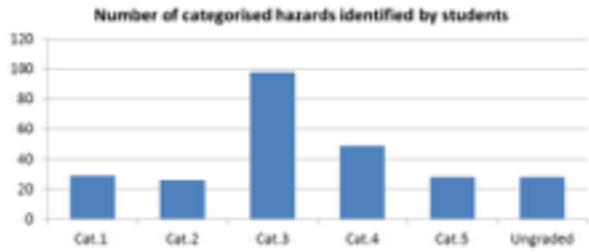

Figure 4. Number of hazards identified by practitioners categorised 1 to 5 and ungraded

An analysis of the category 1 hazards was undertaken similar to the student tests with 19 hazards being identified by 7 members of staff, the results being shown in figure 5.

Figure 5. Effect of site experience on Cat.1 hazard mitigation for practitioner tests

With the exception of one hazard identified by a fresh graduate, the remaining category 1 hazards were all identified by engineers with at least 8 years in the industry. The vast majority of the responses showed a good understanding so these specific results were not analysed to determine the potential effect of site experience.

DISCUSSION

The hazard perception test results undertaken by both the students and practising engineers produced noteworthy results. The research appears to show a possible link between the ability to identify and mitigate hazards (Category 1) to prolonged periods of site experience. Whilst this link is perhaps not unexpected, little research is known to exist that demonstrates the association that the empirical evidence is indicating. The link is further reinforced by the subjective testimony of the interviews with experienced engineers. It is clear that they believe site experience is imperative in understanding site activities and, therefore, being able to identify potential hazards.

Whilst the link between site experience and the mitigation of hazards is similar for students and practitioners, they differ appreciably in the number of design hazards that are identified. Of the hazards identified by the students, 1% were related to design issues whereas 19% of the hazards identified by the engineers related to design issues. Additionally, all except one of the design hazards were identified by engineers with at least 8 years' experience. A potential reason for this divergence could again be linked to the relative experiences of the two groups. The engineers have appreciably more experience of design and the associated hazards such as lack of movement joints in brickwork or floor loadings than the students who have not been exposed to prolonged periods of time in design offices.

The cohort of engineers who took part in the test comprised of the entire structural engineering group within the office with the exception of the 2 directors who were unavailable that day. All the engineers were university educated having bachelor degrees with the younger engineers and graduate engineers also having masters degrees, as now required by the institutions. None of the designers had progressed through the HNC/HND route which would have probably been the case 20 years ago. It is evident that this demographic is not a team of mixed experiences encompassing academic engineers, practical engineers and traditionally trained technicians as extolled in the interviews with practitioners. The composition of the group could be argued as polarised and unbalanced compared with the spread of experience that would have been evident 20 years ago.

DfS relies on an ability to identify and mitigate hazards during the design stage of a project. The existence of a potential link between hazard identification and site experience raises doubt in the competence of building designers to deliver DfS particularly as fewer engineers are now undertaking prolonged periods of site experience.

CONCLUSIONS AND RECOMMENDATIONS

The empirical research indicates a potential link between the ability to identify hazards in designs and extended periods of site experience. The connection is evident in undergraduate students and practising engineers which questions the viability of the engineering institutions decision to remove the requirement of site based training placements in order to become chartered.

This link raises serious questions about the effectiveness of design engineers lacking extensive site experience being able to identify construction hazards within their designs. This is reinforced by the subjective data from the interviews which also relates site experience with an understanding of site processes. The interviewees also raise the issue of a lack of diversity in the experience of engineers as they are increasingly all university educated and very few are progressing through the HND/HNC route. These issues raise significant questions of the ability and effectiveness of modern design studios to deliver the principles of design for safety, particularly for construction hazards.

Although the interviewees represented several companies the hazard tests were conducted at a single office and further tests at other companies should be carried out. Additionally, research should be carried out to investigate if the different types of site experience (contractor, resident engineer or specialist sub-contractor, etc.) impact the ability to identify hazards in designs.

REFERENCES

Baxendale, T. Jones, O. (2000) Construction design and management safety regulations in practice—progress on implementation. International Journal of Project Management, vol.18, pp.33–40.

Behm, M., 2005. Linking construction fatalities to the design for construction safety concept. Safety Science, 43(8), pp. 589-611.

Cameron, I., Hare, B. (2008) Planning tools for integrating health and safety in construction, Construction Management and Economics, vol. 26:9, pp. 899-909

EEC, (1992), European Union directive 92/57/EEC temporary or mobile construction sites, [Online] Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:01992L0057-20070627&from=EN [Accessed 25 April 2013]

Gibb, A., Haslam, R., Gyi, D., Hide, S., Duff. R., (2006) What causes accidents? Civil Engineering 159, 46-50.

Gambatese, J.A., Behm, M., Rajendran, S., (2008) Designers role in construction accident causality and prevention: Perspective from an expert panel, Safety Science vol.46, pp.675-691

Gambatese, J.A., and Hinze, J.W., Haas, C.T., (1997), Tool to design for construction worker safety, Journal of Architectural Engineering, ASCE3 (1), 32-41.

Gangolells, M., Casals, M., Forcada, N., Roca, X. Fuertes, A. (2010) "Mitigating construction safety risks using prevention through design", Journal of Safety Research, Vol. 41, no. 2, pp. 107-122.

Hadikusumo, B.H.W. Rowlinson, S. (2002) "Integration of virtually real construction model and design-for-safety-process database", Automation in Construction, Vol. 11, no. 5, pp. 501-509.

Hadikusumo, B.H.W. Rowlinson, S. (2004) "Capturing safety knowledge using design-for-safety-process tool", Journal of Construction Engineering and Management, Vol. 130, pp. 281-289.

Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, D.E., Pavitt, T., Atkinson, S. (2005) "Contributing factors in construction accidents", Applied Ergonomics, Vol. 36, pp. 401-415.

Hayne, G., Kumar, B., Hare, B. (2014) The Development of a Framework for a Design for Safety BIM tool. Proceedings of the 2014 International Conference on Computing in Civil and Building Engineering pp. 49-56

Hayne, G., Kumar, B., Hare, B. (2015) The Development of a Framework for a Design for Safety BIM tool. Proceedings of ARCOM Doctoral Workshop Health, Safety and Wellbeing. 11th February 2015. University of Edinburgh. pp. 21-35

Howarth, T., Stoneman, G., Hill, C. (2000) A review of the construction (design and management) regulations, Association of Researchers in Construction Management, vol. 1, pp433-441

HMSO (1994) Construction(Design and Management)Regulations 1994, [Online] Available at: http://www.legislation.gov.uk/uksi/1994/3140/contents/made [Accessed:23April 2013]

HMSO (2007) Construction(Design and Management)Regulations 2007, Her Majesties Stationary Office, London

HSE (2011) Management of risk when planning work: The right priorities [Online] Available at: http://www.hse.gov.uk/construction/lwit/assets/downloads/hierarchy-risk-controls.pdf [Accessed: 23 January 2015]

HSE (2015) Managing health and safety in construction. Construction (Design and Management) Regulations 2015 Guidance on Regulations [Online] Available at: http://www.hse.gov.uk/pubns/priced/l153.pdf [Accessed 16 April 2015]

Institution of Civil Engineers (2013) Membership Guidance Note MGN 42 – Site experience requirements for candidates, involved in the construction process, who are preparing for a Professional Review

Institution of Structural Engineers (2014) Initial professional development [Online] Available at: http://www.istructe.org/webtest/files/31/319c117a-a1e4-475e-b5c9-01711684155c.pdf [Accessed: 30May 2012]

Lingard, H.C., Cooke, T. Blismas, N. (2012) Designing for construction workers' occupational health and safety: a case study of socio-material complexity. Construction Management and Economics, 30(7), pp. 599-599.

Martínez Aires, M.D., Rubio Gámez, M.C. Gibb, A. (2010) "Prevention through design: The effect of European directives on construction workplace accidents", Safety Science, Vol. 48, No. 2, pp. 248-258.

Trethewy, R.W., Atkinson, M. (2003) Enhanced Safety, Health and Environment Outcomes Through Improved Design, Journal of Engineering, Design and Technology, Vol. 1 Iss 2 pp. 187-201.

Toole, T. M., Gambatese, J., (2008) The trajectories of prevention through design in construction, Journal of Safety Research vol.29, pp.225-230.

THE NEED FOR THE INCLUSION OF CONSTRUCTION HEALTH AND SAFETY (H&S) IN ARCHITECTURAL EDUCATION TO ASSURE HEALTHIER AND SAFETY CONSTRUCTION

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A disproportionate number of accidents occur in construction relative to other industries, the direct and indirect cost of which, contributes to the cost of construction. Construction is a multi-stakeholder process and consequently all stakeholders, architectural designers included, influence the construction process. Design influences and impacts on construction health and safety (H&S) directly and indirectly. Given the aforementioned, architectural designers should be empowered to contribute to construction H&S. However, the need for such empowerment is amplified by legislation in certain countries, such as the OH&S Act and Construction Regulations in South Africa.

The primary objectives of the study were to determine architectural designers' perceptions with respect to the influence and impact of architectural design on construction H&S, and the extent to which architectural departments at Universities and Universities of Technology address construction H&S. A descriptive survey was conducted among architectural departments at Universities and Universities of Technology in South Africa using self-administered questionnaires.

Findings include: construction H&S is addressed / included to a degree in architectural programmes, and the importance of the inclusion of a range of subject areas relative to construction H&S in an architectural programme, the extent to which actions / activities / aspects impact on construction H&S, and the extent to which design related aspects impact on construction H&S were identified to varying degrees.

It can be concluded that construction H&S is not embedded in architectural programmes, and respondents have an appreciation of the importance of the inclusion of construction H&S in the tertiary education programmes of the built environment disciplines, but less so relative to the design disciplines. Furthermore, there is a degree of appreciation for the: importance of the inclusion of a range of subject areas relative to construction H&S in an architectural programme; extent to which actions / activities / aspects impact on construction H&S, and extent to which design related aspects impact on construction H&S.

The findings of the literature and descriptive surveys amplify the need for the following relative to architectural programmes: the inclusion of construction H&S as a module; consideration of H&S when designing, detailing, and specifying, and the inclusion of H&S among the criteria used for evaluating design projects and working drawings.

Keywords: Architectural education, Construction, Design, Health and safety

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INTRODUCTION

Twenty-three years ago the International Labour Office (ILO) (1992) specifically stated that designers should: receive training in H&S; integrate the H&S of construction workers into the design and planning process; not include anything in a design which would necessitate the use of dangerous structural or other procedures or hazardous materials which could be avoided by design modifications or by substitute materials, and take into account the H&S of workers during subsequent maintenance.

Thorpe (2006) in turn states that there is no more important stage in the construction process than that of design as at this stage conceptual ideas are converted into constructable realities. He further states that a variety of considerations need to be balanced simultaneously, *inter alia*, designing for H&S. He highlights that designing for H&S is an integral part of the wider design process and therefore needs to be included in design planning as doing so will result in healthier and safer construction and maintenance of structures and facilities.

Given the aforementioned, prior research conducted by the author (Smallwood, 2002), and the Department of Construction Management's focus on the role of all built environment stakeholders in construction H&S, a survey was conducted among Departments of Architecture and Architectural Technology based at traditional universities and universities of technology respectively to determine:

- Whether architectural programmes address construction H&S, and if so, the form in which it is addressed;
- The importance of the inclusion of construction H&S in the tertiary education programmes of built environment disciplines;
- The importance of the inclusion of subject areas relative to construction H&S in an architectural programme;
- The extent to which actions / activities / aspects impact on construction H&S, and
- The extent to which design related aspects impact on construction H&S.

Furthermore, architectural practitioners attending a one-day 'Designing for Construction H&S' seminar were surveyed to determine their perceptions relative to construction H&S in general and also 'designing for construction H&S' and related issues.

REVIEW OF THE LITERATURE

Legislation and recommendations pertaining to designers

Within the context of South Africa, prior to the promulgation of the Construction Regulations in 2003, all designers were required to address H&S, as in terms of Section 10 of the OH&S Act (Republic of South Africa, 1993) designers are allocated the responsibility to ensure that any 'article' is safe and without risks when properly used.

However, the Construction Regulations (Republic of South Africa, 2014) lay down important requirements with respect to clients and designers. Clients are required to, *inter alia*: prepare a baseline risk assessment (BRA); prepare an H&S specification based on the BRA; provide the designer with the H&S specification; ensure that the designer takes the H&S specification into account during design; ensure that the designer carries out the duties in Regulation 6 'Duties of designers'; include the H&S specification in the tender documents; ensure that potential principal contractors (PCs) have made provision for the cost of H&S in their tenders, and ensure that the PC to be appointed has the necessary competencies and resources.

In terms of the Construction Regulations, designers include architects, engineers, interior designers, landscape architects, and quantity surveyors. Construction project managers (CPMs) may also be included depending on the functions they fulfill. Designers are required to, *inter alia*: ensure that the H&S standards incorporated into the regulations are complied with in the design; take the H&S specification into consideration; include in a report to the client before tender stage all relevant H&S information about the design that may affect the pricing of the work, the geotechnical-science aspects, and the loading that the structure is designed to withstand; inform the client of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is changed; modify the design or make use of substitute materials where the design necessitates the use of dangerous procedures or materials hazardous to H&S, and consider hazards relating to subsequent maintenance of the structure and make provision in the design for that work to be performed to minimize the risk.

Impact of designers on construction H&S

Design influences and impacts on construction H&S directly and indirectly. Directly through: concept design; selection of structural frame; detailed design; selection of cladding, and specification of materials. Indirectly through: the selection of procurement system; related interventions such as prequalification; decision regarding project duration, and selection of contractor (Smallwood, 2008).

Furthermore, Behm (2006) analysed 450 reports of construction workers' deaths and disabling injuries in the USA to determine whether addressing H&S in the project designs could have prevented the incidents. The findings of this research identified that in 151 cases (33.6%), the hazard that contributed to the incident could have been eliminated or reduced if design-for-H&S measures had been implemented.

Obstacles to designing for construction H&S

Hecker et al. (2006) cite the following as obstacles to designing for construction H&S: the narrow specialisation of design and construction practice; limited pre-construction collaboration between the designer and constructor due to the traditional construction procurement system (TCPS); the limited availability of H&S-in-design tools, guidelines and procedures, and the limited education architects and engineers receive regarding construction H&S.

The Construction Industry Development Board (cidb) (2009) report highlights that H&S relevant education and training (or lack thereof), at all levels, has a major impact on construction H&S. At the tertiary level, not all construction related programmes in South Africa include H&S within their curricula.

Health and Safety and the six stages of projects

Within the context of South Africa, it is notable that the South African Council for the Architectural Profession's (SACAP's) Interim Policy on the Identification of Work for the Architectural Profession (Republic of South Africa, 2011) does not mention H&S in any of the six stages of work in terms of providing a standard service: inception; concept and viability; design development; documentation and procurement; construction contract administration, and close out. This is in stark contrast to, *inter alia*, the identification of work for Construction Managers, and CPMs, which record a range of H&S interventions over the six stages. In the case of CPMs, *inter alia*, the following: facilitate input from the designer as required by the H&S agent; facilitate and monitor the presentation of the H&S specification by the H&S agent; monitor the preparation of the H&S plan by the PC, and the approval thereof by the H&S agent; monitor the auditing of the PC's H&S performance relative to their H&S plan by the H&S agent, and monitor the production of the H&S file by the PC and the H&S agent.

RESEARCH METHOD

Development of the survey instrument

The actions / activities / aspects and the design related aspects which impact on construction H&S, and the importance of the inclusion of subject areas relative to construction H&S in an architectural programme, were derived from a previous study conducted by the author (Smallwood, 2008).

Sample strata

The first study was conducted among 19 architectural practitioners attending a one-day 'Designing for Construction H&S' seminar. They were required to indicate their degree of concurrence with 28 statements upon commencement and completion of the seminar, which all 19 did.

The sample stratum for the 'Inclusion of Construction H&S in Architectural Education' study consisted of twelve Departments of Architecture and Architectural Technology based at traditional universities and universities of technology respectively. The respective heads of departments (HoDs) were surveyed using a self-administered questionnaire delivered per e-mail. Six responses were received, which equates to a response rate of 50%.

Research findings 1

Table 1 indicates the degree of concurrence relative to 10 'designer related' statements of a total of 28 statements in terms of mean scores (MSs) between 1.00 and 5.00, based upon percentage responses to a scale of strongly disagree to strongly agree. It is notable that all the MSs > 3.00, which should be the case. However, both the pre and post-seminar MSs relative to 'Tertiary designer education should include construction H&S' are > 4.20 ≤ 5.00, which indicates the concurrence is between agree to strongly agree / strongly agree. It is notable that the post-seminar MSs relative to 'Design influences H&S', 'Design can positively influence H&S', and 'Designers can identify hazards at design stage' also fall within the same range. Then, the other statements' MSs are all > 3.40 ≤ 4.20, which indicates the concurrence is between neutral to agree / agree, namely 'Design can negatively influence H&S', 'Design can negatively influence H&S', 'Designers can quantify risk at design stage',

'Designers can mitigate hazards at design stage'. 'Designers can eliminate hazards at design stage', 'Design contributes to accidents', and 'Designing for H&S is a designer competency'. Furthermore, with the exception of 'Design can negatively influence H&S' all the post-seminar MSs were higher than the pre-seminar MSs. The greatest percentage increase was relative to 'Designers can quantify risk at design stage' (24.2%), followed by 'Designers can eliminate hazards at design stage' (21.5%), and 'Designers can identify hazards at design stage' (14.4%).

Table 1: Degree of concurrence with statements by 'Designing for Construction H&S' seminar delegates

Statement	MS		Diff
	Pre	Post	(%)
Design influences H&S	4.00	4.32	8.0
Design can positively influence H&S	3.89	4.21	8.2
Design can negatively influence H&S	3.79	3.68	(2.9)
Designers can identify hazards at design stage	3.68	4.21	14.4
Designers can quantify risk at design stage	3.26	4.05	24.2
Designers can mitigate hazards at design stage	3.89	4.16	6.9
Designers can eliminate hazards at design stage	3.16	3.84	21.5
Design contributes to accidents	3.26	3.47	6.4
'Designing for H&S' is a designer competency	3.68	3.84	4.3
Tertiary designer education should include construction H&S	4.21	4.47	6.2

Research findings 2

66.7% of the responding HoDs stated that their Departments of Architecture addressed / included construction H&S in their architectural programme / curriculum. 33.3% responded in the negative.

In terms of the form construction H&S is addressed, no departments offered a 'Separate subject' construction H&S. 66.7% maintained that it is an 'Issue in design project briefs', and 33.3% responded relative to each of 'Criterion for assessment in design project assessments', 'Component of a subject', 'Module in various subjects', and 'On an ad-hoc basis' (Table 2).

Table 2: Form in which construction H&S is addressed / included in the architectural programme / curriculum offered by responding Departments of Architecture HoDs

Form	Response (%)		
	Unsure	Yes	No
Separate subject	0.0	0.0	100.0
Issue in design project briefs	0.0	66.7	33.3
Criterion for assessment in design project assessments	0.0	33.3	66.7
Component of a subject	0.0	33.3	66.7
Module in various subjects	0.0	33.3	66.7
On an ad-hoc basis	0.0	33.3	66.7

Table 3 indicates the importance of the inclusion of construction H&S in the tertiary education programmes of nine built environment disciplines in terms of percentage responses to a scale of 1 (hardly) to 5 (very), and MSs between 1.00 and 5.00 according to Departments of Architecture HoDs. It is notable that 8 / 9 (88.9%) of the MSs are > 3.00, which indicates that in general the inclusion of construction H&S in the tertiary education programmes of the disciplines can be deemed to be more than important as opposed to less than important. However, a review of the MSs in terms of ranges provides a more detailed perspective. 5 / 8 (62.5%) MSs > 4.20 ≤ 5.00, which indicates that the importance can be deemed to be between more than important to very important / very important: Construction Management; Civil Engineering; Electrical Engineering; Mechanical Engineering, and Project Management. The disciplines ranked sixth to eighth have MSs > 2.60 ≤ 3.40, which indicates the importance can be deemed to be between less than important to important / important: Landscape Architecture; Architecture, and

Quantity Surveying. It should be noted that the MS of Landscape Architecture, namely 3.40, is at the upper end of the range. The MS of Interior Design (2.60) falls within the range > 1.80 ≤ 2.60 and thus the importance can be deemed to be between hardly important to less than important / less than important. In essence, it is important that construction H&S is included in the tertiary education programmes of all nine built environment disciplines.

Table 3: Importance of the inclusion of construction H&S in the tertiary education programmes of nine built environment disciplines according to responding Departments of Architecture HoDs

Discipline	Response (%)						MS	Rank
	Unsure	Hardly……………….…………… Very						
		1	2	3	4	5		
Construction Management	0.0	0.0	0.0	0.0	0.0	100.0	5.00	1
Civil Engineering	0.0	0.0	0.0	0.0	25.0	75.0	4.75	2
Electrical Engineering	0.0	0.0	0.0	0.0	50.0	50.0	4.50	3
Mechanical Engineering	0.0	0.0	0.0	25.0	25.0	50.0	4.25	4
Project Management	0.0	0.0	25.0	0.0	0.0	75.0	4.25	5
Landscape Architecture	0.0	0.0	20.0	40.0	20.0	20.0	3.40	6
Architecture	0.0	16.7	16.7	16.7	16.7	33.3	3.33	7
Quantity Surveying	0.0	0.0	25.0	50.0	0.0	25.0	3.25	8
Interior Design	0.0	20.0	20.0	40.0	20.0	0.0	2.60	9

Table 4 indicates the importance of the inclusion of nineteen subject areas relative to construction H&S in an architectural programme in terms of percentage responses to a scale of 1 (hardly) to 5 (very), and MSs between 1.00 and 5.00 according to responding Departments of Architecture HoDs. It is notable that 13 / 19 (68.4%) of the MSs are > 3.00, which indicates that in general the inclusion of the subject areas relative to construction H&S in an architectural programme can be deemed to be more than important as opposed to less than important. However, a review of the MSs in terms of ranges provides a more detailed perspective. No MSs > 4.20 ≤ 5.00 - between more than important to very important / very important. 9 / 19 (47.4%) of the MSs > 3.40 ≤ 4.20, which indicates that the importance can be deemed to be between important to more than important / more than important. ‘Occupational health’ and ‘Occupational safety’, which are ranked first and second is important as architects need to be knowledgeable with respect to the related issues. Similarly with respect to third ranked ‘OH&S Act & Regulations’. Fifth ranked ‘H&S specifications’ are of particular importance as in terms of the South African Construction Regulations, clients are required to provide designers with an H&S specification, which is based upon their baseline risk assessment and includes their H&S requirements. Designers are then required to provide the client with a report, which although not stated in the regulations should indicate the residual risk. Clients are also required to provide principal contractors the H&S specification, and to respond in the form of an H&S plan, which is ranked fourth. Therefore, designers should also review such H&S plans to determine the PC and contractors’ response to design related construction H&S issues. Sixth ranked ‘Role of project managers in construction H&S’ is important as project managers are invariably the lead consultant on most large projects in South Africa. Role of construction H&S in project performance, ranked seventh, is important relative to all stakeholders as it constitutes the motivation for their contributing thereto. Eighth ranked role of designers in construction H&S and ninth ranked specifying for construction H&S are important as as they empower graduates to contribute positively to construction H&S.

MSs > 2.60 ≤ 3.40 indicate that the importance can be deemed to be less than important to important / important, more so those > 3.00. Tenth ranked need for construction H&S and eleventh ranked designing for construction H&S both have MSs of 3.40, which are the upper limit of the range. Stakeholders need to understand and appreciate the need for construction H&S in terms of the motivation for their contributing thereto.

Table 4: Importance of the inclusion of subject areas relative to construction H&S in an architectural programme according to responding Departments of Architecture HoDs

Subject area	Response (%)						MS	Rank
	Unsure	Hardly…………………………Very						
		1	2	3	4	5		
Occupational health	0.0	0.0	0.0	16.7	50.0	33.3	4.17	1
Occupational safety	0.0	0.0	0.0	16.7	50.0	33.3	4.17	2
OH&S Act & Regulations	0.0	0.0	0.0	33.3	33.3	33.3	4.00	3
H&S plans	0.0	0.0	0.0	33.3	33.3	33.3	4.00	4
H&S specifications	0.0	0.0	0.0	50.0	16.7	33.3	3.83	5
Role of PMs in construction H&S	0.0	0.0	16.7	16.7	33.3	33.3	3.83	6
Role of construction H&S in project performance	0.0	0.0	16.7	0.0	83.3	0.0	3.67	7
Role of designers in construction H&S	0.0	0.0	0.0	66.7	0.0	33.3	3.67	8
Specifying for construction H&S	0.0	0.0	16.7	33.3	33.3	16.7	3.50	9
Need for construction H&S	16.7	0.0	16.7	16.7	50.0	0.0	3.40	10
Designing for construction H&S	0.0	20.0	0.0	20.0	40.0	20.0	3.40	11
Hazard identification and risk assessment	0.0	16.7	16.7	16.7	16.7	33.3	3.33	12
Designing for construction ergonomics	0.0	16.7	16.7	0.0	66.7	0.0	3.17	13
Role of QSs in construction H&S	0.0	0.0	50.0	0.0	50.0	0.0	3.00	14
Detailing for construction H&S	0.0	16.7	16.7	33.3	33.3	0.0	2.83	15
Role of clients in construction H&S	0.0	0.0	50.0	33.3	16.7	0.0	2.67	16
Environment and construction H&S	0.0	16.7	33.3	16.7	33.3	0.0	2.67	17
Economics of construction H&S	0.0	33.3	33.3	0.0	16.7	16.7	2.50	18
Influence of procurement on construction H&S	16.7	33.3	16.7	16.7	16.7	0.0	2.20	19

Designing for construction H&S, twelfth ranked hazard identification and risk assessment, thirteenth ranked designing for construction ergonomics, and seventeenth ranked detailing for construction H&S are important as they empower graduates to contribute positively to construction H&S. Fourteenth ranked role of quantity surveyors in construction H&S, and sixteenth ranked role of clients in construction H&S are important as they enable an understanding and appreciation of the role of the other stakeholders. Eighteenth ranked environment and construction H&S is important as many environment and H&S issues are interrelated.

MSs > 1.80 ≤ 2.60 indicate that the importance can be deemed to be hardly important to less than important / less than important. Despite the MSs and related rankings, economics of construction H&S, and influence of procurement on construction H&S are both important.

Table 5 indicates the extent to which fourteen actions / activities / aspects impact on construction H&S in terms of percentage responses to a scale of does not, and 1 (minor) to 5 (major), and MSs between 0.00 and 5.00 according to responding Departments of Architecture HoDs. It is notable that 12 / 14 (85.7%) of the MSs are > 3.00, which indicates that in general they are deemed to have a major as opposed to a minor impact on construction H&S. During the prior study conducted by Smallwood (2008) only 9 / 14 (64.3%) of the MSs were > 3.00.

First ranked H&S pre-qualification of contractors, which is a Stage 4 and procurement related action, is the only action / activity / aspect with a MS > 4.17 ≤ 5.00 – deemed to have between a near major to major / major impact on construction H&S.

Second to sixth ranked actions / activities / aspects have MSs > 3.34 ≤ 4.17 – deemed to have between an impact to a near major / near major impact on construction H&S. Site handover, and site inspections / discussions are Stage 5 activities, detailed design, constructability reviews, and design are Stage 3 activities.

Seventh to twelfth ranked actions / activities / aspects have MSs > 2.51 ≤ 3.34 - deemed to have between a near minor to some impact / some impact on construction H&S. Project duration is a Stage 1 aspect that will possibly be reviewed during Stages 2 – 4. Stage 3 activities include design coordination meetings. Pre-tender meeting, evaluation of tenders, and working drawings are Stage 4 activities, and site meetings are a Stage 5 activity. Working drawings are also a Stage 3 and Stage 5 aspect.

Thirteenth to fourteenth ranked actions / activities / aspects have MSs > 1.68 ≤ 2.51 - deemed to have between a near minor to some impact / some impact on construction H&S. Project documentation is a Stage 4 aspect and client brief is a Stage 1 activity.

Table 5: Extent to which actions / activities / aspects impact on construction H&S according to responding Departments of Architecture HoDs

Action / Activity / Aspect	**Response (%)**							**MS**	**Rank**
	Unsure	**Does not**	**Minor ………………………….Major**						
			1	**2**	**3**	**4**	**5**		
H&S pre-qualification of contractors	0.0	0.0	0.0	0.0	0.0	66.7	33.3	4.33	1
Site handover	0.0	0.0	0.0	0.0	33.3	33.3	33.3	4.00	2
Site inspections / discussions	0.0	0.0	0.0	0.0	33.3	50.0	16.7	3.83	3
Detailed design	0.0	0.0	0.0	0.0	50.0	33.3	16.7	3.67	4
Constructability reviews	16.7	0.0	0.0	0.0	33.3	50.0	0.0	3.60	5
Design	0.0	0.0	0.0	0.0	66.7	16.7	16.7	3.50	6
Project duration	0.0	0.0	0.0	16.7	50.0	16.7	16.7	3.33	7
Pre-tender meeting	16.7	0.0	0.0	16.7	33.3	33.3	0.0	3.20	8
Evaluation of tenders	16.7	0.0	0.0	16.7	33.3	33.3	0.0	3.20	9
Site meetings	0.0	16.7	0.0	0.0	60.0	20.0	20.0	3.00	10
Design coordination meetings	0.0	16.7	0.0	0.0	50.0	33.3	0.0	2.83	11
Working drawings	16.7	0.0	0.0	33.3	33.3	16.7	0.0	2.80	12
Project documentation	16.7	0.0	16.7	16.7	50.0	0.0	0.0	2.40	13
Client brief	0.0	16.7	16.7	16.7	33.3	0.0	16.7	2.33	14

Table 6 indicates the extent to which sixteen design related aspects impact on construction H&S in terms of percentage responses to a scale of does not, and 1 (minor) to 5 (major), and MSs between 0.00 and 5.00 according to responding Departments of Architecture HoDs. The sixteen aspects influence the construction process in terms of, *inter alia*, methods of work required, the plant and equipment and materials used, resulting in, *inter alia*, exposure to hazardous chemical substances (HCSs). It is notable that 14 / 16 (87.5%) of the MSs are > 3.00, which indicates that in general they are deemed to have a major as opposed to a minor impact on construction H&S. During the prior study conducted by Smallwood (2008) 14 / 16 (87.5%) of the MSs were also > 3.00.

The aspects ranked first to fifth have MSs > 3.34 ≤ 4.17 – deemed to have between an impact to a near major / near major impact on construction H&S: method of fixing; mass of materials; edge of materials; type of structural frame, specification; plan layout, and finishes.

The aspects ranked sixth to fourteenth have MSs > 2.51 ≤ 3.34 – deemed to have between a near minor impact to some impact / some impact on construction H&S: site location; content of material; design (general); surface area of materials; texture of materials; position of components; details; plan layout, and finishes.

Fifteenth and sixteenth ranked aspects elevations and schedule have MSs > 1.68 ≤ 2.51 - deemed to not have an impact to a near minor / near minor impact on construction H&S.

Table 6: Extent to which design related aspects impact on construction H&S according to responding Departments of Architecture HoDs

Aspect	Response (%)							MS	Rank
	Unsure	Does not	Minor……………………………Major						
			1	2	3	4	5		
Method of fixing	0.0	0.0	0.0	0.0	16.7	50.0	33.3	4.17	1
Mass of materials	16.7	0.0	0.0	0.0	16.7	50.0	16.7	4.00	2
Edge of materials	0.0	0.0	0.0	0.0	66.7	16.7	16.7	3.50	3
Type of structural frame	0.0	0.0	0.0	16.7	33.3	33.3	16.7	3.50	4
Specification	0.0	0.0	0.0	16.7	33.3	33.3	16.7	3.50	5
Site location	0.0	0.0	16.7	0.0	33.3	33.3	16.7	3.33	6
Content of material	0.0	16.7	0.0	0.0	16.7	50.0	16.7	3.33	7
Design (general)	0.0	0.0	16.7	0.0	33.3	50.0	0.0	3.17	8
Surface area of materials	0.0	16.7	0.0	16.7	16.7	16.7	33.3	3.17	9
Texture of materials	0.0	0.0	16.7	16.7	16.7	50.0	0.0	3.00	10
Position of components	0.0	20.0	0.0	0.0	40.0	20.0	20.0	3.00	11
Details	0.0	0.0	0.0	33.3	50.0	16.7	0.0	2.83	12
Plan layout	0.0	0.0	16.7	33.3	16.7	33.3	0.0	2.67	13
Finishes	0.0	16.7	0.0	33.3	16.7	16.7	16.7	2.67	14
Elevations	0.0	0.0	16.7	33.3	33.3	16.7	0.0	2.50	15
Schedule	0.0	0.0	16.7	50.0	16.7	16.7	0.0	2.33	16

Respondents were required to provide comments in general regarding tertiary architectural construction H&S education. Four comments were recorded and are presented verbatim.

- It is probably an area where more practical exposure would benefit the students. If they are able to visit a particularly sensitive site this would assist them in further projects.
- Please note that H&S issues are currently embedded in the different years of tuition at DUT. We are recurriculating for a new degree (ca 2016), and will focus more specifically in terms of inclusion of H&S in the process of planning this qualification.
- While the design detailing and the methods of construction can be modified to politely acquire best practices of H&S on file, greater training and wage of skilled workers, and practices are essential to safeguard the interests of all concerned.
- As architects we rely on the construction managers' knowledge of H&S. It is an important role which I do think most designers would rather let the knowledgeable person handle it, unless it has an impact on the design. Inclusion of H&S in the curriculum would be determined by the body of knowledge that SACAP prescribes for inclusion. Currently H&S is not in the 'Purple Book'.

CONCLUSIONS

The practicing architectural designers appreciate the role of design in construction H&S and the role of design HIRAs. This appreciation was more profound after completing a one-day 'designing for construction H&S' seminar. Furthermore, they expressed resounding support for the inclusion of construction H&S in tertiary designer education. This leads to the conclusion that architectural designers must be empowered to contribute to construction H&S, and continuing professional development (CPD) is important and does have an effect.

Construction H&S is addressed / included to a degree in architectural programmes. However, it is not readily easy to determine the extent. Respondents contend that it is addressed as a component of a subject, a module, and on an ad-hoc basis. The aforementioned lead to the inclusion that construction H&S is not embedded in architectural programmes.

Then it can be concluded that respondents have an appreciation of the importance of the inclusion of construction H&S in the tertiary education programmes of the built environment disciplines, but less so relative to the design disciplines.

Furthermore, there is a degree of appreciation for the: importance of the inclusion of a range of subject areas relative to construction H&S in an architectural programme; extent to which actions / activities / aspects impact on construction H&S, and extent to which design related aspects impact on construction H&S.

RECOMMENDATIONS

Tertiary education architectural programmes should include a module 'designing for construction H&S' as a component of a subject – probably design. The minimum content of such a module would include: H&S legislation and regulations; the role of the various project stakeholders in construction H&S; actions / activities / aspects that impact on construction H&S; the design related aspects that impact on construction H&S, and 'designing for construction H&S' aspects such as design HIRAs, 'design and construction' method statements, the designer report, the H&S specification, and H&S plans. Underpinning knowledge such as the nature of materials and the construction process and its activities is essential. Then, construction H&S should be included among criteria used for evaluating design projects, working drawings, and details. The subject 'History of Architecture' should also address construction H&S. Furthermore, SACAP accreditation reviews of tertiary education landscape architectural programmes should interrogate the extent to which construction H&S is addressed

Construction H&S should be included in CPD for architects. The South African Institute of Architects (SAIA) should develop practice notes relative to construction H&S, and the South African Council for the Architectural Profession (SACAP) should include construction H&S in their six work stages (IoW).

REFERENCES

Behm, M (2006) "An Analysis of Construction Accidents from a Design Perspective". Silver Spring: The Center to Protect Workers' Rights.

Construction Industry Development Board (cidb) (2009) "Construction Health & Safety in South Africa Status & Recommendations". Pretoria: cidb.

Hecker, SF, Gambatese, JA and Weinstein, M (2006) Designing for construction safety in the US: Progress, needs, and future directions, *Proceedings of the 16th Triennial Congress of the International Ergonomics Association*, Maastricht, The Netherlands, 10-14 July 2006, D:\data \pdfs\art0563.pdf.

International Labour Office (ILO) (1992) “Safety and health in construction”. ILO, Geneva: ILO.

Republic of South Africa (1993) “Government Gazette No. 14918. Occupational Health & Safety Act: No. 85 of 1993”. Pretoria.

Republic of South Africa (2011) “Government Gazette No. 34645. Architectural Profession Act (44/2000): South African Council for the Architectural Profession’s (SACAP’s) Interim Policy on the Identification of Work for the Architectural Profession”. Pretoria.

Republic of South Africa (2014) “No. R. 84 Occupational Health and Safety Act, 1993 Construction Regulations 2014. Government Gazette No. 37305”. Pretoria.

Smallwood, JJ (2002) The need for the inclusion of construction health and safety (H&S) in architectural education. In: S. Rowlinson (ed.) Proceedings 3rd International Conference of CIB Working Commission W99 Implementation of Safety and Health on Construction Sites, Hong Kong, 7-10 May, Hong Kong: The University of Hong Kong, 207-212.

Smallwood, JJ (2008) The influence of architectural designers on construction ergonomics, “ergonomicsSA”, 20(1), 40-55.

Thorpe, B (2006) “Health and Safety in Construction Design”. Aldershot: Gower Publishing Limited.

BEHAVIOUR-BASED SAFETY (BBS): A CONSTRUCTION INDUSTRY'S PERSPECTIVE

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The behaviour related approach to dealing with occupational safety and health (OSH) has been shown to be valuable and as a result many construction organisations employ this method to achieve robust safety management systems. Behaviour-based safety (BBS) has various elements and comes in different forms and designs; and different organisations pay more attention to different elements. As a result, organisations typically give their behaviour-based safety programmes (BBSP) different names and pride themselves for achieving high safety standards because of the aspects of behavioural safety that they focus on. However, it is unclear as to which specific aspects of such programmes are the keys to success and which are of secondary importance to improving OSH. This paper presents the findings of a desk study of the top 100 UK and USA construction organisations (contractors and consultants) ranked by turnover; this involved a comparative analysis of BBSPs that led to the development of seven major themes. This study reveals the need to encourage smaller companies to undertake BBS as well as understand employees' ideals so that they can be effectively and efficiently supported. This study is part of a three-year doctoral research programme that investigates the human aspect of OSH.

Keywords: behaviour-based health and safety, construction, safety behaviour, safety performance.

INTRODUCTION

The behaviour-based approach to dealing with occupational safety and health (OSH) issues, which is recognised as behaviour-based safety (BBS), is known to be effective in reducing accidents that cause harm, and incidents which do not cause harm but have the potential to (Krause et al. 1999). Figure 1 shows Pybus' (1996) evolution of safety culture model, which helps to contextualise the importance of the relationship between behaviour and safety performance.

Pybus' model postulates that safety culture starts from the 'traditional' phase where rules, enforcement and individuality dominate. This helps to reduce accidents but is limited in its effectiveness; hence the rate of reduction of accidents/incidents plateaus. The 'transitional' phase then places an emphasis on the importance of engineering controls and safety management systems; helping to reduce accidents further until another plateau is reached. Finally the innovative phase, where trust in people and being proactive are seen to be essential in order to further reduce accidents, is generated. In this phase, people are key elements and their behaviours become crucial in enhancing safety performance.

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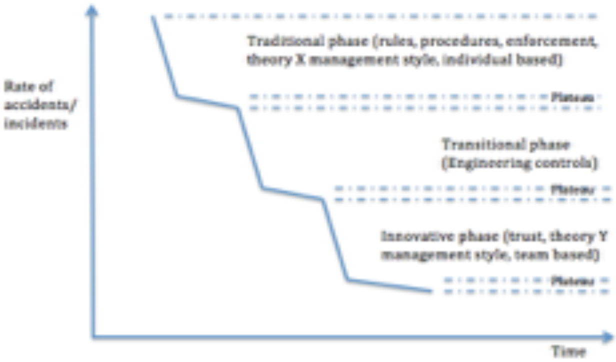

Figure 1: Evolution of safety, adapted from Pybus (1996)

It is important to note that the features of the earlier phases must continue to be applied along with the emphases of the newer phase. Other similar but slightly different models exist (Hudson 2007). However, they all seem to converge on the position that a more humanistic approach to safety is the way to further enhance safety performance.

Various organisations have implemented BBSPs and different studies have shown its effectiveness, for example Sulzer-Azaroff and Austin (2000). However, BBSPs exist in various designs and forms and there is a gap in knowledge regarding the elements of BBSPs that organisations currently rely on to improve safety performance. This paper therefore explores construction organisations' BBSPs as presented on their company websites. The study explored BBSPs to discover emerging themes, differences and similarities between such safety programmes. More emphasis is placed on the safety aspect of OSH as it costs the UK economy more (Health and Safety Executive (HSE) 2014).

SAFETY BEHAVIOUR: FIRST OR LAST LINE OF DEFENCE?

Reason (2009) argues that human acts are a primary cause of accidents; these acts are sometimes intentional and other times, unintentional. Garlapati et al. (2013) buttress this and argue that unsafe behaviours cause most of the accidents in the oil and gas sectors. It therefore follows that, if wrong acts can be reduced, accidents will be reduced as well. HSE (2009) claims that, on one hand, people make calamitous choices despite their awareness of the risks and on the other hand, their interpretations of risks may be flawed. They warn against focussing solely on human behaviour arguing that this is only one factor that affects safety amongst a raft of other factors. Therefore, it should not be treated as the only solution but rather as a part of an effective OSH management system.

Anderson (2005) approaches this matter from a slightly different angle arguing that there are two causes of accidents. One is the direct cause and the other is an underlying or fundamental cause that is further away but has an impact on the accident. Reason (2009) is of the same opinion that many accidents are caused as a result of organisational factors, which can influence unsafe acts. He argues that unsafe acts can essentially be viewed as a consequence of poor organisational factors and maintains that human conditions cannot be changed but the circumstances in which they work can be. Figure 2 explains Reason's (2009) model.

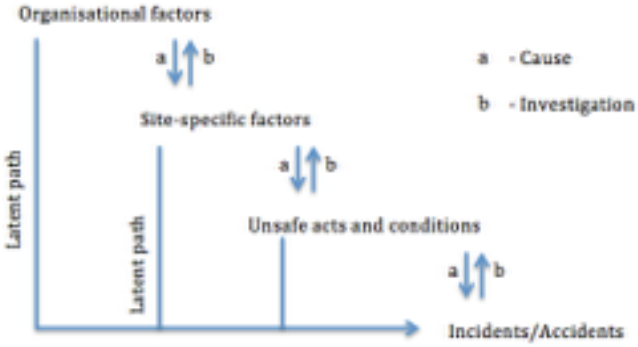

Figure 2: Accident causation prototype, adapted from Reason (2009)

Reason (2009) asserts, like Hopkins (2006b), that there are latent condition pathways that can result in an accident without any direct acts as shown in Figure 2. He further explained that causes of accidents ('a' in Figure 2) should be considered starting from the organisational factors through the site-specific factors ("local conditions"), which Gibb et al. (2006) term "shaping factors" in their ConCA accident causality model, and finally the unsafe acts; whilst the direction of the investigation of accidents ('b' in Figure 2) should be the reverse starting from the unsafe acts.

HSE (2009) agrees with Reason and Hopkins adding that active failures have instant repercussions while latent failures may not be instantly obvious. Active failures are caused by frontline staff like ground workers, labourers and painters whilst latent failures are usually caused by management staff such as managers, directors and designers. Some examples of active failure include disobeying traffic rules on site, not using personal protective equipment (PPE) when required and reversing without a vehicle banksman. Some examples of latent failures include inadequate training, poor communication, inadequate supervision and poor safety procedures. BBS tries to resolve both types of failures though HSE (2009) claims that latent failures are regularly concealed and are potentially worse than active failures.

Figure 3 shows Heinrich's (1931) somewhat simplistic view of the relationship between fatalities and unsafe acts and conditions. The model focuses on the active failures and suggests that fatalities can be reduced and perhaps eliminated if unsafe acts and conditions are eliminated.

Figure 3: Relationship between safety behaviour and fatalities, adapted from Heinrich (1931)

HSE (2009) explains that unsafe acts can be either "errors" or "violations". They define human error as "an action or decision which was not intended, which involved a deviation from an accepted standard, and which led to an undesirable outcome", while a violation is defined as "a deliberate deviation from a rule or procedure". As safety behaviour can ultimately make or break OSH systems (Reason 2009), it consequently becomes important to understand the motivating factors that drive the 'right' behaviours whilst reducing errors and violations. There seems to be advantages in combining Pybus' (1996) model in Figure 1 and Reason's (2009) model in Figure 2 (following the approach of Gibb et al. 2006). Reason's (2009) Swiss cheese model has been adapted in Figure 4 to show how this combination will work.

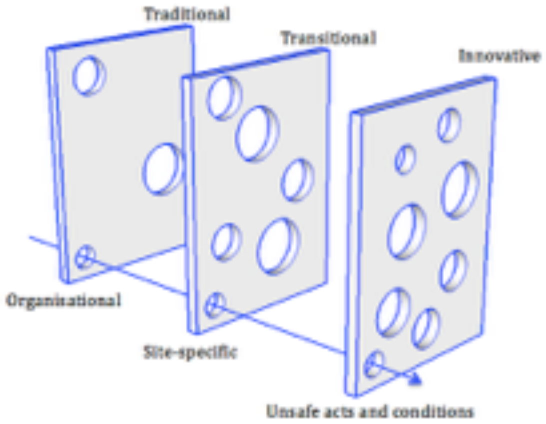

Figure 4: Combination of Pybus' and Reason's models

Figure 4 shows the positional relationship of the traditional, transitional and innovative phases of the Pybus model; parallels can be drawn with the Reason model. The traditional phase parallels organisational factors, the transitional phase parallels site-specific factors and the innovative phase parallels unsafe acts and conditions.

Figure 4 also shows that there can be multiple causes of an accident and the latent and active pathways to failure postulated by Reason (2009) somewhat explains this. It must be acknowledged that accident causality is a complex matter and it is difficult to envisage a simplistic solution for it (Haslam et al. 2003). The arrow that runs through each of the plates illustrates an accident path and an accident occurs when all the holes in all the plates line up. If the organisational and site-specific conditions improve, the amount of accidents that materialise are likely to reduce as more holes in the first two plates will be blocked, inevitably cutting off some accident paths. Whether to tackle the traditional (organisational) or the innovative (unsafe acts and conditions) phase first is arguable, however literature suggests that tackling safety behaviours tends to be a last line of defence in practice.

METHODOLOGY

This exploratory study sought to uncover current practice in the construction industry regarding BBS. The websites of 400 organisations were reviewed to extract their safety content, which gives an indication of their safety practices. It is appreciated that organisations are able to place whatever they deem fit on their web pages therefore they may boast of success that they do not have. Also, they may claim to have good BBSPs even if they have none whatsoever; winning more work, being current and remaining competitive are some reasons why a company may do so. In any case, falsely boasting of BBS gives it more credit, as organisations do not normally associate themselves with anything that will bring their reputation down.

The top 100 companies in 2014, ranked by turnover, as listed by Building.co.uk and ENR.construction.com in the UK and USA respectively were considered, as shown in Table 1. The top companies tend to be the leaders of the industry that the smaller companies follow. These companies subcontract work to smaller companies, who often have to meet the requirements already set (by the top companies).

Table 1:Breakdown of the sample size of 400 construction companies

Region	Contractors	Consultants	Total
UK-based companies (Building.co.uk)	100	100	200
US-based companies (ENR.construction.com)	100	100	200
Both UK and US-based companies	200	200	400

Gathering and analysing the data

Companies' names were searched using Google and their websites were accessed. Their health and safety (H&S) sections were scanned thoroughly to comprehend their contents; any points found on behaviour-based safety/behavioural safety were noted. It was found that most of the UK organisations called this kind of safety programme 'behavioural safety' whilst most of the USA organisations called it 'behaviour-based safety'. Many organisations positioned their safety content under the 'Corporate Social Responsibility' (CSR) or 'Sustainability' sections and many others had theirs under the 'Who we are' or 'Our core values' sections. This suggests that whilst some organisations treat safety as a responsibility that is externally bestowed on them or one that they bestow on themselves, others believe that safety is a value of their organisation; not an extra responsibility but simply the way they work.

After all the readily accessible safety information was gathered, the companies' own search engines were used to check for more safety information to identify any additional relevant safety information. For companies that did not have H&S sections and or where nothing was found on H&S, their search engines were used to explore further. Searches on 'safety', 'health and safety', 'safety behaviour', 'behaviour and safety', 'behavioural safety' and finally 'behaviour-based safety' were conducted. The same was done for the USA companies with the adaptation of the spelling of the word 'behaviour' to 'behavior'. To ensure equity across the sample, only the first pages of each of the results were given attention.

The websites of group companies were reviewed as well as that of their individual subsidiaries and it was found that, for some, different subsidiaries had different names associated with their BBSPs. After reviewing the results and going through the relevant content from the links generated by the search, the companies' names were typed in the Google search engine again but this time succeeded by the words 'behavioural safety' and 'behavioral safety' for UK and USA respectively; the same was done with 'behaviour-based safety' and 'behavior-based safety'. As with the website search, only the first pages of each of the results were considered. This secondary search conducted with Google was undertaken because it was found that some organisations had poorly built internal web search engines that did not produce relevant results to searches made. From the searches made, organisations' BBSPs were identified and noted along with text pertaining to safety and behaviour.

A mind map was used initially to synthesize the text and subsequently, a computer aided qualitative data analysis software – NVivo (version 10.2.0) was used to code the text, and emerging themes were identified. Pairing and elimination of themes subsequently helped to narrow the data down, and finally the themes were placed under higher order themes. Braun and Clarke (2006), Bryman (2012) and Saunders et al. (2012) best describe this form of analysis as a thematic one.

FINDINGS

Prevalence of BBSPs

Table 2 shows the number of construction organisations whose websites indicate that they have BBSPs in comparison to those that do not.

Table 2: Number of companies with and without BBSPs (sample size=400)

	UK Contractors	UK Consultants	USA Contractors	USA Consultants	Total
BBSP	22	8	22	18	70
No BBSP	77	92	76	82	327
No website/website issues	1	0	2	0	3
Total	100	100	100	100	400

It is evident that most organisations do not have BBSPs, which is surprising given the emphasis in the literature and the media over recent years. This may suggest that many of the organisations in the sample do not know about the behavioural approach to dealing with safety. It is also possible that some organisations have such programmes but do not want to reveal the contents of their programme, perhaps to hide their flaws or for competitive reasons. Further, companies may be of the opinion that the return on investment of such programmes is low, although Cooper (2010) claims that the opposite is the case.

Figure 5 shows that BBS engagement increases with an increase in turnover.

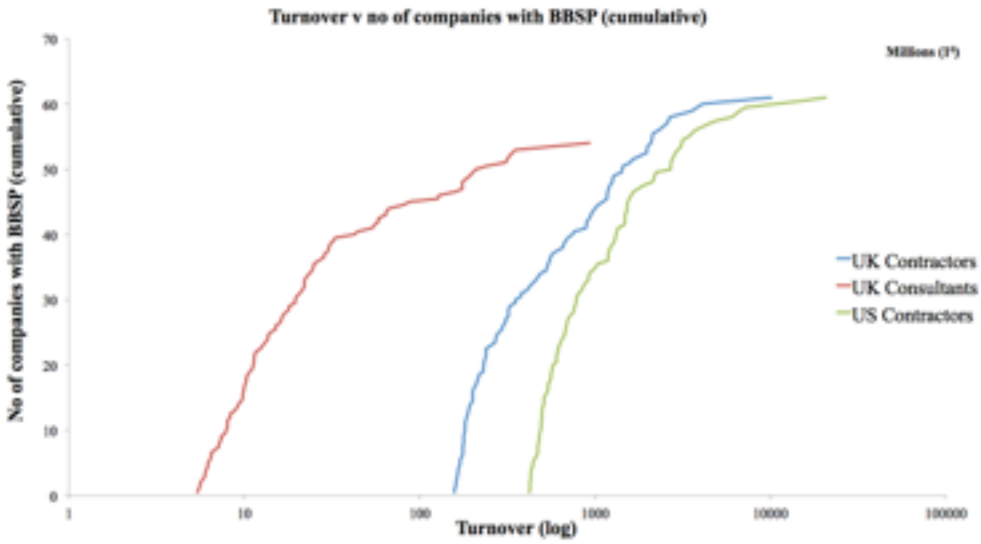

Figure 5: Relationship between contractors/consultants' turnover and BBS engagement

The relationship between turnover and BBS engagement is directly proportional for construction organisations in both the UK and USA; further investigation into these organisations will help clarify why this is the case. Figure 5 suggests that most people in the UK's construction industry do not avail of BBS since small-medium organisations (SMEs) hold the majority of its industrial sector (based on employment) (DBIS 2014). The USA consultants' graph was not plotted, as the individual revenues for these companies were not available, though the trend remains the same. The graph shows that contractors in both countries engage with BBS more than consultants; one possible reason for this is the notion that clients expect contractors to be more safety aware as they are at the 'sharp' end of accident causation. Further, contractors themselves may deem it necessary to improve their OSH management systems substantially, perhaps to win more work or because they genuinely care for employees to be safe.

Key themes emerging from current BBSPs

A word frequency query was performed on the entire data set using NVivo. The first (bbsp), second (behaviours) and third (safety) words generated were expected as these are generic terms.

'Zero' was the fourth on the list. Many organisations have 'zero' in the title of their BBSPs, for example 'beyond zero', 'zero harm', 'zero incidents' and 'target zero'. According to Wilkins (2011), zero accident cultures have become increasingly popular in the construction industry. Sherratt (2014) argues that zero target programmes may encourage people's commitment to safety, however they may also have a counterproductive effect if people believe that it is an impossible target.

'Culture', ranked fifth, appears to be a significant tool that companies rely on to ameliorate OSH. The term "safety culture" can be used to describe the behavioural elements (what people do) and the situational elements (what the organisation has) of an organisation (Human Engineering 2005). Cooper (2002) argues that good safety culture can help to reduce accidents and injuries, ensure that enough attention and regard is given to safety, ensure members of a company understand and share beliefs about risks, accidents and safety and increase people's commitment to safety. Hudson (2007) argues that safety culture metamorphoses through 5 stages from 'pathological', through 'reactive', 'calculative', 'proactive' and finally the 'generative' stage.

The culture within an organisation can be different and fragmented (Richter and Koch 2004). Martin (2002) concurs with this view arguing that the superiors within an organisation ought to aim to align these fragments such that they are in agreement with the corporate culture of the organisation. On the other hand, Weick and Sutcliffe (2007) argue that integrated cultures do not deal with uncertainty as well as fragmented cultures, which are more flexibility. They report that High Reliability Organisations are more resilient because many of them have flexible cultures.

Hopkins (2006a) suggests that culture and climate are occasionally used interchangeably. The authors' previous work suggests that safety culture is different from safety climate (Talabi et al. 2015). They argue that culture is a deep-rooted quality, which is usually influenced by senior management while various organisational actors (internal and external) influence climate. It therefore follows that whilst many organisations refer to culture, they may indeed be referring to climate. Garlapati et al. (2013) argue that climate is equally important, as it is a medium through which greater performance can be achieved.

'Compliance' also emerged many times which implies that many organisations are still focused on complying with legislation and indeed, many focus on the requirements of British Standard (BS) OHSAS 18001 (Occupational Health and Safety Assessment Series), which is a framework used to assess and audit OSH management systems. Previous work undertaken by the authors suggests that whilst legislation has undoubtedly reduced accidents, the problem with mere compliance is that the amount of accidents that occur in the construction industry is still unacceptable and safety performance seems to be plateauing (Talabi et al. 2015).

Some other words emerging with high frequency counts include leadership, communication, commitment, engagement, attitude, and awareness, which have all been discussed in past studies (Fernández-Muñiz at el. 2012 and Flin et al. 2008).

Figure 6 highlights seven higher order themes, which all have broader elements that organisations associate with BBS.

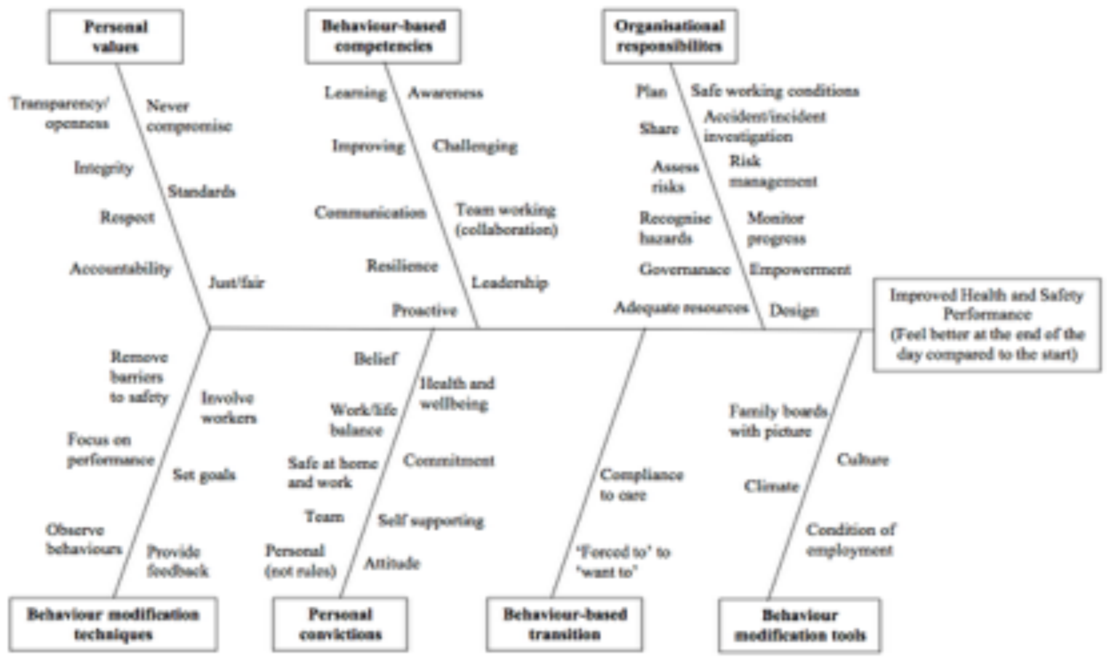

Figure 6: Factors currently used by construction companies to improve OSH

These themes were methodologically organised and categorised based on their definition and significance; after several iterations, the figure evolved. 'Personal values' relate to attributes that make people trustworthy and reliable, 'behaviour-based competencies' relates to people's competence, 'organisational responsibilities' are the fundamental duties of a company, 'behaviour modification techniques' suggest methods by which behaviours can be altered, 'personal convictions' are drivers that nudge people to choose to behave safely, 'behaviour-based transition' is the direction in which organisations that currently utilise BBS are moving and 'behaviour modification tools' are practical ways by which behaviours can be changed.

Most of these higher order themes are behaviour oriented however one of them – 'organisational responsibilities' is more structural. This finding is in line with research that suggests that BBS should not be used as a 'one fits all' solution but rather as part of a comprehensive OSH management system (HSE 2009; Reason 2009; Hopkins 2006b; Anderson 2005; DeJoy 2005). The broader elements of this higher order theme appear to be largely covered by UK legislation whereas the broader elements of the others are not covered in the same way.

Interestingly, out of the entire sample of 400 companies, only one company (in the USA) specified that it wanted its employees to return home better than the way they came to work. Many of the others specified that they wanted their employees to leave the same way they came and this is admirable in itself, however it is recommended that more companies should aspire to ensure that their employees leave work safer and healthier than when they arrived. It appears that more needs to be done to show genuine care and concern for employees in the construction industry. People's safety and health ought to be valued more and employers should strive to ensure that their employees return home from work physically, mentally and emotionally better than when they arrived. Straker and Mathiassen (2010) argue that organisations are more competitive when work is designed to achieve this.

CONCLUSIONS

The findings of this study have been classified into seven groups, which companies that currently practice BBS pay attention to: personal values, behaviour-based competencies, organisational responsibilities, behaviour modification techniques, personal convictions, behaviour-based transition and behaviour modification tools. Two important classifications emerge from this study: individual values and organisational values. This implies that organisations should critically assess employees' ideals and nurture an environment that allows individuals to align their values with its own. However, they must be aware that this is a development and not the end. This study also suggests that organisations that currently endeavour to do this are in the minority; therefore more companies are urged to adopt BBS. Further, this study suggests that contractors appear to utilise BBS more than consultants. Further research into other industries to investigate whether there is agreement or disagreement with the construction industry is encouraged; lessons can be learnt and transferred among various industries. The next phase of this study will explain why the construction industry focuses on these aspects of BBS.

REFERENCES

Anderson, M (2005) Behavioural safety and major accident hazards: Magic bullet or shot in the dark? “Process Safety and Environmental Protection”, 83(2), 109–116.

Braun, V and Clarke, V (2006) Using thematic analysis in psychology. “Qualitative Research in Psychology”, 3(2), 77–101.

Bryman, A (2012) “Social research methods”. 4ed. Oxford University Press.

Cooper, D (2010) The return on investment of the B-BS process. “Giornale italiano di medicina del lavoro ed ergonomia”, 32(1), A15–A17.

Cooper, D (2002) Safety culture: a model for understanding and quantifying a difficult concept. “Professional Safety”, 47(6), 30–36.

Department for Business and Skills (DBIS) (2014) “Business population estimates for the UK and regions 2014”. Statistical release, Ref – URN 14/92, 1-19.

DeJoy, D M (2005) Behavior change versus culture change: Divergent approaches to managing workplace safety. “Safety Science”, 43(2), 105–129.

Fernández-Muñiz, B, Montes-Peón, J M and Vázquez-Ordás, C J (2012) Safety climate in OHSAS 18001-certified organisations: antecedents and consequences of safety behaviour. “Accident Analysis and Prevention”, 45, 745–58.

Flin, R, O’Connor, P and Crichton, M (2008) “Safety at the sharp end: A guide to non-technical skills”. Aldershot: Ashgate.

Garlapati, A, Siddiqui, N and Al-Shatti, F (2013) Behavioral study of diverse workforce towards various health, safety and environment engagement strategies in upstream oil and gas industries. “International Journal of Scientific and Engineering Research”, 4(7), 1768–1779.

Geller, E S (2011) Psychological science and safety: Large-scale success at preventing occupational injuries and fatalities. “Current Directions in Psychological Science”, 20(2), 109–114.

Gibb, A G F, Haslam, R, Gyi, D, Hide, S and Duff, R (2006) What causes accidents? “Proceedings of ICE - Civil Engineering”, 46–50.

Haslam, R A, Hide, S A, Gibb, A G F, Gyi, D E, Atkinson, S, Pavitt, T C, Duff, R and Suraji, A (2003) “Causal factors in construction accidents”. Health and Safety Executive, HSE Report, RR 156. Sudbury: HSE Books.

Health and Safety Executive (HSE) (2014) “Health and safety in construction in Great Britain, 2014”. 1–15.

Health and Safety Executive (HSE) (2009) “Reducing error and influencing behaviour”. Sudbury: HSE Books.

Heinrich, H W (1931) “Industrial accident prevention: A scientific approach”. New York: McGraw-Hill.

Hopkins, A (2006a) Studying organisational cultures and their effects on safety. “Safety Science”, 44, 875–889.

Hopkins, A (2006b) What are we to make of safe behaviour programs? “Safety Science”, 44(7), 583–597.

Hudson, P (2007) Implementing a safety culture in a major multi-national. “Safety Science”, 45(6), 697–722.

Human Engineering (2005) “A review of safety culture and safety climate literature for the development of the safety culture inspection toolkit”. HSE Books.

Krause, T, Seymour, K and Sloat, K C (1999) Long-term evaluation of a behavior-based method for improving safety performance: a meta-analysis of 73 interrupted time-series replications. “Safety Science”, 32(1), 1–18.

Martin, J L (2002) “Organizational culture: Mapping the terrain”. Calif.: SAGE.

Pybus, R (1996) “Safety Management: Strategy and Practice”. Oxford: Butterworth-Heinemann.

Reason, J (2009) “Managing the risks of organizational accidents”. Aldershot: Ashgate.

Richter, A and Koch, C (2004) Integration, differentiation and ambiguity in safety cultures. “*Safety Science”*, 42(8), 703–722.

Saunders, M, Lewis, P and Thornhill, A (2012) “Research methods for business students”. 6ed. Lewis, P and Thornhill, A (Eds). Harlow: Pearson.

Sherratt, F (2014) Exploring “Zero Target” safety programmes in the UK construction industry. “Construction Management and Economics”, 32(7-8), 737–748.

Straker, L, Mathiassen, S E (2009) Increased physical workload in modern work – a necessity for better health and performance? “Ergonomics”, 52(10), 1215-1225.

Talabi, B, Edum-Fotwe, F and Gibb, A (2015) Construction actor safety behaviour: Antecedents, current thinking and directions. In: Smith, S and Sherratt, F (Eds.), “Proceedings of ARCOM Doctoral Workshop: Health, Safety and Wellbeing”, 11 February 2015, University of Edinburgh, 9–20.

Weick, K E and Sutcliffe, K M (2007) “Managing the unexpected: Resilient performance in an age of uncertainty”. 2ed. San Francisco: Jossey-Bass.

Wilkins, J R (2011) Construction workers’ perceptions of health and safety training programmes. “Construction Management and Economics”, 29, 1017–1026.

IRONWORKER PERSPECTIVES ON ACCIDENT CAUSES AND IMPROVING SAFETY PLANNING

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Paper Abstract: One of the most dangerous trades in the construction industry is structural steel erection and ironworker safety has been studied from multiple viewpoints. Researchers in the United States (US) conducted a recent study aimed at all types of incidents and injury severity levels commonly sustained by ironworkers. The study utilized ironworkers' perspectives regarding safety issues including what might help in improving safety planning, their attitudes towards working in a risky environment, and usability of safety rules. To conduct the study, the researchers performed a literature review followed by a survey of ironworkers in the US Pacific Northwest to obtain both experiential and a first-person understanding of the risk exposure. According to the survey results, ironworkers feel that the causes of accidents are, in descending order of frequency, worker's misjudgement, unsafe work conditions, and design mistakes, followed by other causes. The respondents indicated that these causes lead to the known primary types of accidents: caught in/between, struck by objects, and fall from height. Moreover, the predominant types of injuries reported by the survey participants are cuts, burns, and chemical exposures. The ironworkers felt that utilizing workforce feedback is one of the most effective means to improve safety planning. Increasing use of personal protective equipment (PPE) and adopting new technologies are also examples of suggested solutions for improving safety. Lastly, the study reveals that a high percentage of ironworkers understand that the conditions in which they work create a risky environment. The study findings reveal that ironworker perspectives on how to improve safety are consistent with that of contemporary safety management practices. Additionally, increased focus should be placed on worker behaviour issues related to worker misjudgement, poor risk management, and mistakes.

Keywords accident causes, ironworkers, risk, safety, steel erection.

INTRODUCTION

The nature of construction site safety has transformed over the years through different phases in its lifecycle. Safety on construction projects has transitioned from one death per floor during the construction of the Empire State Building in New York City (Modrue and Finch 2014) to targeting zero accidents on many of today's mega-construction projects. There is additionally increased interest in construction safety research. Safety has gained more attention because injuries do not only affect human lives, which is the top priority, but other project aspects such as cost, schedule, and quality as well. Higher insurance premiums, treatment costs, and lost productivity are examples of the impacts of worker injuries on projects (Irizarry et al. 2005). Although, safety regulations and standards have been established and issued by the Occupational Safety and Health Administration (OSHA) in the US

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and other government agencies and industry organizations around the world, safety issues are still commonly present (Beavers et al. 2009) and occasional spikes in injury and fatality rates have been observed (McCabe et al. 2014). In the US, there were 838 fatalities in the construction industry in 2012 (BLS 2014) – an average of more than two fatalities per day. Injury statistics reveal that the US construction industry experiences one of the highest fatal injury rates in comparison with other developed countries (CPWR 2013).

Safety issues on jobsites can lead to different levels of injury severity and different rates of injuries. Frequency and severity of accidents often depend on the construction trade, and steel erection is a trade that commonly experiences a high rate of fatalities (CPWR 2013). Ironworkers are impacted significantly in terms of exposure to safety risk (Yang et al. 2014). In addition to severe and fatal injuries, an accident might lead to physical disablement or even long-term health effects such as physiological and psychological problems. These are examples of potential safety and health impacts that ironworkers face regularly while conducting their work. Research on ironworker safety predominantly focuses on hazards and accidents that result in high severity injuries, and studies have been conducted that target fatalities during steel erection fatalities (Beavers 2009). This focus may be due to falls from height being one of the leading causes of injuries in the construction industry and one cause that relates to ironworkers specifically in many cases (CPWR 2013). A comprehensive search by the authors of on-line databases, such as Google Scholar, and journal publisher offerings revealed very few studies of low severity ironworker injuries in the literature. There is a dearth of information on the quantification of risks for the construction and building trades (Baradan and Usmen 2006), and especially for ironworkers. A lack of published research in this area may be due to the focus on the larger effect of severe injuries. While the extent of research is less for low severity ironworker injuries, this type of injury may also affect human life and health to a great extent, in addition to the impact on the work in terms of schedule, cost, and quality.

For the reasons stated above, it is important to understand the need for addressing safety issues in general and specifically in steel erection. Given that ironworkers are exposed to the hazards and exposed to the risk on a daily basis, a thorough understanding of the perception of ironworkers regarding safety in general makes it possible to develop safety measures and controls to help mitigate these issues. This reason serves the whole process of ensuring safety and health in construction industry (Irizarry and Abraham 2006). The present study aims to improve our knowledge of the ironworkers' perspective regarding safety on construction sites. The primary research questions that the research described in this paper aims to answer are:

- What are the common causes of accidents in steel erection?
- What are the types of injuries that ironworkers typically experience?
- What is the ironworker's perception regarding the steel erection safety environment and how usable are the safety rules?
- What measures would improve safety and health from an ironworker's perspective?

LITERATURE REVIEW

There are four distinguished specializations in the steel erection trade: structural ironwork, reinforcing ironwork, ornamental ironwork, and machinery moving and rigging ironwork (Forde et al. 2005). Ironworker is defined as the "worker who handles and places steel and ornamental iron, including all types of reinforcing steel and bar supports" (Webster 1997). From this definition, it could be concluded that steel erection is a difficult and dangerous trade. Irizarry et al. (2005) and Irizarry and Abraham (2006) provide additional descriptions and information about the steel erection process.

It is worth noting that the starting point for safety (in the US) is the employer's duty to provide work environments that are free from hazards that cause serious physical harm or death, not from an assumption that danger and risk are inherently necessary. Physical/physiological, psychological, behavioural, and system conditions exist that all-together affect ironworkers and make them susceptible to the risky environment. The physical nature of steel erection work exposes ironworkers to high levels of hazardous physical conditions. Everett (1999) found that all craft workers are impacted by overexertion injuries. With regard to physiological impacts, Kilburn et al. (1992) studied hearing loss symptoms on a specific sample of construction workers. The researchers showed that ironworkers are exposed to hazards that lead to hearing loss and dysfunction. Respiratory symptoms are another health issue related to ironworkers that has been studied in prior research. Skloot et al. (2004) found that the majority of the ironworkers sampled had at least one undesirable respiratory symptom. Lastly, musculoskeletal disorders are another health problem that ironworkers suffer from over time. A study conducted by Forde et al. (2005) revealed that there are different severity levels of musculoskeletal disorders among ironworkers, ranging from lower back, upper extremity, and lower extremity region disorders.

With regard to psychological conditions, Haas (1977) states that ironworkers may feel distress in the presence of those who intentionally tend to fear other workers. A feeling of distress develops because showing fear of other workers makes him/her a distrusted worker. Haas states that this kind of distress adds more pressure on the individual, which ultimately impacts his/her decisions and ability to perform his/her tasks. Other workers are at the same time under stress due to not trusting the scared worker. Safety and health practices have changed since the Hass study and the prevalence of such distress existing in ironworkers may not be present today; further research is needed to confirm that the distress is still an issue of concern.

Outside the jobsite, personnel issues of daily life can be factors that affect the workers' perception and/or behaviour on the jobsite (Hinze 2006). This connection between personal issues and worker behaviour is consistent with the adjustment-stress theory of accident causation (Hinze 2006). Lastly, age, experience, and other characteristics may play a role in safety achievement for an individual. For example, research has shown that older workers tend to focus more on safety rules than younger workers (Siu et al. 2003).

Some researchers assert that worker behaviour is one of the main causes of accidents on construction jobsites (see, for example, Abdelhamid and Everett 2000, and Han et al. 2013). As indicated previously, only a few studies on the topic of ironworker safety and health were found in the literature search and, of those found, most focused on fatal accidents and health issues. Beavers et al. (2009) report that the safety of ironworker and topic of steel erection have not received much focused research. The present research aims to complement prior research by providing an investigation of ironworker safety and health from the ironworker's perspective and also by focusing on all injury severity levels.

RESEARCH METHODS

The goal of the research study was to gain further understanding about ironworkers' perceptions of construction safety. By doing so, it is anticipated that safety measures can then be developed to improve the safety performance of ironworkers.

The research methodology employed was a directed survey of ironworkers currently working in the industry. Surveys provide an opportunity to efficiently gain input from a wide distribution of a population, and are especially useful when the information desired is related to common knowledge, easily described, and efficiently conveyed (Creswell 2009). To obtain ironworker input, a written questionnaire was used as the survey instrument. The questionnaire included a total of 45 questions related to the following areas: respondent demographics (age, years of experience, etc.), worker safety knowledge and training, recommended safety improvements, role of company management in safety performance, causes of accidents, and types of injuries commonly sustained. There was no specific focus in the questionnaire on the severity of injuries or nature of accidents; all accident types and injury severity levels were targeted. Different types of questions were included. Closed-ended questions asking the respondent to answer using a Likert scale, along with open-ended questions that solicited further insight, are examples of the types of questions used. Open-ended questions provided the ability to freely add comments to the closed-ended questions and were utilized in order to reduce potential internal bias in the survey.

A targeted sample of unionized ironworkers in the Pacific Northwest region of the US was chosen for this study. To begin the process, the researchers contacted the local ironworker's union business office located in the Portland, Oregon area. An electronic copy of the questionnaire was then e-mailed to the local business office, and the trade union representative at the office was asked to distribute the questionnaire to the members of the union. The questionnaires were distributed by the union representative to the workers at the regularly-scheduled monthly union meetings for the ironworkers. The number of attendees at each meeting was not recorded; therefore, the total number of participants to which the questionnaire was distributed is not known. Analysis methods included descriptive statistics that are used to explain the results as described below.

RESULTS AND DISCUSSION

A total of 36 completed questionnaires were received from ironworkers in the Portland, Oregon area who are members of one union. The study results apply specifically to unionized ironworkers in the local region; however, extending the results to represent other ironworker communities may be acceptable given that steel erection work and construction procedures are typically consistent from one project to another. The environmental conditions that the work is conducted in is another factor that could impact confidence in extending the results to other areas. Regions that experience significantly different environmental conditions may not be represented in the data. Lastly, results are likely limited to projects that utilize unionized labor. The use of unionized labor is typically connected with larger projects with greater focus on worker training and adherence to safety regulations than projects that utilize non-union labor. Steel erection requires trained and experienced workers and, therefore, most of ironworkers are members of a labor union (Irizarry and Abraham 2006).

The sample of respondents contains employees with a wide gap in work experience. Some of the respondents have limited experience (33% with less than 5 years and 20% have worked on fewer than 10 projects), however the majority of respondents are quite experienced (61% with more than 11 years of experience and 71% have worked on more than 20 projects). The high level of experience in steel erection within the sample population increases confidence in the results. The mean age of the respondents is high, with eighteen of the respondents (50%) being 40 years or older. The high average age of the ironworkers matches the results of previous research focused on steel erectors that was conducted in several regions throughout the US (Irizarry and Abraham 2006). Irizarry and Abraham found that the high average age is a result of the trade attracting older workers because it is more physically demanding on the workers, a characteristic that is not commonly desired amongst younger workers. Another influence on average age may be the need for more focused, experienced, and stable employees, especially with regard to worker behaviour in high risk situations. Younger workers may not place as much importance on controlling risk, particularly if they do not have family responsibilities. Further research related to social impacts on workers may provide greater insights in this regard.

The survey explored level of experience, training, and exposure related specifically to safety and health. One question asked about the level of first aid training that the workers have had. Thirty-five (97%) of the participants have received first aid training. One of the workers is a new apprentice and has not yet received this type of training. Another question asked about whether the respondent had been injured and, if so, how often. Over half of the respondents (59%) do not experience, on average, any injury on an annual basis. Other respondents have been injured more frequently, with 15 (41%) reporting that they sustain, on average, between one and ten injuries per year. Such a high injury rate is potentially alarming if the actual value is closer to the high end of the range. It should be noted that the level of injury severity was not considered in the question; all severity levels were included. Near misses were not addressed in the study. The survey focused on injuries only.

Understanding the safety performance of ironworkers requires knowledge of the typical causes of injury accidents. The questionnaire asked the participants to identify the common causes of accidents. According to the responses received, the respondents recognize that their judgment is critical to preventing accidents. Worker's misjudgement, selected by 18 (52%) of the respondents, was the most commonly identified cause of all types of accidents. Previous research revealed that ironworker misjudgement was the cause of 33% of falls from height (Irizarry and Abraham 2006). Gambatese (2013) states that steel erectors are injured because of several reasons and not just fall from heights. Worksite conditions, identified by 11 respondents (29%), was also perceived as being a common cause of accidents. Together, worker misjudgement and worksite conditions represent 81% of the perceived accident causes based on the ironworkers' perspective. This result compares favourably with current theories and models that divide root causes into behavioural and system conditions (Hosseinian and Torghabeh 2012). Four respondents (10%) think that design mistakes are common causes of injuries in their trade. Difficulty in reaching some welded parts is an example stated by several respondents when referring to design mistakes. Design mistakes may be the root cause of more accidents, but the respondents likely pay attention to immediate causes closer to their work.

Worker misjudgement may be the result of a variety of worker-related health issues, including fatigue. The questionnaire asked the participants about the extent to which they feel fatigued while on the job. Thirty-five percent of the respondents indicated that they do not feel fatigued while at work. For those who feel fatigued, 15 (41% of total) experience fatigue in the afternoon (12:00pm or later). As a result, safety while conducting afternoon tasks may be affected. Previous research by Hinze (2006) indicates that a peak in injuries for all trades occurs in the early- to mid-afternoon. Of the 15 respondents who indicated positively regarding feeling fatigued in the afternoon, 10 (64%) are more than 40 years old. Age could play a role in ironworker injuries, and is one of the indirect accident causes (Irizarry and Abraham 2006).

OSHA and US Bureau of Labour Statistics records reveal that falls from height leads to a high number of fatal injuries in the US construction industry. As a result, much focus is placed on falls when targeting safety improvements (Beavers et al. 2009). The majority of injuries in the construction industry, however, are low severity (CPWR 2013). In the present study, one question asked about the typical types of accidents that lead to injuries. The results are shown in Figure 1. Cuts from sharp objects was by far the most common answer (72% of respondents). This was followed by slips and falls (38%). Caught in/between objects, struck by objects, and fall from height were identified by 25% of the respondents. The higher severity injuries, like falls from height, are less frequent. The workers recognize and remember the lower severity injuries, such as cuts, that may occur on a weekly or monthly basis. In terms of the part of the body that is injured, the majority of the respondents (40%) stated they injure their hands most often (see Figure 2). Other body parts commonly injured include arms (29%), back (26%), and legs (20%).

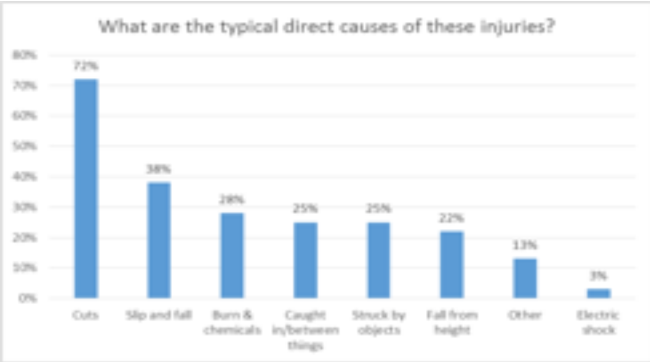

Figure 1: Typical direct cause of the injuries

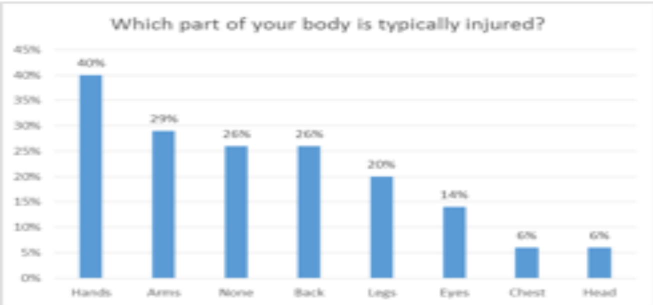

Figure 2: Body part commonly injured

Identifying ways to prevent accidents is important for improving safety performance. One part of the survey aimed at getting the ironworkers' opinions about how best to improve their company's safety program and reduce the number of injuries. The results are shown in Figure 3. Taking worker feedback regarding safety planning was cited most often (20 respondents, 56%). Workers are the first line of employees facing safety issues and perhaps know more than others of what might be useful to control safety hazards. This result does not mean that safety engineers and project planners have to depend on workers to set safety plans, but it is worthwhile to solicit and incorporate ironworker feedback. A worker with extensive jobsite knowledge and experience is likely able to provide expert judgment regarding expected hazards, which leads to efficiency of training programs. Safety programs should be planned and introduced in a way that benefits the worker in preventing injuries to himself/herself or others. The safety program also needs to be concentrated in such a way that he/she is able to identify the deficiencies and how it could be improved.

Figure 3: Suggestions for improving firm's construction safety program

Quantity and type of personal protective equipment (PPE) is another suggestion that the respondents believe is useful in improving safety performance. Forty-seven percent of the respondents indicate that improving PPE quantity and type would result in improved safety programs. Ahmed and Azhar (2015) found that only 62% of contractors provide enough and suitable PPE, indicating that PPE is not sufficient on many jobsites. The findings of this previous research are with respect to all types of workers, not just ironworkers. The results of both the present and previous studies indicate that greater focus on PPE is needed.

Using building information modelling (BIM) and other technologies was also suggested by the respondents to enhance safety. Six respondents (18%) stated that the technology is beneficial in achieving this enhancement. Electronic technologies, and specifically BIM, are being increasingly adopted in the construction industry (Mordue and Finch, 2014). The field of construction worker safety and health is gaining or will gain the benefit of these technologies since the technologies are being increasingly used on construction projects. BIM, for instance, which is used during the design phase helps in discovering hazardous situations. Also, these technologies provide the benefit of reporting and communicating safety issues more effectively and efficiently.

The questionnaire presented several statements to the participants to gauge how they understand the environment that they work in, especially with regards to safety. These responses are shown in Figure 4. The respondents were asked to indicate whether they agree or disagree with each statement. Twenty four respondents (68%) indicated that they were either neutral or agree that it is exciting to work in a risky environment. Desiring to work in a risky environment might be considered a psychological issue that some people express because they lack confidence (Haas 1977). Having such a desire could impact safety performance because it makes the worker more attracted to risky conditions. Moreover, it is a behaviour that has been shown to lead to accidents (Abdelhamid and Everett 2000). Mitigating this issue could be achieved by addressing risky behaviour in safety meetings and training sessions. A psychological study of workers linked with construction studies might result in a better understanding of the safety impacts of workers' personalities.

Figure 4: Worker understanding and perspective of safety environment

With regards to management support for safety compared to cost, schedule, and quality, the respondents had mixed opinions. Without including the 13 respondents (37%) who are neutral in their decision, the other respondents are divided into two equal groups. Eleven (32%) of the participants agree that management does put less emphasis on safety while the same number (11) disagree with this statement. This result does not provide sufficient evidence to consider the impact on construction safety of management's primary area of emphasis. However, past research has indicated that company management is responsible for some safety issues (Abdelhamid and Everett 2000)

With regards to the suitability of safety rules and controls, only 6% of the respondents disagree that some rules and controls are not suitable for use. This result gives a clear view that the majority of ironworkers do not agree with some safety rules and controls on jobsites. Safety engineers and planners should always check the feasibility and applicability of the safety measures on projects in order to develop and improve them. The assumed contradiction to this suggestion of further developing safety procedures is that the higher cost will decrease profit. Doing so will supposedly decrease the contractor's advantage in competition against other bidders. However, improving a firm's reputation, reducing insurance premiums, saving treatment costs, and keeping the work on schedule by not having accidents might be appraised as adequate reimbursement for the extra time spent. Focused studies on the trade-off between costs resulting from less efficient safety plans against continuously developed plans could provide a clearer view of this issue.

Reporting accidents or near misses is an effective strategy to address and mitigate work operations that may lead to injuries. The survey results (see Figure 6) show that 18 of the respondents (51%) confirmed that reporting incidents or near misses is beneficial. Twenty-three percent (8 respondents) were neutral in their response, and 26% percent believe that it is sometimes a good idea to not report near misses. Encouragement and guidance to report all near misses should be given to workers so that they pay attention to safety and timely report all safety issues. Those near misses that are not reported may lead to a more severe incident and injury in the future if they are not addressed.

CONCLUSIONS AND RECOMMENDATIONS

This research study was conducted to obtain a better understanding of worker perspectives about accident causes and safety performance in steel erection. Also of interest was to determine the types of accidents that ironworkers typically experience while conducting their work, the ironworkers' perceptions regarding improving construction safety, and the perceived level of risk in the environment that they work in. The findings reveal that, based on the workers' perspective, worker's misjudgement is the main reason for accidents occurring jobsites. Unsafe conditions were also noticeable causes of safety issues. Other causes such as design mistakes strain, and other crew member mistakes were viewed as frequent reasons for safety incidents. The most common types of injuries are low severity injuries. Cuts from contact with sharp objects are experienced most often, which is followed by slips and falls, and chemical burns. Struck by objects, caught in/between, and fall from height are types of incidents that are not as common.

To improve safety performance, the results reveal that seeking workers' feedback is one of most effective ways for this purpose. Increasing the availability and suitability of personal protective equipment, and using technologies such as BIM are examples of additional means for enhancing safety performance. According to the ironworkers, some safety rules are not effective and need to be revised. A review of company safety program requirements that incorporates worker input is recommended. Ironworkers recognize that steel erection is performed in a risky environment and some workers enjoy working in such an environment. Workers with this attitude should be monitored so that they do not take excessive shortcuts or disregard the safety controls in place to mitigate the risk. Lastly, the study revealed that there is no clear evidence that ironworkers perceive management's emphasis on safety is less or more than the emphasis placed on other project performance criteria such as cost, schedule, and quality. To ensure a healthy safety culture, company management should strive to ensure that workers know that safety comes first.

REFERENCES

Abdelhamid, T. and Everett, J. (2000). "Identifying Root Causes of Construction Accidents." Journal of Construction Engineering and Management, ASCE, 126(1), 52–60.

Ahmed, S.M. and Azhar, S. (2015). "Addressing the Issue of Compliance with Personal Protective Equipment on Construction Worksites: A Workers' Perspective." http://ascpro0.ascweb.org/archives/cd/2009/paper/CPRT176002009.pdf, accessed March 15, 2015.

Baradan, S. and Usmen, M.A. (2006). "Comparative Injury Fatality Risk Analysis of Building Trades." Journal of Construction Engineering and Management, ASCE, 132: 533-539.

Beavers, J.E., Moore, J., Rinehart, R.R., and Schriver, W.R. (2009). "Steel Erection Fatalities in the Construction Industry." Journal of Construction Engineering and Management, ASCE, 135(3), 227-234.

BLS (2014). National census of fatal occupational injuries in 2012. Bureau of Labor Statistics, U.S. Department of Labor, Washington, D.C.

CPWR (2013). The Construction Chart Book, 5th Edition. The Center for Construction Research and Training (CPWR), Silver Spring, MD.

Creswell, J.W. (2009). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches," 3rd Edition. Sage Publications, Inc., Thousand Oaks, CA.

Everett, J. (1999). "Overexertion Injuries in Construction." Journal of Construction Engineering and Management, ASCE, 125(2), 109-114.

Forde, M., Punnett, L., and Wegman, D. (2005). "Prevalence of Musculoskeletal Disorders in Union Ironworkers." Journal of Occupational and Environmental Hygiene, JOEH LLC, 2, 203-212.

Gambatese, J.A. (2013). "Final Report – Activity 2: Assess the Effects of PtD Regulations on Construction Companies in the UK." National Institute for Occupational Safety and Health (NIOSH), Education and Information Division, May 2013.

Haas. J. (1977). Learning Real Feelings: A Study of High Steel Ironworkers' Reactions to Fear and Danger. Sociology of Work and Occupation, 4(2), 147-170

Han, S., Lee, S., and Peña-Mora, F. (2013). “Vision-Based Detection of Unsafe Actions of a Construction Worker: Case Study of Ladder Climbing.” Journal of Computing in Civil Engineering, ASCE, 27(6), 635–644.

Hinze, J. (2006). Construction Safety, 2nd Edition.

Hosseinian, S. and Torghabeh, Z. (2012). “Major Theories of Construction Accident Causation Models: A Literature Review.” International Journal of Advances in Engineering & Technology, IJAET, 4(2), 53-66.

Irizarry, J. and Abraham, D.M. (2006). “Assessment of risk perception of ironworkers.” Journal of Construction Research, World Scientific Publishing, Co., 7(01n02), 111-132.

Irizarry, J., Simonsen, K.L., and Abraham, D.M. (2005). “Effect of safety and environmental variables on task durations in steel erection.” Journal of Construction Engineering and Management, ASCE, 131(12), 1310–1319.

Kilburn, K., Warshaw, R., and Hanscom, B. (1992). “Are hearing loss and balance dysfunction linked in construction ironworkers?” British Journal of Industrial Medicine, 49, 138-141.

McCabe, B., Karahalios, D., and Loughlin, K. (2014). “Attitudes in Construction Safety.” Proceedings of the Construction Research Congress 2005, ASCE, 1-9.

Mordue, S. and Finch, R. (2014). BIM for Construction Safety. RIBA Publishing, Newcastle, England, UK.

Siu, Oi-Ling., Phillips, D.R., and Leung, Tat-Wing (2003). “Age Difference in Safety Attitudes and Safety Performance in Hong Kong Construction Workers”. Journal of Safety Research, Elsevier, 34, 199-205.

Skloot. G. Goldman, C., Schechter, C., Levin, S., and Teirstein, A. (2004). Respiratory Symptoms and Physiologic Assessment of Ironworkers at the World Trade Center Disaster Site. CHEST 2004, American College of Chest Physicians, 125, 1248–1255.

Webster, L.F. (1997). The Wiley Dictionary of Civil Engineering and Construction. John Wiley & Sons, Inc. New York, NY.

Yang, K., Aria, S., Ahn, C.R., and Stentz, T.L. (2014). “Automated Detection of Near-miss Fall Incidents in Iron Workers Using Inertial Measurement Units.” Proceedings of the Construction Research Congress 2014, ASCE, 935-944.

LEGITIMISING PUBLIC HEALTH CONTROL ON SITES: EVALUATING THE UK CONSTRUCTION INDUSTRY RESPONSE

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Following the launch of the Public Health Responsibility Deal in the UK, companies can sign up to the H10 Construction and Civil Engineering Industries Pledge, making a commitment, amongst other things, to seek to improve the health and wellbeing of their workforce beyond the workplace. This exercise of corporate paternalism, and the potential challenges this approach makes to worker autonomy and personal freedoms have been explored from philosophical perspectives elsewhere. However, industry response to the pledge has not yet been examined. Quantification of the scope and scale of adoption was made through analysis of the Pledge website, examining the organisations (n = 110) signed up to both the Pledge and the Responsibility Deal in terms of their level and scope of commitment. Content analysis of the Delivery Plans (n = 75) submitted in support of this commitment enabled evaluations to be made of how this commitment has been articulated. Findings suggest that whilst industry may have had initial enthusiasm for the pledge, this is not reflected in a consistent level of firm commitment. The potential for organisations to commit to other Pledges alongside H10 has been identified, enabling them to maximise their 'return on efforts' from a corporate social responsibility perspective. Where detailed Delivery Plans have been created, content analysis suggests that focus has been made on occupational rather than public health, whilst ownership, responsibility and the mechanisms for delivery of the commitments made, have been revealed as potentially fruitful areas for more detailed analytic investigation. The construction industry has adopted the Pledge on its own terms, and whilst this may go some way to moderate the theoretical critique that can be made of such initiatives, there is still the need for further research to examine the management of and relationships between public and occupational health on sites.

Keywords: health, public health, content analysis, UK.

INTRODUCTION

The UK government launched its Public Health Responsibility Deal in spring 2011, aiming to bring improvements to the public health of the UK as a whole, representing " … the Government's ambition for a more collaborative approach to tackling the challenges caused by our lifestyle choices." (Department of Health (DoH) 2013a). Commercial organisations 'sign up' to the Deal and its Pledges, to demonstrate their commitment to supporting the public health of the nation as part of their operations, in an explicit act of Corporate Social Responsibility (CSR).

The Health at Work Pledge asks commercial organisations to "… actively support our workforce to lead healthier lives" (DoH 2011). This Pledge originally contained four 'sub-pledges' (chronic conditions guide, occupational health standards, health and wellbeing reporting and the provision of healthier staff restaurants) which have been added to as the programme has developed. In the autumn

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of 2013, a specific Pledge H10 for Construction and Civil Engineering Industries was launched (DoH 2013b).

However, to incorporate aspirational public health improvements within the construction management remit is arguably a distraction from existing issues of poor occupational health within the industry. In the UK there were an estimated 76 thousand total cases and 31 thousand new cases of work-related ill health, and an estimated 1.7 million working days lost due to ill health in the period 2013/14 (HSE, 2014). Health has become the industry's most serious problem, greatly surpassing safety in terms of the numbers affected. Even large contractors who have significantly improved their safety records in recent years struggle to effectively manage occupational health on their sites, without the responsibility for public health being added to their remit.

Furthermore, the inclusion of public health within any commercial operation can be critiqued; indeed the commodification of worker health, and the challenges this makes to worker autonomy and personal freedoms have been explored from philosophical perspectives in earlier work elsewhere (Sherratt 2015). The significant yet subtle shift of paternalistic power from the government to those with more mercenary goals at heart requires explicit acknowledgement within an industry which clearly has such a heavy reliance, and a detrimental effect, on worker health for its productivity.

How the UK construction industry has responded to this Pledge has not yet been empirically examined, and this is what is presented in this paper. The Pledge website contains a list of all 'Partners currently committed to this pledge' (DoH 2015b) below which all Pledges committed to are noted, along with brief 'Delivery Plan' statements. Analysis of this data will enable an initial picture of the reaction to the pledge to be produced, and early evaluations of any theoretical concerns to be made.

CONTEXT

The Pledge

The UK Government opened their Public Health Responsibility Deal with the statement that 'Public health is everyone's business' (DoH 2011:2). Accordingly, the Deal aims to " … tap into the potential for businesses and other influential organisations to make a significant contribution to improving public health", and to do this by creating an environment that " … can empower and support people to make informed, balanced choices that will help them lead healthier lives." (DoH 2015a).

The Construction and Civil Engineering Industries Pledge was launched under a press release entitled: "Britain's beefy builders say bye bye to baring bottoms" (DoH 2013b). A critical review of this specific document has already been carried out (Sherratt 2015), which put forward a philosophical critique of the approach taken in the promotion of the Pledge. The Pledge itself takes a less provocative approach in its promotion of public health. Specifically, it asks organisations to '… manage the causes of occupational disease and take action to improve the health and wellbeing of people working across offices and sites large and small' (DoH 2015b). It sets out three action points, and a minimum of one must be taken up as company practice: (1) annual reporting of the health and wellbeing of employees, (2) the provision of clinical occupational health services (OHS) that work in accordance with relevant standards, and (3) arrangements to develop a programme to actively promote health and wellbeing and the effective management of health. These actions are also to be carried out down organisational supply chains 'where relevant' (DoH, 2015b). Pledge H10 also sets out the benefits to organisations, and what they can do in order to deliver it through several more specific approaches, and how this must be reported.

Although there are many aspects to explore and unpack within the Pledge and its supporting documentation, this paper is naturally limited in terms of scope. This has resulted in a focus on the three action points noted above. Omission of other elements that are certainly worthy of debate, such as the ethics and morality of 'public health' interventions, is an unfortunate but inevitable consequence of this approach.

Reporting, Data and Epidemiology

Reporting of health and wellbeing is ultimately reliant on the gathering of information from the workforce through health surveillance, relating to epidemiology and the collection of health data (Kass 2001). Within the Pledge, reporting of sickness and absence rates is required, although no reference is made to the UK legislation already in place for the reporting of many occupational diseases, including hand-arm vibration syndrome and occupational asthma (HSE 2014). Existing legal requirements are most notable in their absence from the Pledge; the idea of health reporting is not tied back to the legislation and is instead positioned as a voluntary commitment.

Reporting is also placed alongside the need for management. Considered holistically, these aspects are likely to become integrated with occupational health services, resulting in the development of a symbiotic health screening programme. However this relationship has consequences; in order to enable reporting, surveillance must to be carried out of the entire workforce, which raises questions of ethics and the freedom of the individual to participate or not. It is often assumed that people will be glad to participate in such schemes; however this is not always the case as those companies and individuals who opted out of the occupational health programme on the Olympic park project (Tyers and Hicks 2012) show. People simply may not wish to know; indeed Illich (1976:99) suggested that screening and testing "… transforms people who feel healthy into patients anxious for their verdict".

Health screening within wider public health research is highly debated and grounded in ethics and morals, although within the pledge such considerations are not evident. Childress et al (2002) propose a framework that considers the effectiveness of the programme, its proportionality and whether the probable benefits will outweigh the infringed general moral considerations. Whilst Kass (2001) considers such aspects the "burdens of the programme", including the risk to privacy and confidentiality in collection of health data, the risks to liberty and self-determination, and risks to justice if only certain groups are targeted. Although under the guise of 'public health', surveillance and reporting under Pledge H10 it is actually being carried out by employers on their own private workforces. This raises questions around confidentiality, ownership and future use of the data. For example, workers recorded as vulnerable to lung diseases through smoking may be restricted in the work they can do by their employers, in case of future illness and repercussions around liability. However, the provision of face-fit masks and extract systems should arguably make the work suitable for all, not just those deemed currently 'healthy' enough to do it.

Medical diagnosis of diseases that supposedly take shape in the individual's body has also been seen as a surreptitious and amoral way of blaming the victim (Illich 1976:174), reflecting in health the 'blame the worker' arguments that challenged behaviour based safety (Frederick and Lessin, 2000). Many health issues in construction are the result of poor industrial practices and management, yet health surveillance of the individual shifts the perspective from the work to the worker, placing ownership back with the individual. Indeed, research has found people will accept greater responsibility and self-blame for illness much more than that for accidents, where the causes can be 'othered' (Cooter and Luckin 1997). These considerations deserve further examination than can be made here, yet the shift in ownership of health that screening processes can produce is of significance in an environment where work may be more 'to blame' than the individuals undertaking it.

Occupational Health (OH) Services

Within the Pledge, the scope of OH services is examined only through their quality control, requiring providers to meet certain certificated standards. More interesting comments can be made on the level of understanding of OH, certified or not, within the industry and indeed the UK as a whole. Research on the Olympic Park found a lack of understanding of elements of OH amongst contractors, particularly in relation to legal obligations around health surveillance and what it actually means in practice (Tyers and Hicks 2012). Similarly research of medium sized enterprises in construction also found that duty holders were not clear what was meant by the term 'occupational health' (Thompson and Ellis 2011).

Again, the provision of OH management is enshrined in UK law, but not explicitly referenced within the Pledge. For example the Control of Noise at Work Regulations 2005 sets exposure limits and necessitates health surveillance for affected employees to avoid occupational deafness.

Promoting Health and Wellbeing

Ideas of health are considered unchallengeable, "…medical categories, unlike those of law and religion, rest on scientific foundations exempt from moral evaluation" (Illich 1976:55). Despite the World Health Organisation's definition of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", many wellness measures are actually about prevention of disease, rather than promotion of health (Conrad 2005:545). However, such an approach is then vulnerable to the labelling of individuals with certain diseases, " … unwittingly contributing to stigmatizing certain lifestyles and creating new forms of personal guilt" (Conrad 2005:547) as problems are revealed through both health surveillance and highlighted by preventative programmes, such as smoking cessation.

All health campaigns are potentially paternalistic, suggesting that certain ways of being (e.g. slim or high levels of fitness) are universally valued (Kass 2001). Yet many also consider the voluntary nature of participation to be critical. For example in their promotion of libertarian paternalism, Sunstein and Thaler (2003:3) state that such programmes should include the "straightforward insistence that in general, people should be able to opt out of specified arrangements if they choose to do so". However, in the world of health surveillance and reporting, and the nature of the Pledge as something to re-focus health away from the workplace and onto the worker, the option to make the decision not to participate may not be clearly signposted. In such cases, more fundamental questions must be considered, especially when people's choices do not directly affect others and the "… ethical question then is when can paternalistic interventions … be justified if then infringe general moral considerations such as respect for autonomy, including liberty of action?" (Childress et al 2002:175).

The aim of the Pledge itself is also suggestive in terms of the relationship between the worker and the workplace with regard to their health, stating that: "Construction workers nationally have a higher overall mortality rate, independent of social class". (DoH 2015b). However, if the health of construction workers is ' … independent of social class', this is contrary to the vast majority of research around public health, in which it is generally agreed that social class is a highly significant factor in poor health (c.f. Kass 2001; Conrad 2005; Coggon 2012). But if class is not a relevant factor, the only other aspect that unites the disparate construction workforce is just that - they are the construction workforce. And as such are suffering the consequences of it through poor occupational health.

METHODOLOGY

A post-positivistic methodology was employed to support a mixed methods approach to the data. The sample included all organisations (n = 110) that have publicly committed to the H10 Pledge and are listed on the H10 Pledge website, which can be found here: http://bit.ly/1ucJvBC. The data comprised the commitments made and recorded on the website, and also the text within the web pages found under the Delivery Plans posted by some of the organisations. This included both original plans (n = 75) and update documents (n = 19). These webpages formed the documentary data for this study, and were managed as such throughout the analytical process.

Initially, a quantitative approach was made to determine the scope and scale of adoption, and what pledge(s) had been committed to by the organisations concerned. The findings of this analysis have been presented statistically. More specific content analysis (Tonkiss 2004) was then carried out of all the published Delivery Plans for each company. There are of course limitations is adopting this approach, not least that the characteristics of the sample will influence the content contained therein. Furthermore, the meaning and positioning of these words within the text is also lost. However it must be recognised that this paper is presenting an early, yet essential step in the wider project, and indeed the content analysis employed here is used to reflect on the wider literature, previous work in this area and is used suggest areas for future research utilising a more detailed and nuanced approach.

In order to carry out the content analysis, the word frequency facility within NVivo8 was used to establish the 50 most frequently used words with the exception of 'common words'. The findings of the content analysis have been presented visually through the use of Wordle as a tag cloud, the sizes of the words representing their relative frequency within the data. Although a very 'rough-and-ready' approach to the data, such content analysis is able to illuminate key areas for consideration, and direct future inquiry (Tonkiss 2004). These findings have been embedded within discussion to link them back to the theoretical framing of this study.

FINDINGS, ANALYSIS AND DISCUSSION: EVALUATING INDUSTRY RESPONSE

110 organisations have signed up to the Responsibility Deal Pledge H10 Construction and Civil Engineering Industries. The organisations come from a variety of sectors. Analysis of their self-categorisation on the Pledge website established that 45% were civil engineering or construction contractors, 27% were contractors specific to the railway industry, 6% were specialist contractors, 6% were project delivery organisations (such as High Speed 2 (HS2) and Crossrail), 5% were OH services providers, the remaining 11% included housebuilders, utility distributors and asset managers. The relatively large number of self-categorising railway contractors could be linked to the significant push the Office of Rail Regulation has made for its contractors to sign up to the Pledge (ORR 2015). This may in turn link to future pre-qualification for work within this specialist sector, which has therefore provided an impetus for commitment. The OH service providers did not carry out any construction work themselves, their commitment to the Pledge suggesting the grasping of an advertising opportunity to others signing up, who may now be actively seeking their services.

Level of Commitment

Of the 110 organisations signed up to the Pledge, 32% had no supporting Delivery Plan of how they were going to achieve it in practice. Of those lacking a Plan, 37% were railway contractors and 37% were civil engineering or construction contractors, whilst 4 out of 7 of the project delivery organisations (11% of this total) did not have a plan in place either. This includes the HS2 Project Team, lauded as the 100th organisation to sign up to the H10 Pledge in a government press release. This document stated that "Through signing up to these pledges HS2 aims to break new ground to establish innovative, world-class ways of working that set the standard for the rest of the industry, by committing to the promotion of health in construction and setting challenging performance standards for its supply chain." Yet no clear specification of how this will be delivered has been published since the Pledge itself was signed by the HS2 team on the 10th December 2014. Indeed whilst some organisations had only recently made the commitment, and could therefore be formulating their delivery proposals, over 80% had signed up over 6 months previously to the research date, and 17% of these over a year before. This suggests a lack of structured delivery, and could indicate a reluctance to specify processes or key performance indicators against which future assessment of either commitment or success in delivery could be made. It may also be suggested that initial commitment to the Pledge was deemed 'sufficient' for organisational involvement, and as suggested by the prominence of rail sector organisations, there may be other factors in operation that led to this initial commitment being made.

A similar pattern can be seen in the 'Annual Updates' required for each Delivery Plan. A total of 36 of the organisations had reached the date when an Annual Update was required, yet 47% had not published one, which could again be considered representative of the level of commitment to the Pledge as a whole. Of the 53% that had completed an Update, with just one exception, these had been completed early (before the date required by the initial Delivery Plan) within a three month period in the spring of 2014. The lack of adherence to the 'Annual' nature of the update could indicate that this was requested, and driven by the need for some form of response, rather than the review of any formal performance metrics.

Scale of Commitment

50% of organisations had only signed up to the H10 Construction and Civil Engineering Industries Pledge, the other 50% had made commitments to other Pledges within the Responsibility Deal, one organisation making a commitment to 11 Pledges in total. The spread of this 'scale of commitment' can be seen in Figure 1.

As Figure 1 shows, some organisations have elected to commit to additional Pledges within the Responsibility Deal, as well as Pledge H10. Of those who signed up to more than 5 Pledges, one was Constructing Better Health, the industry non-profit membership scheme, and two were project delivery organisations. The remainder were railway or civil and construction contractors, with the Kier Group making a commitment to 11 Pledges in total.

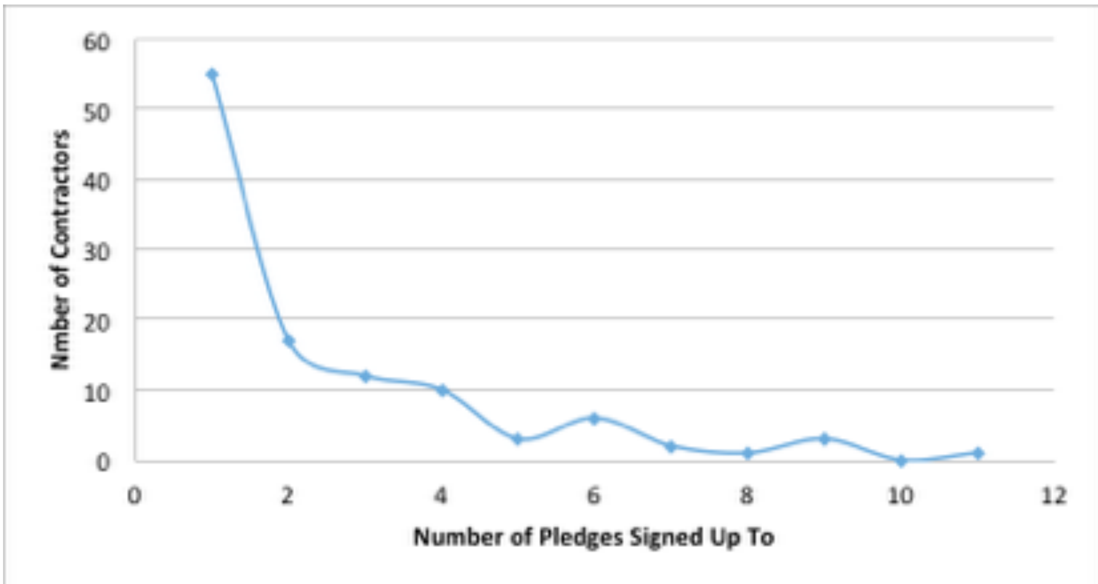

Figure 1: Scale of Commitment to the Responsibility Deal Pledges

When the H10 Pledge is considered in terms of its content, there is potential overlap with three of other Pledges; specifically H2 occupational health standards, H3 Health and wellbeing reporting, and H6 staff health checks. To sign up to all four could therefore be considered a beneficial return on efforts; meeting H2, H3 and H6 through the same delivery mechanisms required for H10, demonstrating a 'wider commitment' to workforce health. Indeed further analysis as shown in Figure 2, confirms that H2, H6 and H3 are ranked first, second and third respectively.

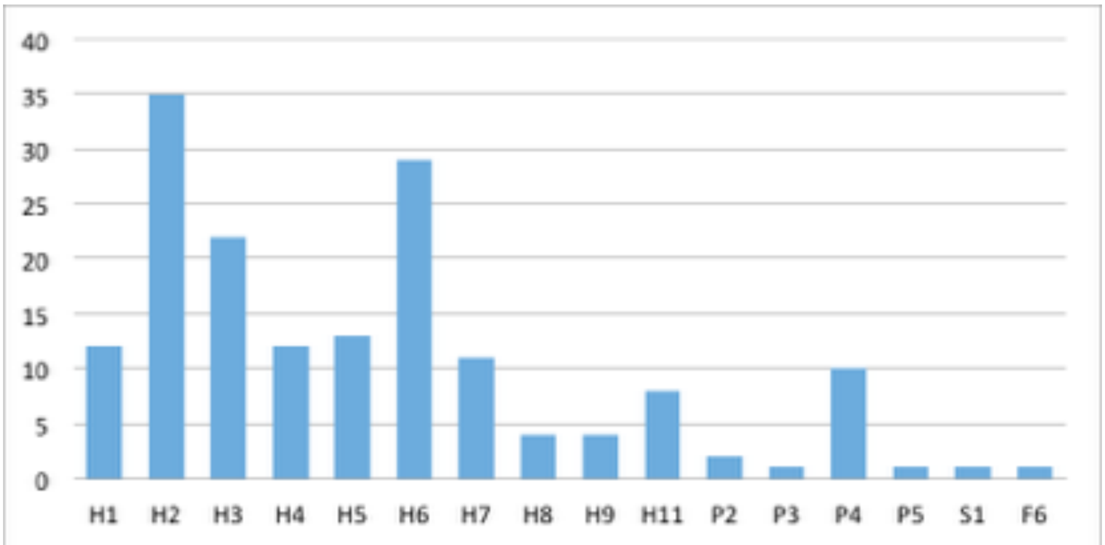

Figure 2: Pledges signed up to alongside H10 Construction and Civil Engineering Industries.

Key: H1 Chronic conditions guide and carers; H2 occupational health standards; H3 health and wellbeing reporting; H4 healthier staff restaurants; H5 smoking cessation/respiratory health; H6 staff health checks; H7 mental health and wellbeing; H8 young people in the workplace; H9 domestic violence; H11 alcohol in the workplace; P2 Physical activity guidelines; P3 Active travel; P4 Physical activity in the workplace; P5 Physical activity inclusions; S1 Local engagement on the Responsibility Deal agenda; F6 Fruit and vegetables.

However, as Figure 2 also shows, many other Pledges have also been committed to alongside H10, not only from the suite of Pledges related to Health at Work, but also to a lesser extent from areas seeking to improve public health through physical fitness and healthy eating. Beyond the links to the H10 Pledge noted above, no pattern could be found within the data in terms of the Pledges committed to, and this may indeed relate to the individual organisations' visions, goals and wider CSR agendas.

Lexicon of the Commitment

Unsurprisingly, as shown in Figure 3, 'health' (1st) was the most prominent word within the Delivery Plans and Annual Update Documentation provided in support of the H10 Pledge. However, what was interesting was that 'public' did not feature at all within the 50 most frequent words. Instead, 'occupational' was prominent (5th), suggesting that industry has positioned the pledge within its current work practices, rather than using it for aspirational public health gains. Focus on the occupational aspects of health does to some extent allay concerns of interventions relating to individuals' personal health beyond work, and suggests industry acknowledgement of the workplace and not just the worker. However, the personal (public) health of individuals may still be incorporated within the delivery plans yet not explicitly signposted as such; further analysis is required to reveal the specifics of this relationship. What is worthy of note is that this seems to dismiss the overall aim of the Responsibility Deal itself, the focus on OH neglecting the very goals of the government's public health project.

Figure 3: Content analysis results (top 50) from the H10 Delivery Plans and Updates

Ownership and responsibility was found within the data through the prominence of 'our' (2nd) and 'we' (3rd). Whether this ownership was used to link the delivery plans the organisation's 'employees' (6th) back to the organisations requires further examination. However, the relationship between employees and management (16th) and staff (17th) suggests that the workforce have been given priority, yet whether they have been positioned as organisational resources or individuals capable of agency with regard to their health remains to be seen. Furthermore, the responsibilities of management to maintain healthy places of work under UK regulatory frameworks could not be identified, this emphasis on the health of the worker potentially obscuring the (un)healthy nature of the workplace.

The actions points of the Pledge itself were to varying extents identifiable within the data. The requirement for health reporting was indicated in the presence of a 'report' (28th) of some form being relatively prominent within the data, however the supporting health 'surveillance' (35th) or 'screening' (42nd) required for the production of such reports (Kass 2001) was much less prominent. This could be due the desire to leave unspecified the processes through which organisations would seek this data. Further research is required to clarify how reporting and the collection of data necessary to achieve it are positioned relationally within the data. There is also the potential for these data collection processes to be embedded within the OH provision required by the Pledge, as suggested by the presence of a 'programme' (9th), although the push for accreditation with reference to SEQOHS (43rd) was not as conspicuous.

The 'programme' could also relate to the requirement to promote health and wellbeing as part of H10. Indeed 'wellbeing' (4th) was easily identifiable within the data, suggesting a new amalgamation formed in the response to H10, superseding health and 'safety' (12th). The approaches made in the various programmes can be suggested by the presence of 'awareness' (14th), initiatives (31st), campaigns (32nd) support (33rd) within the data. Focus on awareness could indicate the prominence of education within the programmes, rather than the enforcement of practices, the latter indicated by the use of initiatives or campaigns and the need for support in their attainment. Alternatively, these could simply be variations in mechanistic terminology. Although this could be associated with a shift in responsibility for health to the worker, it could equally be a desire for engagement and indeed encouragement to demand higher OH standards within the industry as a whole. Again, whilst this limited content analysis has highlighted several potentially fruitful areas of enquiry, further research is needed to explore these relationships further.

CONCLUSIONS

Earlier theoretical examinations of the three action points of the H10 Construction and Civil Engineering Industries Pledge raised several concerns; issues of autonomy and personal freedom, the potential for stigmatisation, and the shift in health responsibility from management to the worker were all considered. However, the empirical evaluation presented in this paper of the industry response to the H10 Pledge suggests that it has been somewhat lacking. The level and scale of commitment indicates the industry may simply not be that interested in engaging at a public health level. Those that have taken up the pledge with supporting documentation, appear to have focused more on occupational than public health, beneficial for the construction industry, yet disappointing for the UK government.

Further research is required to supplement these initial investigations, and explore in detail the responses made to the H10 Pledge, and how these may align with organisational CSR strategies. Although the findings of this early work suggest some moderation of any theoretical challenges, the potential remains for the dominant discourses of the industry response to reflect that of the press release that launched H10; the worker positioned as a unit of production with little regard for agency, and held responsible for their own health. A social constructionist approach will therefore be made to this data, to seek the discourses of health within this specific context. Indeed, the industry response to the Pledge, and other Pledges committed to from within the wider Responsibility Deal, should be explored and illuminated in full, given the close relationships between health and productivity within the construction industry.

The author would like to acknowledge and thank Professor Andrew Hale for his helpful comments and insights, both on this paper and the throughout wider project.

REFERENCES

Childress, J.F., Faden, R.R., Gaare, R.D., Gostin, L.O., Kahn, J., Bonnie, R.J., Kass, N.E., Mastroianni, A.C., Moreno, J.D. and Nieburg, P. (2002) "Public Health Ethics: Mapping the Terrain "Journal of Law, Medicine and Ethics" 30, 170-178.

Coggon, J. (2012) "What Makes Health Public? A Critical Evaluation of Moral, Legal and Political Claims in Public Health", Cambridge University Press, Cambridge.

Conrad, P. (2005) Wellness in the Work Place: Potentials and Pitfalls of Work-Site Health Promotion, in Conrad, P. (Ed) "The Sociology of Health and Illness: Critical Perspectives", 7th Edition, Worth Publishers: NYC, USA.

Cooter, R. and Luckin, B. (1997) Accidents in History: An Introduction, In Cooter, R. and Luckin, B. (Eds) "Accidents in History: Injuries, Fatalities and Social Relations", Editions Rodopi B.V. Amsterdam – Atlanta GA, pp. 1-16.

Department of Health (2011) "The Public Health Responsibility Deal", Department of Health, http://bit.ly/1BY6mUM [9 March 2015]

Department of Health (2013a) "Health at Work Network" UK Government http://bit.ly/1kXxYOw [14 April 2014]

Department of Health (2013b) "Britain's beefy builders say bye bye to baring bottoms" UK Government, http://bit.ly/PAoK0R [6 April 2014]

Department of Health (2015a) "About the Public Health Responsibility Deal", UK Government, http://bit.ly/1aXJwCi [9 March 2015]

Department of Health (2015b) "H10 Construction and Civil Engineering Industries", UK Government, http://bit.ly/1ucJvBC [9 March 2015]

Frederick, J and Lessin N (2000). Blame the Worker – The Rise of Behavioural-Based Safety Programmes. "Multinational Monitor". November 2000 21(11).

HSE (2014) "Health and safety in construction in Great Britain, 2014", Health and Safety Executive, http://bit.ly/Sgu84d [9 March 2015]

Illich, I. (1976) "Limits to Medicine – Medical Nemesis: The Expropriation of Health", Penguin Books, London.

Kass, N.E. (2001) An Ethics Framework for Public Health, "American Journal of Public Health" 91(11) 1776-1782.

Office of Rail Regulation (2015) "Occupational Health Programme Update", ORR, http://bit.ly/1BPm6bc [18 March 2015]

Thompson, M. and Ellis, N. (2011) "Research to explore how medium sized organisations understand occupational health issues and manage health risks" Health and Safety Executive Research Report 841, HSE Books.

Tonkiss, F. (2004) Content and Discourse Analysis, In Seale, C. (Ed) "Researching Society and Culture", Second Edition, Sage Publications Limited, London, pp305-321.

Tyers, C. and Hicks, B. (2012) "Occupational health provision on the Olympic Park and athletes' village" Health and Safety Executive Research Report 921, HSE Books.

Sherratt, F. (2015) Legitimising Public Health Control on Sites? Construction Management and Economics, DOI 10.1080/01446193.2015.1013045.

Sunstein, C.R. and Thaler, R.H. (2003) "Libertarian Paternalism is Not an Oxymoron", John M Olin Law and Economics Working Paper No 185, The University of Chicago.

ESTABLISHING NUTRITIONAL INTAKE AND DETERMINANTS OF FOOD CHOICE AMONGST CONSTRUCTION WORKERS IN GAUTENG, SOUTH AFRICA

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Nutrition is known to be linked with worker health and safety (H&S) performance. Literature suggests that construction workers have poor nutrition and this adversely affects their safety performance on construction sites. However, little attention is being given to the nutrition of construction workers in South Africa and indeed Africa, both in research and in practice. This paper presents findings on the nutritional intake of construction workers and the determinants which contribute to the predominant intake amongst construction workers. Empirical data were collected through a field questionnaire survey conducted on site construction workers in the Gauteng Province of South Africa. Participants were selected using heterogeneity and convenience sampling techniques. Data were analyzed using Statistical Package for the Social Sciences, version 22 software. Mean values and standard deviation were computed. The rank of the foods and determinants was established. Findings revealed that construction workers' nutrition consisted mainly of meat and corn meal. Other frequently consumed food items were found to be fruits and vegetables. The study also found that nutritional knowledge, as well as economic and physiological factors were significant determinants of food choices and intake amongst construction workers. The study will increase awareness about the contribution of nutrition in H&S performance improvement. In addition, design of explicit nutrition intervention programmes will be guided, taking cognizance of the determinants of construction workers' food choices. By highlighting the nutritional intake of construction workers and the determinants of their food choices, relevant and effectual intervention programmes can be designed for nutrition improvement and in turn, construction health and safety performance improvement. In addition, nutrition will be given more attention in health and safety considerations on construction sites.

Keywords: construction workers, food choice determinants, nutrition, safety performance, South Africa

INTRODUCTION

Workers' nutrition has been a source of concern to researchers and organizations. According to the World Health Organization (WHO) 2015), national productivity can be increased by 20% if workers are adequately nourished.Adequate nourishment can be attained through consumption of a variety of foods from different food groups including proteins, carbohydrates, vitamins and minerals in moderation and balance (Amareet al. 2012). Over-consumption or under-consumption of nutrients can lead to the development of chronic diseases such as diabetes, heart disease, etc., and obesity and nutrient deficiencies, leading to increased susceptibility to infections, fatigue, dizziness, confusion, and lack of concentration which may result in accidents, injuries and even death (Du Plessis 2011; Okoro et al. 2014). Therefore, poor nutrition results in poor health which in turn results in reduced physical and mental capacity, increased risks and rates of accidents, incidents and injuries, reducedefficiency and productivity, increased costs incurred in treating avoidable illnesses and diseases, lost working days, losses in profits, and ultimately reduced Gross Domestic Product (Okoro et al. 2014).

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Construction workers have poor nutrition and this affects their health, safety and productivity (Groenveld et al. 2011; Tiwary et al. 2012; Okoro et al. 2014). Despite the undeniable role of nutrition in health, safety and productivity improvement on construction sites, it appears that there is a dearth of literature focusing on the nutrition of construction workers in South Africa and indeed Africa.Research on construction workers' nutrition is overriding since they are the human capital in the industry and therefore indispensable. Moreover, construction activities are labour-intensive, and physically and mentally demanding, requiring moderate to maximum levels of physical strength and stamina, manual dexterity and coordination as well as mental concentration and alertness (Construction Labour Contractors (CLC) 2014). Construction is a high-risk and hazardous sector. Hence, construction workers cannot perform certain construction activities while fatigued or suffering from ill-health. Their nutrition therefore requires considerable attention. Improving nutrition requires an understanding of the determinants of food choice among the subject population (European Food Information Council (EUFIC) 2005).

Research has been conducted on the factors which influence construction workers' nutrition (Du Plessis 2011 & 2012; Okoro et al. 2014). Previous studies have either incorporated workers in general (Watkins et al. 2008); focused on particular factors such as socio-cultural factors (Puoane et al.2006) and environmental factors (Watkins et al. 2008); focused on construction apprentices only (Du Plessis 2012); or presented a literature review of the factors (Du Plessis 2011; Okoroet al.2014). The present paper investigates nutritional intake and determinants of construction workers' food choice and intake. Knowledge of these factors will help in focusing interventions for nutrition to the specific determinants to avoid expenditure on irrelevant and ineffectual intervention programmes. Improving the nutrition of construction workers will in turn contribute to improvement in productivity and H&S in the construction industry. The objectives of the present paper are therefore to establish the predominant nutritional intake and the determinants of food choice and intake amongst construction workers in the Gauteng Province of South Africa.

LITERATURE REVIEW

Workers' nutritional intake

Extant literature revealed that poor nutrition exists amongst workers in most sectors of economies. According to Hurst et al. (2007), agricultural workers, like construction workers, have predominantly poor nutrition due to their socio-economically backward status and generally low level of nutritional knowledge. The plight of the agricultural workers is complicated by the informality of employment and seasonal nature of work which further complicates efforts to establish collective bargaining agreements in terms of provision of welfare facilities such as catering facilities, and food (Hurst et al. ibid.). A similar study by Dabhadker et al. (2013) indicated that coal mine workers in India had poor nutritional status and as a result, their work efficiency was affected. Dabhadker et al. (ibid.) used nutrient intake counts and anthropometric measurements of height and weight to determine nutritional adequacy. Similar studies also reported that transit and manufacturing workers have unhealthy diets with high rates of fast-food consumption and these food choices are mostly determined by their social environment (French et al. 2007; Inoue et al. 2014).

In the construction industry, Tiwary et al. (2012) revealed that construction workers in India were bread-winners to large families and were poorly paid and this lead to regular, but sometimes inadequate, consumption of staple foods including rice, beans and potatoes. According to the authors, meat consumption was rare amongst these workers because they could not afford it. In a similar study, it was found that male construction workers in Australia, especially younger ones, had poor nutrition (Du Plessis 2011). This study focused on young apprentices in the construction industry. Older construction workers in South Africa were also reported to have a lifetime of inadequate nutrition (English and Bowen 2011).

The above literature evinces that the problem of nutrition might not be peculiar to the construction industry. The situation also seems to exist in informal sectors of the economy which are fraught with difficult circumstances associated with poor working conditions and low income. Unsurprisingly, the EUFIC (2005) noted that low-income groups have a tendency to eat unhealthily. However, eating behavior is not a constant phenomenon, but will change with differing circumstances and experiences of an individual (Arganini et al. 2012). Therefore, improving construction workers' nutrition, in particular, requires an understanding of the factors which are peculiar to their circumstances.

Measuring nutritional intake

Various food intake methodologies have been used to determine nutritional intake, for instance, 24-hr dietary recalls, food frequency questionnaires, anthropometric measures and measurement with bio-markers (Sultana et al. 2014). Which method one decides to use depends on the questions to be probed, the settings, the participants and the outcomes required (Huang et al. 2011). Amare et al. (2012) designed and validated a FFQ to obtain quantitative information about the usual food consumption patterns with the aim of assessing the frequency with which certain food items or groups (including meat, fish, eggs, fat-rich foods, dairy products, fruits, vegetables, etc.) were consumed during over a period of time.

Determinants of Food Choice and Intake

According to Arganini et al. (2012), the choices people make about food determine which nutrients enter their body and these choices are influenced by many interrelating factors. The determinants were identified as nutritional knowledge, as well as economic, environmental, social, psychological and physiological factors.

Knowledge about nutrition and its associated health benefits and requirements with regard to age and body size, determine nutritional intake (Arganini et al. 2012). According to Grunert et al. (2010), nutritional knowledge is indicated by ability to identify healthiest foods from various sources or knowledge of what a healthy diet means; knowledge of the sources of nutrients; and knowledge of the health implications of eating or failing to eat particular foods. Food preparation and cooking skills also influence food choices and eating behaviours (Chenhall 2010).

With regard to economic determinants, research indicated that wages/income (Tiwary et al. 2012), cost and availability of food (Du Plessis 2012), marketing strategies of food vendors and companies (Kushi et al. 2006), brand names and food variety (Berger et al. 2007) influence food choices and intake.

Environmental determinants include the physical environment and features at a workplace (Ball et al. 2006). Welfare facilities for washing up before eating, storing and heating up food, and eating areas are physical features which are limited or non-existent on construction sites(Food and Agriculture Organization (FAO) n. d.) Thus, foods get contaminated from the dirty worksites, leading to ill-health. Eating locations (Stroebele & De Castro 2004), seasonality and time constraints (Kolbe-Alexander et al. 2008) also influence food choices.

What people eat is also formed and constrained by circumstances that are essentially social including peer pressure or co-workers (Du Plessis 2011), family needs, social values attached to food and a need to belong or gain socio-economic standing in the community (Puoane et al. (2006).

Psychological factors such as beliefs, attitudes (which usually stem from unfamiliarity of foods or their effects on health), habits, perceptions, motives (for example, to be thin or lose weight) and personality were reported to influence food intake (Babicz-Zielinska 2006). Dindyal and Dindyal (2003) argued that some cultures and traditions may encourage or frown upon consumption of certain foods by individuals who belong to their groups, leading to restrictions such as exclusion of meat and milk from the diet.

With regard to physiological determinants, hunger, taste, appetite, genetic predispositions and personality traits play important roles in determining food choice and dietary behaviour (Delaney and McCarthy 2009). Satiety, taste and appetite also significantly influence consumption of fast-foods, especially amongst younger adults and the less educated (Marreiros & Ness 2009; Blanck et al. 2009).

These determinants relate to general industry and affect workers in varying degrees simultaneously or independently. For construction workers, the effects or impact may be more given the complexities surrounding their working conditions (for instance, low wages and non-provision of welfare facilities), which appear to be peculiar to the industry.

METHODS

A 5-point likert-scale survey questionnaire was constructed from an extensive literature review of workers' nutrition and determinants of nutrition. The questionnaire consisted of two sections; the first section (14 items) enquiring aboutthe frequency of consumption of a list of food items in a working week (adapted from Amare et al. 2012) and the second section (42items) related to nutrition determinants. The questionnaire was pilot-tested, reviewed and revised by the researcher's supervisor, co-supervisor and statistician. The final questionnaire was self-administered to construction workers on eight construction sites (five building construction sites and three civil engineering). Participants included craft workers (comprising brick layers, electricians, carpenters, steel-fixers, plumbers, pavers, cleaners, tillers, manhole specialists, painters and glass-fitters) who were actively engaged in the physical construction activities and who are more susceptible to poor nutrition and safety on sites, as opposed to the site managers and supervisors. Heterogeneity sampling was used to select sites because the concern was not about representing the views proportionately, but about including all the views (Trochim 2006). Attention was paid to including workers from different organizations in order to obtain a representative population. On site, participants who were present and willing to take part in the study were conveniently chosen based on their relative ease of access (Goyal & Goyal 2012). 180 completed questionnaires were recovered out of a total of 220. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 22software. Internal consistency was assessed using Cronbach's alpha *a*. The *a* value for the nutritional intake items was 0.758, while the values for the determinants ranged from 0.705 to 0.837, indicating good internal consistency (Pallant 2013). Outputs were mean (M) and standard deviation (SD) values.Weights were assigned to each response ranging from 1 to 5 for "strongly disagree" to "strongly agree". The ranking or relative importance of the food items and nutrition determinants were also assessed based on the mean values.

RESULTS AND DISCUSSION

Findings on nutritional intake

Respondents were asked to indicate how often they consumed the listed food items in a working week (Table 1). Corn meal consumption recorded the highest mean (M=4.46) with standard deviation (SD) of 0.888, followed by meat consumption (M=4.01, SD=0.946), then vegetables (M=3.79, SD=0.986) and fruits (M=3.73, SD=0.976). That construction workers' nutrition consisted mainly of corn meal, meat, vegetables and fruitsis inconsistent with the findings from Tiwary et al. (2012) which found that construction workers consumed mostly staple foods like rice and potatoes and little or no meat because they could not afford the latter. A possible explanation for the inconsistency could be that what might be considered "staple" in one geographical area might not be considered as such in another. In South Africa, meat is generally affordable, even by low-income earners like construction workers.

Findings on determinants of food choice and intake

Respondents were asked to express their level of agreement to statements about the factors which determine their food choices. The findings presented here show the respondents' agreement relative to the extent to which the respective factors influence their food choice and intake in terms of mean values ranging between 1.00 and 5.00.

Nutritional knowledge

Table 2 shows that knowledge about sources of energy (M=3.91, SD=0.698), knowledge about the sources of nutrients (M=3.76, SD=0.841) and knowledge about nutritional requirements for the type of work engaged in (M=3.68, SD=0.862) were reported to be the most influential in this category. Most of the recorded SDs were less than 1.0, indicating similar opinions among the respondents. These findings support Grunert et al.'s findings (2010) which found that knowledge about various sources of nutrients or what constitutes a healthy diet and knowledge of the health benefits of eating or avoiding particular foods essentially determine food choices.

Table 1: Findings on nutritional intake measures

Measures	Responses (%)					Mean	SD	Rank
	Never	Rarely	Sometimes	Often	Always			
Corn meal	2	1	10	22	65	4.46	0.888	1
Meat	2	4	21	38	35	4.01	0.946	2
Vegetables	1	7	34	28	30	3.79	0.986	3
Fruits	0	8	38	26	28	3.73	0.976	4
Eggs	2	8	41	33	16	3.53	0.914	5
Grains like rice	2	7	43	33	15	3.51	0.909	6
Dairy products	3	11	47	26	13	3.35	0.941	7
A lot of fried foods	6	16	46	20	12	3.18	1.029	8
A lot of sugary foods	15	12	40	21	12	3.04	1.190	9
Fish	7	17	51	17	8	3.03	0.971	10
Cereals	8	19	51	15	7	2.95	0.979	11
Pasta	10	22	44	18	6	2.90	1.020	12
Nuts	4	29	48	12	7	2.88	0.921	13
Extra salt	23	26	30	14	7	2.58	1.199	14

Table 2: Findings on nutritional knowledge

Measures	Responses (%)					Mean	SD	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
Knowledge of sources of energy	1	4	10	72	13	3.91	.698	1
Knowledge of sources of different nutrients	2	6	20	59	14	3.76	.841	2
Knowledge of requirements for type of work	3	6	21	60	10	3.68	.862	3
Knowledge of requirements for an adult	2	9	25	54	10	3.60	.870	4
Knowledge of health consequences of eating or not eating particular foods	5	8	25	50	13	3.58	.975	5
Knowledge of requirements for current health status	2	10	34	39	14	3.53	.937	6
Knowledge of requirements for my age	3	8	42	38	10	3.43	.872	7
Knowledge of requirements for my body size	4	12	42	29	14	3.38	.983	8
Knowledge of what I should eat as a man or woman	10	18	34	34	5	3.06	1.054	9
Cooking skills	10	19	35	30	7	3.04	1.074	10

Economic determinants

Table 3 evinces that cost (M=3.92, SD=0.946), availability of food (M=3.91, SD=0.903) and wages (M=3.73, SD=1.152) are most influential among economic factors. The SD values recorded for cost and availability of foods (0.946 and 0.903, respectively) seemed to suggest that they were equally deemed to be influential determinants. The findings that cost and availability determine food choices align with findings from Du Plessis (2012) which indicated that these factors chiefly influenced food choices among construction apprentices in Australia.

Table 3: Findings on economic determinants

Measures	Responses (%)					Mean	SD	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
Cost/price of food	2	6	15	49	28	3.92	.946	1
Availability of food	1	7	18	49	26	3.91	.903	2
Wages/income	8	9	10	49	24	3.73	1.152	3
Discounts/subsidies	5	15	17	48	16	3.55	1.067	4
Brand name	10	22	33	27	10	3.05	1.122	5
Advertising/marketing	9	26	35	23	7	2.92	1.068	6

Environmental determinants

Table 4 shows that time (M=3.23, SD=1.073) and seasonality (M=3.18, SD= 0.984) recorded the highest mean scores, while facilities provided for eating (M=3.09, SD= 1.172) recorded the lowest. The recorded SD for foods in season seemed to suggest that the respondents' views about seasonality being a nutrition determinant were similar, while their views were relatively more varied with respect to on-site facilities for food storage and eating. These findings align with findings from Stroebele & De Castro (2004) and Kolbe-Alexander et al. (2008) which identified location, time and seasonality as significant food choice determinants.

Table 4: Findings on environmental determinants

Measures	Responses (%)					Mean	SD	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
Time	6	21	27	36	10	3.23	1.073	1
Foods in season	5	18	41	28	9	3.18	.984	2
Location	5	23	32	34	7	3.16	1.011	3
Facilities for storing and heating up food	9	21	31	28	12	3.15	1.137	4
Eating facilities on site	11	19	31	28	11	3.09	1.172	5

Social determinants

From Table 5, it can be seen that family norms and traditions (M=3.51, SD=1.023) were found to be the most influential social determinants as perceived by the sample workers. This result is consistent with Puoane et al.'s (2006) findings which reported that individuals make food choices based on their family orientation and values attached to food.

Table 5: Findings on social determinants

Measures	Responses (%)					Mean	SD	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
Family norms and traditions	4	15	19	49	12	3.51	1.023	1
Social belonging	10	33	19	27	11	2.95	1.196	2
Peer/colleagues' influence	12	31	22	29	6	2.86	1.141	3
Social media and networking	13	35	30	17	6	2.67	1.078	4

Psychological determinants

From Table 6, it can be seen that the fact that healthy food will help increase productivity at work (M=3.88, SD=0.781) and help to improve concentration and avoid injuries (M=3.68, SD=0.945) recorded the highest mean scores. It is also notable that beliefs regarding consumption of meat seemed not to be significant determinants of food choices amongst the respondents. This does not align with findings from Dindyal and Dindyal (2003) which revealed that individuals may choose to exclude meat based on certain beliefs and restrictions.

Physiological determinants

Table 7 shows that that there is concurrence amongst the respondents regarding the physiological determinants as being influential on their food choice decisions as evinced by the recorded mean scores. The recorded SD values (less than 1.0) suggest that the respondents viewed all the factors as being equally influential. These findings concur with findings from Du Plessis (2011) which indicated that appetite, satiety, and taste influence choice of food.

Table 6: Findings on psychological determinants

Measures	Responses (%)					Mean	SD	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
Fact that healthy food helps to increase my productivity	2	4	11	69	14	3.88	.781	1
Fact that healthy food helps me to concentrate and avoid injuries	4	8	17	58	13	3.68	.945	2
My idea that particular foods make me lose or add weight	7	12	28	43	11	3.41	1.046	3
Mood eg. happy, sad, etc.	9	17	37	31	7	3.10	1.053	4
Cynical attitude about nutrition promotions	8	21	35	24	11	3.10	1.112	4
Eating habits	14	20	25	32	9	3.02	1.200	6
Belief that current diet is adequate	17	27	16	33	7	2.86	1.247	7
Belief of eating food from my culture	15	36	18	22	9	2.74	1.218	8
Belief that avoiding meat saves money	30	38	8	21	3	2.29	1.189	9
Belief that avoiding meat keeps me healthier	33	35	12	14	7	2.27	1.242	10
Belief that killing animals for food is not good	34	38	9	12	7	2.21	1.232	11

Table 7: Findings on physiological determinants

Measures	Responses (%)					Mean	SD	Rank
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree			
Hunger	4	2	10	59	26	4.02	.865	1
Appetite	2	2	18	59	19	3.91	.806	2
Satiety	4	4	12	63	17	3.87	.872	3
Taste	4	4	16	57	19	3.81	.929	4
Quality of food	2	4	21	58	15	3.79	.832	5
Appearance of food	4	9	24	49	15	3.64	.965	6

CONCLUSION

The study set out to establish the predominant nutritional intake and the determinants of food choice among construction workers in Gauteng, South Africa. Findings revealed that the nutrition of construction workers consists mainly of meat and corn meal. It was also found that nutritional knowledge, economic factors (including cost, availability of healthy food alternatives, wages and food discounts/subsidies) and physiological factors (including hunger, appetite, satiety, taste and quality of food) were the most influential food choice determinants.

With these findings, nutrition intervention programmes can focus on the identified significant factors. Nutrition education could be intensified to encourage construction workers to make more varied food choices. The importance of healthy eating on their H&S should continuously be emphasized. In addition, supplementary feeding programmes can be organized to support construction workers' nutrition given their plight regarding the low wages they earn. Employers could collaborate with organizations to provide varied foods on site. Healthy and varied food alternatives could be provided in vending machines, and discounted to encourage purchase of such foods.

The study provides useful evidence to develop measures to improve construction workers' nutrition, which will in turn help in maintaining their physical and mental health and prevent occurrence of accidents, injuries and/or deaths on construction sites. Hence, productivity will be increased, expenditure on avoidable on-site exigencies will be decreased and Gross Domestic Product will be increased.

REFERENCES

Amare, B, Moges, B, Moges, F, Fantahun, B, Admassu, M, Mulu, A and Kassu, A (2012) Nutritional status and dietary intake of urban residents in Gondar, Northwest Ethiopia. "BMC Public Health", 12,752.

Arganini, C, Saba, A, Comitato, R, Virgili, F and Turrini, A (2012) Gender differences in food choice and dietary intake in modern western societies. "Public Health - Social and Behavioral Health", 83-102.

Babicz-Zielinska, E (2006) Role of psychological factors in food choice – A review. "Polish Journal of Food and Nutrition Sciences", 15/56(4),379-384.

Ball, K, Timperio, A F and Crawford, D A (2006) Understanding environmental influences on nutrition and physical activity behaviours: Where should we look and what should we count? "International Journal of Behavioural Nutritional and Physical Activity", 3,33.

Berger, J, Draganska, M and Simonson, I (2007) The influence of product variety on brand perception and choice. "Marketing Science",26(4),460-472.

Blanck, H M, Yaroch, A L, Atienza, A A, Yi, S L, Zhang, L J and Masse, L C (2009) Factors influencing lunchtime food choices among working Americans. "Health Education and Behaviour",36,289-301.

Chenhall, C (2010) Improving cooking and food preparation skills: A synthesis of the evidence to inform program and policy development. "Health Canada" Canada: North America.

Construction Labour Contractors (CLC) (2014) Construction workers' essential qualities. CLC.

Dabhadker, K, Shrivastva, R and Sharma, A (2013) Nutrition of coal mine workers: A case study of Korba coalmines, Chhattisgarh. “International Journal of Scientific and Technology Research”, 2(5).

Delaney, M and McCarthy, M (2009) Food choice and health across the life course: A qualitative study examining food choice in older Irish adults. “113th EAAE Seminar “A resilient European food industry and food chain in a challenging world”, 3-6 September 2009, Chania, Crete, Greece.

Dindyal,S and Dindyal,S (2003)Howpersonalfactors,includingcultureandethnicity,affect thechoicesandselectionoffoodwemake.“InternetJournalofThirdWorldMedicine”,1(2).

Du Plessis, K (2011) Diet and nutrition: A literature review of factors influencing blue-collar apprentices. “Incolink”, Victoria, Australia.

Du Plessis, K (2012) Factors influencing Australian construction apprentices dietary behaviours. “American Journal of Men’s Health”,6(1), 59-66.

English, J and Bowen, P (2011). Factors in personal health and safety of women in the South African construction industry explored from the perspectives of both genders. “Royal Institution of Chartered Surveyors (RICS) construction and property conference”, University of Salford, Manchester: United Kingdom.

European Food Information Council (EUFIC) (2005) The determinants of food choice. European Food Information Council.

French, S A, Harnack, LJ, Toomey, T Land Hannan, P J (2007) Association between body weight, physical activity and food choices among metropolitan transit workers. “International Journal of Behavioural Nutrition and Physical Activity”, 4, 52.

Food and Agriculture Organization (FAO) (n. d.) The food system and factors affecting household food security and nutrition. Agriculture, Food and Nutrition for Africa. FAO Corporate Repository. FAO.

Goyal, V M and Goyal, G (2012) Consumer perception towards internet banking w.r.f. to private and foreign banks in India. “International Journal of Computing and Business Research”. Proceedings of I-Society at GKU, Talwandi Sao Bathinda: Punjab.

Groenveld, I F, van der Beek, A J, Proper, K I, Hildebrandt, V H and van Mechelen, W (2011) Short and long-term effects of a lifestyle intervention for construction workers at risk for cardiovascular disease: A randomized controlled trial. “BMC Public Health”, 11,836.

Grunert, K G, Wills, J M, Fernandez-Celemin, L (2010) Nutrition knowledge and use and understanding of nutrition information on food labels among consumers in the United Kingdom. “Appetite”, 5,045.

Huang, V, Lee, M, Pan, W and Wahlqvist, M L (2011) Validation of a simplified food frequency questionnaire as used in the Nutrition and Health Survey in Taiwan (NAHSIT) for the elderly. “Asia Pacific Journal of Clinical Nutrition”, 20(1), 134-40.

Hurst, P, Termine, P and Karl, M (2007) Agricultural workers and their contribution to sustainable agriculture and rural development. Geneva: International Labour Office.

Inoue, M, Minami, M and Yana, E (2014) Body mass index, blood pressure, and glucose and lipid metabolism among permanent and fixed-term workers in the manufacturing industry: A cross-sectional study. “BMC PublicHealth”, 14,207.

Kolbe-Alexander, T L, Buckmaster, C, Nossel, C, Dreyer, L, Fiona B, Noakes, T D and Lambert, E V (2008) Chronic disease risk factors, healthy days and medical claims in South African employees presenting for health risk screening. “BMC Public Health”, 8, 228.

Kushi, L H, Byers, T, Doyle, C, Bandera, E V, McCullough, M, Gansler, T, Andrews, K S and Thun, M J (2006) American Cancer Society guidelines on nutrition and physical activity for cancer prevention: Reducing the risk of cancer with healthy food choices and physical activity. 56(5). American Cancer Society.

Marreiros, C and Ness, M (2009) A conceptual framework of consumer food choice behaviour. “Working Paper Series”, University of Evora: Portugal. Centre for Advanced Studies in Management and Economics (CEFAGE-UE).

Okoro, C S, Musonda, I and Agumba, J N (2014) A review of factors influencing construction workers’ nutritional uptake. “DII-2014 Conference on Infrastructure Investments in Africa”, 25-26 September 2014, Livingstone: Zambia.

Pallant, J (2013) “SPSS survival manual: A step by step guide to data analysis using IBM SPSS”. 5ed. Australia: Allen and Unwin.

Puoane, T, Matwa, P, and Bradley, H (2006) Socio-cultural factors influencing food consumption patterns in the Black African. “Human Ecology”. Special Issue (14), 89-93.

Stroebele, N and Castro, J M (2004) Effect of ambience on food intake and food choice. “Nutrition”, 20,821-38.

Sultana, P, Ysmain, N, Chaklader, M A and Yasmin, R (2014) Energy intake and energy expenditure of female ready-made Bangladeshi garment workers. “International Public Health Forum”, 1(3),14-7.

Tiwary, G, Gangopadhyay, P K, Biswas, S, Nayak, K, Chatterjee, M K, Chakraborty, D and Mukherjee, S (2012) Socio-economic status of workers in the building and construction industry. “Indian Journal of Occupational and Environmental Medicine”, 16(2), 66-71.

Trochim,W M K (2006) Levels of measurement. “Research Methods Knowledge Base”.Web Centre for Social Research Methods.

Watkins, C M, Lartey, G K, Golla, V and Khubchandani, J (2008) Workers’ perception: Environmental factors influencing obesity at the workplace. “American Journal of Health Studies”, 23(2), 74-80.

World Health Organization (WHO) (2015) Nutrition: Micronutrient deficiencies. WHO.

IDENTIFYING CONSTRUCTION WORKERS INJURY PREDICTORS: A THEMATIC CONTENT ANALYSIS

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Construction is a dangerous industry globally, with high rates of fatal and non-fatal injuries. Furthermore, there is paucity of analytical research that considers the predictors of injuries among construction workers in South Africa construction industry and in the developing countries. The objective of this paper is to review existing research literature to identify the variables that are considered to be predictors of occupational injuries among construction workers. It also aimed to identify the gaps that exist in the current literature. The review spanned two decades between the periods January 1995 to 2015. The search was based on a systematic keyword combination search in two databases that is- emerald and science direct and in google. Twenty one quantitative and mixed method research studies were adjudged relevant for analysis in this current study. They were analysed using thematic content analysis, by identifying themes. All the studies reviewed had different predictors of construction workers injury. Furthermore, no study identified the safety leadership characteristics of the construction workers especially the tradesmen, hence a further gap identified in the current literature. Despite the gaps identified, five broad themes were adjudged to be good predictors of construction workers injuries, these were: work related variables, demographic variables, unsafe health and safety (H&S) behaviour, poor safety climate, and psychosocial factors. A further study is advocated to develop a predictive model for injury occurrence among construction workers in South Africa using logistic regression analysis. The model to be tested will also include the safety leadership characteristics of the construction workers.

Keywords: construction workers, injury, predictors, thematic analysis.

INTRODUCTION

According to Statistics South Africa (2014), the construction industry contributed about 2.7% year on year of the total Gross Domestic Product (GDP) to the South Africa economy in the third quarter of 2014. Hence, the importance of the construction industry in the economy of South Africa cannot be underestimated.

Despite the importance of the construction industry to the economic development of different nations, its construction H&S performance has for many years been a concern to industry stakeholders (Rajendran and Gambatese 2009; Lingard and Rowlinson, 2005) largely because construction projects are generally complex and hazardous. They are complex (Lingard and Rowlinson, 2005) because of the extensive use of sophisticated plant, equipment, modern methods of construction, and its multidisciplinary workforce and multi-tasked aspects of its project team and workforce (Debrah and Ofori, 2001). The industry is hazardous because of the high incidence of accidents and fatalities (Bakri et al., 2006). Hinze (1997) opined that when compared with other labour intensive industries, construction industry has historically experienced a disproportionately high rate of disability injuries and fatalities for its size. Haupt (2001) indicated that construction workers were two to three times more likely to die on the job than workers in other industries, while the risk of serious injury was

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almost three times higher. The International Labour Organization (ILO, 2005) further indicated that 25 to 40 per cent of fatalities in the industrialised world workplace occur in construction industry.

The incident rate for fatal accidents in most countries in the construction industry is high (Ling et al., 2009; Abudayyeh et al., 2006). In the United Kingdom, the Health and Safety Executive (HSE) reported that in 2010/2011, 50 fatal injuries occurred in construction compared to an average of 61 in the previous five years (HSE, 2012). However, despite this decrease the number of fatalities is still unacceptable. In the United States of America (U.S.A), the number of work-related fatalities declined by 10% in 2010. However, the construction industry still accounted for far more fatal work injuries than any other industry sector with 774 fatal work injuries at an average rate of 9.8 per 100, 000 workers in 2010 (Bureau of Labour Statistics (BLS, 2011). From 2011 there was gradual increase of work related fatalities. The numbers of fatalities were: 781, 849 and 856, in the years: 2011, 2012 and 2013 respectively (BLS, 2015).

In South Africa the most recent data by the Department of Labour (2012), indicated that during the period 2007-2010 there were 171 fatalities and 755 injuries. Furthermore, the construction sector paid out more than R287 million (about USD34 million, 1USD = ZAR8.441 this rate was in the year 2012) on claims for injuries and illnesses, that were work-related in the period ending March 2012. In a recent accident on June 4th 2015 in Pretoria South Africa, five construction workers were injured when the scaffold collapsed at approximately 10-15 meters high (Africa News Agency, 2015).

The construction industry in South Africa continues to pose an inherent risk to the H&S of its employees. This negatively impacts on the employee morale, resulting in productivity loss and reputational risk. Hence, the industry needs to address the causes of workers injuries.

PROBLEM STATEMENT

Despite the benefits of the construction industry highlighted in this paper. The construction industry is viewed as a dangerous working environment, which would lead families losing their loved ones or leaving them permanently or temporarily injured or disabled. This could eventually lead to the loss of financial support of the family especially when one was a bread winner. In relation to this problem this current study is a literature discourse to unearth information from previous studies related to the determinants of injuries in relation to construction workers. The research question to be addressed is:

What are the predicators of a construction worker being injured on site?

METHODOLOGY

The literature search spanning two decades in the period January 1995 to December 2015 was undertaken. This was based on systematic keyword combination search in a number of databases namely; emerald and science direct. The researcher also utilized google search. Advance search was used for the data base engines and basic search for google. The keywords used for the data base search of articles were; “injury predictors” AND “construction workers”. The keywords used for basic search were “injury predictors for construction workers”. The search in the data bases retrieved 4888 articles. However, after filtering the articles only 16 were relevant. Google search retrieved 390 000 articles and reports. Five relevant articles and report which were not duplicates with those obtained from emerald and science direct search were used as tabulated in Table 1. It is however acknowledged that searching process was a limitation, as limited key words were used.

The criteria for including the article or report were: the article/report should be peer-reviewed, be written in English, it should state the aim of the study, method used, present the results and conclusion; and finally, report or contain results relating to the aim of this literature review. This approach is similar to the study of Gildberg et al., (2010) which was considered to be rigorous.

The non-experiential data was analyzed using thematic content analysis. The articles were read to obtain a sense of the content and the emerging themes were noted. The themes were further categorized into sub-themes. According to Baxter (1994) themes are threads of meaning that recur in domain after domain.

LITERATURE REVIEW ON CONSTRUCTION WORKERS INJURY PREDICTORS

According to Choi, (2015) age predicted the type of injury of construction workers. The study indicated that older workers and younger workers sustained different types of injuries. Older workers sustained increased sprains/strains. Furthermore, the type of occupation/trade was found to be linked with high injury rate. The highest rates of injuries were linked to labourers, carpenters, iron workers, and operators. Holte et al., (2015) in Norway established that prevalence of injuries was high among apprentices in companies that employed 10-19 employees. Hence, the size of company was a predictor of employees getting injured. Holte et al., (2015) study deduced that employees in electrical trade companies, employing between 10-19 employees and those employees in building trade in companies employing 20-49 employees were at risk of getting injured. This result is not a surprise as these companies are small because of they employ less than 50 employees. Furthermore, the study implied that apprentices who had been employed between 19 to 24 months in the company had the courage to report an injury when it occurred. The study further, suggested that an apprentice working in the company for three months and less, are not courageous to report the injury incurred. It can therefore be suggested that as an employee, in order to report an injury you need to have worked in the company for more than one and half years. Holte et al., (2015) study focused mainly on company size and prevalence of injury among apprentices. Hence, reporting different predicators in comparison with the study of Choi et al., (2015).

Hon et al., (2014) implied that positive workforce safety attitude and acceptance of safety rules and procedures were significant predictors of injury occurrence. The prediction deduced that an increase in the positive workforce safety attitude and acceptance of safety rules and procedures would decrease injury occurrence. Further, the study established that reasonable production schedule was a predictor of injury occurrence. Management commitment and effective safety management were good predicators of injury occurrence. It can therefore be suggested from this findings that negative safety climate among construction workers has a likelihood of increasing injury occurrence. This suggestion concurs with the study of Moore et al., (2014) in the USA. They indicated the causes of accidents to be lack of fall protection or their incorrect use. Further, the study implied that minimal H&S planning, lack of H&S training to the roofers and little or no adherence to the Occupational Safety and Health Administration legislation led to workers injuries. The predicators of injury occurrence established by Moore et al., (2014) and Hon et al., (2014) examined safety climate influence on injury occurrence. However, the studies focused on different areas. Hon et al., (2015) focussed on repair, maintenance, minor alteration and addition works (RMMA), whereas Hon et al., (2014) examined fatal events in residential roofing.

According to Adane et al., (2013), concluded that occupational injuries were common among building construction workers in the study area; the prevalence of the injuries were associated with lack of personal protect equipment (PPE), working overtime, lack of vocational training, workers dissatisfaction with their job. Gender and age were also contributing factors to workers injuries. The findings can be categorized as demographic, safety climate and psychosocial factors. Schofield et al., (2013) found that drug testing programs were predictors of lower injury for the pre-employment/post-accident employees. Unionized and non-unionized employees did not predict lower injuries. Abbas et al., (2013), indicated that working overtime, poor safety climate, short duration of work, job dissatisfaction, young age, and job stress were good predictors of occupational injuries. However, it is interesting to note that sleeping disturbance, and poor machine maintenance and design did not predict occupational injuries among the construction workers. Yoon et al., (2013) found that when occupational health and safety management system (OHSMS) is implemented there was reduction of work related accidents and fatal accidents rates. It can therefore be suggested that when OHSMS is poorly implemented or not implemented there will be increase in accidents among construction workers.

Dong et al., (2013) established that the type of occupation predicts accident occurrence. Construction labourers, construction helpers, ironworkers and roofers are the most dangerous occupations with the highest death rates for falls from roofs. Other types of occupation that were to some extend predictors of accidents were: carpenters, sheet metal and welders. Furthermore, working on residential roofs predicted accidents. In addition age predicted accidents when working on roofs. Workers who were younger than 20 years or older than 44 years were vulnerable to accident occurrence. Race and the citizenship of the worker predicted accidents when working on roofs. Hispanics and immigrants had a high death rate of falls from roofs. It can be argued that immigrants might be in position to compromise the H&S at work in order to earn a living. Lingard et al., (2013) found that immediate factors, that is- site layout, unsafe actions, and communication failure were predictors of plant related fatalities. Furthermore, shaping factors like site constraints, inadequate supervision, plant design and skill of operator were deemed good predictors. Finally they inferred that originating influences that is- safety culture and construction process design were good predictors of plant related fatalities in Australia.

Cheng et al. (2012) undertook a non-experimental quantitative study on factors contributing to occupational injuries in the construction industry. They implied that the causes of accidents leading to injury were: source of injury, unsafe condition, accident location, unsafe acts, project type, gender, safety and health management, worker age and enterprise size. Leung et al., (2012) found that construction workers injuries were predicted directly by lack of goal setting and the safety behaviour of construction workers. The study further implied that safety behaviour is directly influenced by emotional stress, physical stress and inappropriate safety equipment. It is important to note that workers behaviour is influenced by other factors hence leading to workers injuries. Zhang (2012) opined that in China the predictors of injury occurrence among immigrant workers were; training, gender, contract of employment and the age of the workers. The difference of findings in the studies of Cheng et al., (2012); Leung et al., (2012) and Zhang (2012) was a result different focus areas. Furthermore, Leung et al., (2012) did not include demographic variables in their study.

In a study conducted in Norway, young workers are at a higher risk to be involved in workplace injuries compared to older workers, hence age can be deemed to be a predictor of workers injuries. Physical demands that is-(vibration and heavy lifting) and control over the pace of work are associated with increased risk for injuries. However, safety climate was not associated with predicting injuries (Kjestveit et al., 2011). Abbe et al., (2011) implied that injuries were influenced by job control, responsibility for safety of others, safety climate, training, job certainty and personal safety compliance. The study also posited that physical symptom (headache) and psychological symptom (feeling sad on the job) were associated with injury occurrence. Im et al., (2009) established that gender, age, duration of employment; company size and cause of injury e.g. fall from height, structure collapse, and electric shock were injury predictors of construction workers. The type of occupation was also a predictor of injury. This was influenced by falling from heights. The trades mostly affected were painters, plasterers and scaffolders. It can be suggested that frequent training should be offered to this group of tradesmen.

Wong et al., (2009) found that factors leading to fall accidents were, lack of experience, fatigue, the equipment used that is- the ladder, and the negative attitude of workers, or a “don’t care attitude”. Dong et al., in (2009) focused on fatal falls among Hispanics construction workers. The results implied that age, job tenure, occupation, size of organization, ethnicity and types of construction project had an influence in workers falling, therefore leading to injuries. Hinze et al., (2008) opined that injury related to the eyes was influenced by not wearing eye protection. Furthermore, injury on the right or the left eye was influenced by the type of work equipment used. They implied that when grinding metal, 66% of injuries affected the right eye. However, when hammer was used it was associated with the left eye injury. It is important to establish types of tools and equipment that may cause injury on the construction worker. Age was also a determinant of eye injury. Workers in the age group between 25 and 35 were prone to eye injury. Further, close to 65% of operators were injured compared to 35% of bystanders. It can therefore be indicated that the work environment is a contributor to injury. Despite this findings Hinze et al., (2008) study differed from the study of Abbe et al., (2011); Kjestveit et al., (2011); Wong et al., (2009); Dong et al., (2009); and Im et al., (2009) as Hinze et al., (2008) focused on eye injury predictors. Furthermore, the study focused on the type tool that caused injury on either the right or left eye.

In a study by Nissen (2007) immigrant workers had experienced a workplace injury which resulted in loss of work of a day or more. Thirty-nine percent had witnessed a worksite accident serious enough to cause a fellow worker to be taken to the hospital. In their entire construction work career (average length: approximately seven and a half years), eighteen percent had witnessed a death at a worksite where they worked. In Gillen et al., (2002) study implied that the union workers, safety climate, and psychological job demands were the factors adjudged in influencing severity of injury.

Table 1: Literature matrix

Authors, Year	Objective**(s)**
Holte et al., (2015)	To determine injury risk among apprentices in different sized enterprises within different building and construction trades
Choi, (2015)	To identify any trends of injury type as it relates to the age and trade of construction workers
Hon et al., (2014)	To compare the level of safety climate of workers, supervisors and managers in the RAMM sector and explaining/predicting the impact of safety climate on injury occurrence of workers, supervisors and managers
Moore et al., (2014)	To investigate the factors associated with residential roof fatalities
Lingard et al., (2013)	To investigate the circumstances and causes of fatal incidents involving plant in the Australian construction industry
Adane, et al., (2013)	To determine the magnitude and factors related to work related injuries among building construction workers
Abbas et al., (2013)	To determine the magnitude, pattern and risk factors of non- fatal occupational injuries and to explore the level of safety climate and its relationship with occupational injuries
Yoon et al., (2013)	To investigate the status of OHSMS and the effect of OHSMS on accident rates. To determine the differences of awareness of safety issues among site general managers, OHS managers.
Dong et al., (2013)	To investigate the factors associated with roof falls

Continuation Table 1: Literature matrix

Authors, Year	Objective(s)
Schofield et al., (2013)	To evaluate the impact of active company drug testing programs on the rates and severity of injuries sustained by workers in small construction firms
Zhang (2013)	To determine the effect of individual factors, occupational training on occupational injury of migrant workers
Leung et al., (2012)	To identify the impact of various organizational stressors and stress on construction workers safety behaviours and injury incidents.
Cheng et al., (2012)	To establish potential cause-and-effect relationships regarding serious occupational accidents in the industry
Kjestveit et al., (2012)	To explore risk factors for injuries among workers in the Norwegian construction industry, focusing on young workers
Abbe et al., (2011)	To investigate the relationship existing among occupational stressors, psychological/physical symptoms and accident/injury and work days lost outcomes as experienced by manual workers engaged in a range of industrial construction occupations
Wong et al., (2009)	To investigate the problems associated with fall of person from height in the construction industry
Im et al., (2009)	To explore the attributes of fatal occupational injuries
Dong et al., (2009)	To examine deaths resulting from fall injuries among Hispanic workers
Hinze et al., (2008)	To identify factors that are associated with eye injury causation
Nissen, (2007)	To provide a portrait of South Florida immigrant construction workers: demographics, incomes, safety conditions on the job, and employer treatment in other ways that may be related to their safety conditions
Gillen et al., (2002)	To evaluate injured construction workers perception of workplace safety, psychological job demands, coworker support and the relationship with injury severity

RESULTS AND DISCUSSION

Five broad central emergent themes were identified, that is- demographic variables, work related variables, unsafe health and safety behaviour, poor safety climate and psychosocial factors. The subsequent themes are discussed hereto.

Demographic variables

Demographic variables have been indicated to be good predictors of injury. The demographic variables constitute of, gender, age, educational level, job tenure of employee, ethnicity, size and type of company. Zhang (2012) posits gender has an influence in injury occurrence of construction workers. Male migrant workers are 10% more likely to be injured than their female counterparts. Adane et al., (2013) concurs with this result. Lingard et al., (2013) found that most decedents occurred on male workers. It can therefore be opined that majority of male workers get injured or die on construction sites than female workers. Therefore, attention by policy makers needs to focus on male workers by offering them more H&S training.

Age of the worker also influenced construction related injury (Dong et al., 2013; Adane et al., 2013; Zhang, 2012; Dong et al., 2009; Hinze et al., 2008). However, the age groups were categorized differently in all the studies. Adane et al., (2013) posited that workers older (>45 years) were likely to be injured than those in the age group 14 to 29 years. Hinze et al., (2008) implied that workers in the age group 25 to 35 were prone to eye injuries. Kjestveit et al., (2011) indicated that young workers less than 25 years were at a higher risk of workplace injuries compared to older workers. Hence, age is a predictor of workers injuries. According to Lingard et al., (2013) most fatal incidents occurred to workers aged between 46 and 55. Dong et al., (2013) attest that the high rate of roof fatalities was high among young (<20 years) and older (>44 years) construction workers. However, it is interesting to note that older workers were also prone to injuries in some studies. This could have been enhanced by older workers losing concentration through fatigue because of their advanced age. It is important to state that Adane et al., (2013) implied that lack of vocational training is a good predictor of worker injury. In connection with this discussion, it can be suggested that construction workers of any age should be reminded or trained on H&S in the workplace.

In view of tenure of employment, those workers who had worked for 1 year or less were susceptible to fatal incident. Hence, it can be suggested that workers who are new in the company should be thoroughly inducted on H&S. These workers should constantly be reminded of the H&S hazards and dangers in their workplace. This could prevent accidents from occurring. Further, ethnicity was deemed to be a good determinant of fatal accidents Dong et al., (2009). In their study they implied that Hispanics were more likely to incur fatal injuries than their white non-Hispanics workers. It can be suggested that education and training on H&S is invaluable for the Hispanic construction workers. In relation to a diverse cultural environment like South Africa with four distinct ethnicities, H&S training for all construction workers should be administered frequently. This will curb injury occurrence of their workers.

Furthermore, the type of company according to Dong et al., (2013) and Dong et al., (2009) would be susceptible with high fatality rate. They found that roofing contractors working in residential construction sites were vulnerable to fatal incidents. Workers working at heights need to be informed of the hazards they will encounter at work. Rigorous H&S training and planning of such construction activities is crucial in order to stifle any form of accidents. Further, Dong et al., (2013) and Dong, et al., (2009) posited that companies employing 10 or fewer workers are likely to incur more fatal accidents. In the context of South Africa definition of small construction organizations, these sizes of company reported are small. This finding is not surprising, it has been suggested that small companies in the construction industry lack the required resources to maintain good H&S practices (Construction Industry Development Board, 2004). The government should support small companies with necessary resources so that they are not constrained in their H&S.

Work related variables

The subthemes of work related variables unearthed in this study are; type of occupation, hours of work, degree of physical effort required in doing the work, type of plant/machinery or equipment used. These sub-themes are adjudged to be good determinants of construction worker injury. Holte et al., (2015) and Choi (2015) asserted that the type of occupation is a catalyst of worker injury. According to Choi (2015) the occupation most affected are labourers, carpenters, iron workers and operators. Dong et al., (2013) indicates that ironworkers and roofers incurred fatal accidents. Holte et al., (2015) on the other hand posits that electrical trade and building trade were most affected. According to Kjestveit et al., (2011) injury in young workers is catalysed by the physical demand of work activities when using vibrating tools, lifting heavy objects, repetitive movement, and working with arms above shoulders. The work task between different age groups has an impact on the type of injury occurrence. This sentiment is supported by Choi (2015). It can therefore be suggested that work tasks in relation to the type of occupation should be assessed for any hazards before commencing any activity. The workers should be trained on the types of tools and equipment they are using. They should be informed of the H&S risk that they might incur while using those tools. This will assist the workers not to incur any injuries while working.
Lingard et al., (2013) found that drivers/operators were susceptible to fatal incidents. They further attested that different types of plant used led to incidents on site. The most frequent plants causing the incidents were cranes, excavators, and trucks. The plant operators need to be trained in order to stifle the prevalence of accidents on construction sites. Abbas et al., (2003) indicated that poor machine design and inadequate maintenance influenced occupational injury of workers. It should be the prerogative of the company to ensure that when their workers are using any machine it should be in good working condition. The machines need to be maintained and damaged machines should not be used. Construction companies should not focus on profits alone but should ensure their workers welfare is also taken into consideration. Further, Adane et al., (2013) found that the likelihood of injury occurring is exacerbated when the construction workers work for more than 8 hours a day. It is imperative to note that workers should not be forced to work for more than 8 hours a day. Working long hours i.e., more than 8 hours a day could lead to worker fatigue. Hence, the employee may lose concentration which could lead to injuries. The company policies or collective agreement between the employer and the trade union on working time should be developed thoughtfully, to ensure all construction workers are not overworked.

Unsafe health and safety behaviour

The unsafe worker behaviour in H&S has a likelihood of predicting injury occurrence. This is supported in the study of Moore et al., (2014), Abbas et al., (2013) and Hinze, et al., (2008). According to Hinze et al., (2008) workers defiance of not using PPEs led to different types of injuries. Hinze et al., found that the lack of wearing safety goggles led to construction workers injuring their eyes. Furthermore, they opined that when workers use damaged or unmaintained equipment and machinery there is possibility of injury occurrence. However Abbas et al., (2013) findings are not in support of Hinzes' findings. Despite the contrary finding of Abbas et al., (2013), it can be argued that any iota of unsafe H&S behaviour should not be condoned at any level of the construction process on site. Workers who do not obey the H&S best practices at work should be disciplined. The form of discipline would remind workers to be cautious of good H&S practices that have been enshrined in the company H&S policy. Moore et al., (2014) attests that poor behaviour, for example not adhering to H&S standards would predict injury or fatal accident.

The health behaviour of the worker was deemed not to be a predictor of injury occurrence among the construction workers (Adane et al., 2013; Abbas et al., 2013). The health behaviors examined were: drug abuse which included smoking, and alcohol abuse. However, organizations should inform their workers of the dangers of substance abuse and provide counselling to workers who are addicts. Schofield et al., (2013) opined that drug testing programs are associated with lower injury rates. It can therefore be suggested that when drug testing is not undertaken the likelihood of injury happening among construction workers is high.

In the context of job satisfaction, Adane et al., (2013) and Abbas et al., (2013) posited that job dissatisfaction influenced injury occurrence among construction workers. This could be as a result of the employees working without focusing in their delegated work. When workers are not satisfied with their work the employer should render appropriate advice and counsel. The employer should not be silent and hope that dissatisfaction of work by employees will sort itself.

Poor safety climate

Lingard et al., (2013), Abbas et al., (2013) and Hon, et al., (2014) implied that when upstream measures are lacking, the possibility of fatalities occurrence on construction site increases. Hon et al., (2014) found that upper management personnel prioritized production more than the workers safety. This finding suggests the reason for worker injury on site. Nevertheless, Kjestveit et al., (2011) found that safety climate was not a good predicator of workers injuries. Despite this contrasting finding, it is important to note that poor safety climate will influence injury occurrence. Safety climate is the measure of safety culture of the organization. When safety culture is observed in any organization by top management it trickles down to the workers on the lower level of the organizational structure. It is therefore imperative that safety culture is inculcated in the organization. This will stifle injury occurrence on construction sites.

Psychosocial factors

According to Leung et al., (2012) when workers incur emotional and physical stress at work it influences their safety behaviour. Further, they found that injury is indirectly caused by emotional and physical stress. Abbe (2011) found that physical stress as a result of the worker suffering from headache predicted injuries. Abbas et al., (2013) implied that job stress predicted workers occupational injuries. In contrast to Abbe et al., (2011) study, Abass et al., (2013) did not test two separate variables that is- emotional and physical stress. Nevertheless, it can be argued that any work stress experienced by construction workers should be attended to. Caring organizations should assist their employees in periodic medical check-up. This will ensure that workers are healthy to undertake their work.

Social support is defined as a sub-theme of psychosocial factor. In the study of Kjestveit, et al., (2011) and Gillen et al., (2002) social support did not predict workers injury. However, according to Abbe et al., (2011) it predicted self-reporting when an injury occurred. It can be stated that, companies should encourage self-reporting of injuries by their workers, without being punished. Workers should not be fearful when they have been injured, but bold enough to report the injury. Those who report any form of injury should be supported, through advice and counsel. This will assist in stifling injury occurrence in the construction industry.

CONCLUSION AND RECOMMENDATIONS

The studies reviewed had different combination of predictors of construction workers injury. This was as a result of a range of study focus from roof fatalities to general view of injury occurrence on workers on site. Further, some of the studies had contrasting findings. For example Abbas et al., (2013) and Hinze et al., (2008) did not agree, that unsafe H&S behaviour predicted injury occurrence. Furthermore, no study has considered the safety leadership characteristics of the labourers and artisans.

Despite these gaps and contrasting findings in the reviewed literature, five broad injury predictors were determined. These predicators could be significant to construction workers injury occurrence on construction sites in South Africa and other parts of the world. These predictors are; work related variables, demographic variables, unsafe H&S behaviour, poor safety climate, and psychosocial factors.

Based on this identified themes the authors recommend the need to develop a predictive model that will predict construction worker injury occurrence in the South African construction industry, using logistic regression analysis. Logistic regression analysis is preferred to multiple regression analysis. This is because the dependent variable will be categorical, that is- asking if the worker was injured/or not injured. In such a case, multiple regression analysis is not suitable. The latter method is suitable when the dependent variable is continuous, that is in a Likert scale.

In developing this model the authors recommend the inclusion of the safety leadership characteristics of employees in relation to the other predictors identified of injury occurrence. The safety leadership characteristics are proposed because they influence the safety culture of the organization (Krause, 2005), which if not observed might lead to H&S injuries. It is therefore imperative to establish the safety leadership characteristics of the labourers and artisans and determine their influence on occupational injury occurrence. The authors argue that in all construction workers, safety leadership characteristics may or may not exist. Hence, the characteristics that will be examined are:

- Credibility – what leaders say is consistent with what they do;
- Action orientation – leaders act to address unsafe conditions;
- Vision – leaders paint a picture for safety excellence within the organisation;
- Accountability – leaders ensure employees take accountability for safety-critical activities;
- Communication – the way leaders communicate about safety creates and maintains the safety culture of the organisation;
- Collaboration – leaders who encourage active employee participation in resolving safety issues promote employee ownership of those issues; and
- Feedback and recognition – recognition that is- soon, certain and positive encourages safe behaviour (Krause, 2005).

EXPECTED MANAGERIAL IMPLICATIONS

The envisaged model is an upstream management tool that will assist the construction companies H&S department in preventing workers injury at work. It is further contemplated that the model will determine the predictors of workers injury. This will assist top management in different organizations in South Africa and even in other developing countries to channel their H&S resources in the right area to stifle injury occurrence.

LIMITATIONS OF THE STUDY

The research presented in this paper has a number of limitations. First, the search for relevant studies was from 1995 to 2015. This search period could have omitted other important or seminal researches that were conducted prior to 1995. Second, the search engines that were used were three in number i.e. emerald, science direct and google. It is accepted if other search engines were used additional studies could have been obtained. Third, the limited number of keywords used in the search for relevant papers, is further limitation. If other keywords were used such as "causes/reasons of injury" this could have improved the number of relevant papers that were used. In light of these limitations the authors suggest the duration of search period to be increased to 1985, search engines and the keywords to be improved. These adjustments will ensure a comprehensive literature review is discussed and a robust model is tested.

REFERENCES

Abbas, A R, Zalat, M M and Ghareeb, E S N (2013) Non-fatal occupational injuries and safety climate: a cross-sectional study of construction building workers in Mit-Ghamr city, Dakahlia Governorate, Egypt. "Open Journal of Safety Science and Technology", 3:69-79.

Abbe, O O, Harvey, M C, Ikuma, H L and Aghazadeh, F (2011) Modelling the relationship between occupational stressors, psychosocial/physical symptoms and injuries in the construction industry, "International Journal of Industrial Ergonomics", 41(2), 106-117.

Abudayyeh, O, Fredericks K T, Butt, E S and Shaar, A (2006) An investigation of management's commitment to construction safety. "International Journal of Project Management", 24(2), 167-174.

Adane, M M, Gelaye, A K, Beyera, K G, Sharma, H R and Yalew, W W (2013) Occupational injuries among building construction workers in Gondar City, Ethiopia. "Occupational Medical Health Affairs", 1(5), 1-5, Available from: http://dx.doi.org/10.4172/2329-6879.100012

Africa News Agency, (2015) Five injured in Pretoria construction site scaffolding collapse, Available from: http://www.enca.com/south-africa/five-injured-pretoria-construction-site-scaffolding-collapse accessed on 25 June 2015.

Bakri, A, Mohd, Z R, Misnan S M and Mohammed, H A (2006) Occupational Safety and Health (OSH) Management Systems: Towards Development of Safety and Health Culture. *Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC), 5th – 6th September, Kuala Lumpur, Malaysia.*

Baxter, L A (1994) "Content Analysis. In Studying Interpersonal Interaction", The Guilford press, New York and London.

Bureau of Labor Statistics (2011) Injuries, illnesses and fatalities; Fatal occupational injuries and workers memorial day. Available from: http://data.bls.gov/cgi-bin/print.pl/iif/oshwc/cfoi/worker_memorial_data.htm Accessed 29 June 2015.

Bureau of Labor Statistics (2015) Industries at a glance: Construction: NAICS 23. Available from: http://www.bls.gov/iag/tgs/iag23.htm Accessed 18 July 2015.

Hon, C K H, Hinze, J and Chan, A P C (2014) Safety climate and injury occurrence of repair, maintenance, minor alteration and addition work. "Facilities", 32(5/6), 188-207.

Cheng, C-W, Leu, S-S, Cheng, Y-M, Wu, T-C and Lin, C-C (2012) Applying data mining techniques to explore factors contributing to occupational injuries in Taiwan's construction. "Accident Analysis and Prevention", 48: 214-222.

Choi, D S (2015) Aging workers and trade related injuries in the US construction, "Safety and Health at Work", 6(2), 151-155.

Construction Industry Development Board (2004) SA Construction industry status report, synthesis review on the South African construction industry and its development, discussion document, April, Pretoria, South Africa.

Debrah, Y A and Ofori, G (2001) Subcontracting, foreign workers and job safety in the Singapore construction industry. "Asia Pacific Business Review", 1(8), 145-66.

Department of Labour, (2012), Department of Labour to sign a Construction Health and Safety Accord to help stem casualty list. Available from: http://www.info.gov.za/speech/DynamicAction?pageid=461&sid=30075&tid=80991 Accessed 19 June 2015.

Dong, S X, Choi, S D, Borchardt, G J, Wang, X and Largay, A J (2013) Fatal falls from roofs among U.S. construction workers. "Journal of Safety Research", 44: 17-24.

Dong, S X, Fujimoto, A, Ringen, K and Men, Y (2009) Fatal falls among Hispanics construction workers. "Accident Analysis and Prevention", 41(5),1047-1052.

Gildberg, A F, Elverdam, B and Hounsgaard, I (2010) Forensic psychiatric nursing: A literature review and thematic analysis of staff patient interaction. "Journal of Psychiatric and Metal Health Nursing", 17(4), 359-368.

Gillen, M, Baltz, D, Gassel, M, Kirsch, L and Vaccaro, D (2002) Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers, "Journal of Safety Research" 33(1), 33-51.

Haupt, C T (2001) "The performance approach to construction worker safety and health", Unpublished PhD Thesis, University of Florida.

Health and Safety Executive, (2012), Statistics on fatal injuries in the workplace 2011/12, Full year details and technical notes, Available from: http://www.hse.gov.uk/statistics/pdf/fatalinjuries.pdf, Accessed 22 June 2015.

Hinze, J, and Giang, G (2008) Factors associated with construction worker eye injuries. "Safety Science", 46(4), 634-645

Hinze, J W (1997) "Construction Safety". New Jersey: Prentice Hall Publications.

Holte, A K, Kjestveit, K, and Lipscomb, J H (2015) Company size and differences in injury prevalence among apprentices in building and construction in Norway, "Safety Science", 71(Part C), 205-212.

Im, H-J, Kwon, Y-J, Kim, S-G, Kim, Y-K, Ju, Y-S, and Lee, H-P, (2009) The characteristics of fatal occupational injuries in Korea construction industry, 1997-2004, "Safety Science", 47(8), 1159-1162.

International Labour Organization, (2005) Promoting safety and health at work; Prevention: A global strategy, the ILO report for world day for safety and health at work.

Kjestveit, K, Tharaldsen, J, and Holte, A K (2011), Young and strong: What influences injury rates within building and construction? "Safety Science Monitor", 15(2), 1-15.

Krause, T R (2005) "Leading with Safety". John Wiley & Sons, Inc., Hoboken, NJ, USA.

Leung, M-Y., Chan, S.Y.I., Yu, J., (2012), Preventing construction worker injury incidents through the management of personal stress and organizational stressors, Accident Analysis and Prevention, 48: 156-166.

Ling, Y.Y.F., Liu, M. and Woo, C.Y., (2009), Construction fatalities in Singapore. International Journal of Project Management, 27(7):717-726.

Lingard, H and Rowlison, S (2005) "Occupational Health and Safety in Construction Project Management". Spon Press 2 Park Square, Milton Park Abington, Oxon OX 14 4rn.

Lingard, H, Cooke, T, and Gharaie, E (2013) The how and why of plant related fatalities in the Australian construction industry? "Engineering, Construction and Architectural Management", 20(4), 365-380.

Moore, R J, and Wagner, P J (2014) Fatal events in residential roofing. "Safety Science", 70:262-269.

Nissen, B., (2007), Research Institute on Social and Economic Policy (RISEP), Center for Labor Research and Studies, Florida International University

Rajendran, S, and Gambatese, A J (2009) Development and initial validation of sustainable construction safety and health rating system. "Journal of Construction Engineering and Management", 135(10), 1067-1075.

Schofield, E K, Alexander, H B, Gerberich, G S, and Ryan, A D (2013) Injury rate, severity, and drug testing programs in small construction companies, "Journal of Safety Research", 44: 97-104.

Statistics South Africa, (2014), Gross Domestic Product Annual estimates 2004 – 2013 Regional estimates 2004 – 2013 Third quarter 2014, Available from: http://beta2.statssa.gov.za/publications/P0441/P04413rdQuarter2014.pdf Accessed on 29 June 2015.

Wong, K W F, Chan, P C A, Yam, C H M, Wong, Y S E, Tse, T C K, Yip, K C K, and Cheung, E (2009) Findings from a research study of construction safety in Hong Kong: Accidents related to fall of person from height, "Journal of Engineering Design and Technology", 7(2), 130-142.

Yoon, J S, Lin, K H, Chen, G, Yi, S, Choi, J, and Rui, Z (2013) Effect of occupational health and safety management system on work related accident rate and differences of occupational health and safety management system awareness between managers in South Korea's construction industry, "Safety and Health at Work", 4(4), 201-209.

Zhang, Q (2012) Occupational injury occurrence and related risk factors among Chinese migrant workers, International Symposium on Safety Science and Engineering in china, 2012 (ISSSE-2012) "Procedia Engineering", 43: 76-81.

COST COMPONENTS FOR EFFECTIVE SAFETY AND HEALTH MANAGEMENT PROGRAM ON CONSTRUCTION PROJECTS

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Health and safety issues on construction projects in Indonesia have been dealt with at the enterprise level. However, the approach to health and safety management is traditional, i.e., it relies on the supervisors and safety specialists. A more innovative approach, where a high level of integration of safety and health into broader management systems and practices, is contemplated. This include the potential to implement Hong Kong's "Contractual Provisions for the Pay for Safety Scheme," in which the owner commits to pay the contractor for safety-related items of expenditure through conditions in a construction contract. Since there is no separate, clearly identifiable costs of safety management, the contractor often restrain on site safety. A study to identify the cost components for such scheme was conducted based on site surveys and interviews with twelve respondents (safety officers or project managers) at construction projects in Jakarta and vicinity. While also considering the Government regulations, thirteen cost components were identified, specifically to be separated and paid by the owner through conditions in a construction contract. These are: site safety plan, updates of site safety plan, safety officers, safety supervisors, site security personnel, induction trainings, toolbox talks, safety signs, safety markings, fire extinguishers and first aid kits, site toilets, housekeeping personnel, and facilities for rest. The study further proposes the concept of specifications for these thirteen components. The total costs of safety and health program on five cases of building construction projects were simulated using the proposed concept of specifications. The results showed that the actual costs spent on projects were much less than the simulated costs. The percentage costs were lower as the contract values increased, varied around 0.1%-0.6%. Based on these limited cases, the patterns for simulated costs have been vague. However, there is a correlation with the number of towers, i.e., the unit cost per worker per month per tower is consistently decreasing with the addition of towers within a project. Also, feedback from project managers suggested that the maximum allocation for OSH-MS of 1% of the contract value would be accepted by the industry, provided that the regulation is enforced nation-wide.

Keywords: *construction, cost, management program, projects, safety and health.*

INTRODUCTION

Indonesia is the world's fourth most populous country, consists of 17,000 islands across three time zones. It is the biggest economy in south-east Asia. Economic growth has been about 5-6% per year, however, the lack of quality and quantity of its infrastructure is hampering Indonesia's economic and social development. "Hard" infrastructure (such as roads, airports and electricity supply) as well as

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“soft” infrastructure (such as social welfare on construction workers) are necessary for efficient development.

There have been several positive developments on occupational safety and health (OSH) issues in Indonesia, according to ILO (Markkanen 2004). The Indonesian OSH regulatory framework is broad. Indonesia is the one of the few countries in Asia that has mandated by the law the implementation of occupational safety and health management system (OSH-MS) at large enterprises. Reporting and dissemination of accident data has also improved. Nonetheless, construction remains a high risk industry.

There have been increases in the numbers of injuries over the years. According to Statistics Indonesia 2013, there were 98,000 accidents (1,200 fatalities) in 2010; meanwhile in 2011, the number was higher (99,000 accidents, 2,218 fatalities); and so on. Although it accounts for only 5.7% (6.9 million) of the workers, about 32% of accidents occured in the construction sector.

Improving the statistics is part of the responsibility of the Directorate General of Construction Development, Ministry of Public Works and Housing (MPWH). In line with their efforts to improve safety culture, the regulation on occupational safety and health management system for construction projects (OSH-MS) was revised (i.e., MPWH Regulation No. 5/2014). The revision includes the classification of projects based on risks; the mandatory employment of full-time safety officer on construction projects categorized as “high risk”; the allocation of OSH-MS cost in the owner’s estimate.

Worksafe Australia (1996) identified there are four approaches to health and safety management: i). Traditional management, where health and safety is integrated into the supervisory role and the 'key persons' are the supervisor and/or any health and safety specialist; ii) Innovative management, where there is a high level of integration of health and safety into broader management systems and practices; iii). A 'safe place' control strategy, which is focused on the control of hazards at source; and iv) A 'safe person' control strategy, which is focused on the control of employee behaviour. In the context of improving safety culture in Indonesia, the government has to implement the ‘innovative management approach.” The industry is complex and the government has a dominant role as the owner of public projects.

There are various measures to drive safety and health improvements in construction. One effective approach is called the “Pay for Safety Scheme” (PFSS) which was first introduced in 1996 by the Hong Kong Government for the public sector. It was later adopted by the Hong Kong Housing Authority. The main objective of PFSS is to remove concerns on safety consideration in competitive bidding by enabling any sums payable for carrying out safety measures to be identified in the construction contract. There are about 2% of contract sum set aside for the contractors to carry out the safety-related items. Coupled with significant amendments to safety legislation, a more effective enforcement strategy, industry awards and reinforced training, the overall safety culture has been seen as encouraging (Choi et al., 2011).

An effective way to ensure that there is sufficient fund is actually allocated and used for safety matters on construction projects is highly anticipated by the public. In a typical contract (there is no standard national contract), the cost allocation associated with OSH-MS is still part of the compliance to the general conditions, not separate, clearly identifiable line items. The Directorate General of Construction Development MPWH was interested in exploring the feasibility of a scheme such as Hong Kong’s “pay for safety.” An initial study in 2012 conducted by MPWH, in which the authors were involved, has identified the specific cost components which are the most relevant to be separated as line items in the tender documents (BP Konstruksi, 2012). While the MPWH study focused on projects within the ministry, the following discussion expands the scope to high-rise building projects in the private sector. The findings will provide supplementary inputs to MPWH for continuous advancement of Indonesian (for both public and private sectors) OSH-MS regulation on construction projects.

CONSTRUCTION HEALTH AND SAFETY IN INDONESIA

The construction industry in many countries faces challenges. However, in a developing country like Indonesia, these difficulties also include institutional weaknesses and lack of basic competencies. The importance of taking measures to improve the performance of the construction industry has been recognised by the government. In 1999, a dedicated agency was formed to administer the continuous improvement of the industry, i.e., the Construction Services Development Board (or LPJK). Also, there is the Directorate General of Construction Development within MPWH, which serves as the partner of LPJK.

There are 182,000 construction firms in Indonesia. However, almost half of this number is doubtful, since until 2014, only 77,000 contractors are certified by the government. Proper certification from the government is crucial; only certified firms are eligible to participate in the national public procurement system. In an effort to improve the competitiveness of the construction industry preparing for the ASEAN Economic Community, the Ministry of Public Works argue that 77,000 contractors are excessive. Because about 80% of certified firms are general contractors, the government have been pushing towards more strict certification requirements with the purpose of increasing the number of specialists.

Thus, the role of the government is strategic to drive changes within the construction services sector (contractors and consultants/engineers), particularly on occupational health and safety. The construction of Indonesian public infrastructure have been mainly supported by the 150 large-sized contractors, while the rest are small and medium enterprises (SMEs). To drive changes in occupational safety and health (OSH) on construction projects, the focus should be on those big firms.

While according to ILO's assessment that Indonesian OSH regulatory framework is comprehensive, its implementation has been weak. Recent internal surveys of MPWH's infrastructure projects on the compliance to internal safety guidelines (which has been in place since 2008), suggested that the overall objective has been long to be met. There are still many challenges including lack of commitments from the top to lower levels of beaurocracy. The competent persons (safety experts) to be involved in those projects are lacking in number. There are much less than adequate number of safety officers within the whole construction sector. Hence, the requirement to hire safety officers/ supervisors on public infrastructure projects is unrealistic on the national level.

Safety compliance as a factor in construction procurement system has recently been contemplated. The National Public Procurement Agency (NPPA), as the center for public procurement policy development, suggest that ISO quality certification and any certifications for safety management systems can be added as the condition during the pre-qualification process. However, this is not yet the standard practice nation wide.

Recently, MPWH revised its regulation on OSH-MS for construction projects (i.e., MPWH Regulation No. 5/2014). In the revision, project owners (in this case, government projects) are obligated to allocate sufficient funding in all project budgets for safety related items as typically needed in an OSH-MS. It further states about the administrative sanctions for project officers who do not comply with these clauses and who do not perform necessary checking on the contractor's compliance.

IDENTIFYING COST COMPONENTS OF OSH-MS

The main objective of this study was to obtain a preliminary overview of the feasibility of separating the costs associated with OSH-MS to be paid by the owner through the construction contract. The first step to study the feasibility of a scheme to ensure the use of OSH-MS allocated funding, is to identify the typical cost components of OSH-MS on construction projects. These cost items should include the mandatory items by law/contract and the practical needs on construction sites. The cost items/components are unique for the context of Indonesian construction industry. These identified cost items/components will then be recommended to the government for further evaluation as the minimum required cost components to be included in the standard bidding document (as separate line items) for nation-wide implementation.

Based on literatures on "pay for safety scheme" (PFSS) in Hong Kong, there is a "Site Safety" section under the bill of quantities (BQ) covered all the payable safety items. When contractors have been certified with satisfactory performance, payment is then to be made. There are eleven typical site safety items specified in PFSS (ETWB 2000): i) Complete draft safety plan, ii) Complete safety plan, iii) Updating of safety plan, iv) Provision of safety officer, v) Attendance to site safety management committee, vi) Attendance to site safety committee, vii) Arrangement of and attendance to weekly safety walk, viii) Provision of safety training in the form of trade specific advanced safety training to skilled workers, ix) Provision of safety training in the form of site specific induction training, x) Provision of safety training in the form of toolbox talk, and xi) Participation in safety promotional campaign as instructed by the Architect/Engineer.

Chan et al. (2010) also explained that in the core components of PFSS, there are links among those eleven payable safety items and four main benefits. These are: 1) Improved safety commitment, 2). Encouragement of developing safety management system, 3). Increased safety training, and 4). Enhanched safety awareness.

The possible adaptation of PFSS' payable safety items was reviewed. The methodology involved two stages: 1). Cross-referencing with OSH-MS requirements as stipulated in MPWH Regulation No. 9/2008, and 2). Interviews with several project managers (including reviewing the typical bill of quantity for high-rise building projects), to obtain inputs on identifying practical safety-related items specific to Indonesian construction sites.

The findings of stage one are shown in Table 1. Regarding the benefits to be acquired by such scheme, it should include an added objective, i.e., "Provide adequate welfare facilities." While the provision of adequate welfare facilities for workers is already the norm in developed countries, this issue still has to be addressed and enforced on project sites in Indonesia. These facilities are provided by construction companies, however, the quality widely varies and in many cases are insufficient. Furthermore, the study has identified eighteen payable safety items. These items conform to the regulation (at the time of this study MPWH Regulation No. 9/2008 was still in effect, which was then recently revised as MPWH Regulation No. 5/2014). The complete list is shown in Table 1.

Table 1: Preliminary list of cost components and their contribution to OSH-MS

The aims of payable OSH-MS items	No.	Cost components of OSH-MS
Improved safety commitment of the management	1	Construction site safety plan
	2	Updating site safety plan
Facilitate effective implementation of OSH-MS	3	Provision of safety officers
	4	Provision of safety supervisors
	5	Provision of site security personnel
Increased safety training	6	Induction training
	7	Job specific training
	8	Specialist training
	9	Supervisory & management training
Increased safety awareness	10	Safety signs
	11	Safety markings
	12	Fire extinguishers and first aid kits
Provide adequate welfare facilities	13	Toilets
	14	Washing facilities
	15	Drinking water
	16	Housekeeping personnel
	17	Facilities for rest
	18	Changing rooms and lockers

The 18 components of OSH-MS listed in Tabel 1 were then discussed with twelve respondents through intervews conducted during the period of November 2013 to April 2014. These respondents were key personnel in charge with site safety issues (included project managers, safety officers, quantity surveyors) and who were working on high-rise building projects in the Jakarta and vicinity. Almost all high-rise building projects are constructed in Jakarta. These five projects were still on-going at the time of the interviews. Questionnaires were circulated to the twelve respondents, which consisted of two main topics: 1). Whether each of those components is relevant to achieve the objective (in Likert scale, i.e. highly agree, agree, no opinion, disagree, highly disagree) and 2). Whether it is appropriate for the owner to separately pay each of those cost components (in Likert scale, i.e. highly agree, agree, no opinion, disagree, highly disagree). The validity of the questionnaires was tested on both topics. Only the components which had been tested valid were consequently used for further analysis.

In the questionnaires of cost components, question #18, i.e., "changing rooms and lockers," is not valid to assess whether it is relevant to achieve the objective of pay-for-safety scheme. It was found that this cost component was not a common safety-and-health related feature on project sites and was deemed irrelevant by the respondents.

Regarding the second topic of the questionnaires, cost components #8, 9, 14, 15, and 18, were not valid as the items to be paid separately by the owner according to the respondents. Respondents suggested that the costs for specialist training (#8) and supervisory and management training (#9) are part of a company overhead, these are not to be included into a specific project OSH-MS. Drinking water (#14) is commonly self-provided by each worker. Washing facilities (#15) and changing room/ locker (#18) were also unnecessary to be enforced through pay-for-safety scheme, since facilities for rest (#17) already covered both features in most project sites.

Development of cost specifications

The final list of 13 (thirteen) cost components was then conveyed back to the same respondents. These respondents were asked for their comments on the list, and they were all in agreement with the proposed list (Table 2). Next, they were interviewed to collect inputs regarding the specification of each cost component (as prospective payable item) based on their experiences on typical high-rise building projects (Table 3).

Table 2: Final list of cost components

No.	Cost components to be paid separately by the owner	Descriptions
1.	Construction site safety plan	The costs associated with developing a project site safety plan, i.e., work-hours used by a competent person/safety expert/officer, and office consumables.
2.	Updating site safety plan	The costs associated with updating the project site safety plan (periodically), i.e., work-hours used by a safety expert/officer, and office consumables.
3.	Provision of safety officers	The remuneration of all safety officers for the entire project duration. MPWH Regulation No. 5/2014 requires safety officers on "high-risk" projects (without any further specifics).
4.	Provision of safety supervisors	The remuneration of all safety supervisors for the entire project duration. MPWH Regulation No. 5/2014 requires safety supervisors on "low and medium-risk" projects (without any further specifics).
5.	Provision of site security personnel	The remuneration of all site security personnel for the entire project duration. These personnel secure sites from unauthorized guests and assist safety officers/supervisors in labors' compliance with PPE etc.
6.	Induction training	General construction induction training before they can carry out construction work. Provides basic knowledge of construction work, the work health and safety laws that apply, common hazards likely to be encountered in construction work and how the associated risks can be controlled.
7.	Job specific training	Certain activities and job tasks require specific training for personnel involved (e.g., fall protection, confined space entry). Also includes specific safety hazards that will be encountered on the project site.
8.	Safety signs	The costs to install all safety signs. People on or near construction sites need to be warned of all hazardous activities taking place. Before any construction work begins, contractors must ensure that an adequate number of general safety signs, depending on the size and complexity of the job site, are erected at the workplace.

9.	Safety markings	The costs to install all safety markings. Markings dangerous/limited areas, minimizing risk of accidents (e.g., safety line).
10.	Fire extinguishers and first aid kits	The costs to provide fire extinguishers and first aid kits based on the number of workers and the size of the site.
11.	Toilets	The costs to provide adequate toilets based on the number of workers. Referring to OSHA: • 1 toilet for workers less than 20 • 1 toilet and 1 urinal per 40 workers, for workers between 20 and 200 • 1 toilet and 1 urinal per 50 workers, for workers more than 200
12.	Housekeeping personnel	The remuneration of all housekeeping personnel for the entire project duration, to keep the site clean and tidy.
13.	Facilities for rest	The cost to provide adequate rest facilities for workers.

Table 3: Specification of OSH-MS cost components

No.	Cost components to be paid separately by the owner	Items	Unit	Quantity
1	Construction site safety plan	Safety expert	man-month	1
		Reporting	copies	6
2	Updating site safety plan	Reporting	copies	12
3	Provision of safety officers	Safety officer	man-month	One safety officer per project during the whole contract period.
4	Provision of safety supervisors	Safety supervisors	man-month	Two safety supervisors for each building tower
5	Provision of site security personnel	Site security	man-month	Two personnel for every gate
6	Induction training	PPE	Set	Complete equipments (helmet, vest, shoes, mask, gloves, goggles) for every worker.
		Flyers	copies	Safety information brochures as reference, one set for each worker.
7	Job specific training	Refreshments	Persons	For every tool box talks, for all attendants
8	Safety signs	Standard safety signs	LS	Standard set for each building tower
9	Safety markings	Vertical safety nets	m^2	Full coverage on building facades
		Horizontal safety nets	Each	One set for every floor
10	Fire extinguishers and first aid kits	Fire extinguishers (6 kg)	Each	One unit for the worked floor and two floors below. Also, one unit in each administrative building
		First aid kits	LS	Complete kit including stretcher
11	Toilets	Portable toilets	Each	One unit for 20 workers. Maximum 20 units.
12	Housekeeping personnel	Personnel	man-month	One personnel is assigned for 2,000 m^2 area. Maximum 50 persons.
13	Facilities for rest	Temporary shelter	m^2	Area of 30 m^2 per 10 workers

ESTIMATING THE COST OF OSH-MS AS "PAY FOR SAFETY"

To further understand the feasibility of the pay for safety scheme, the estimated cost to be allocated on projects have been explored. This study was not intended to be a valid reference for policy making, since the data collected were very limited. This is a preliminary study in the area of cost of safety based on real projects. Contractors are generally reluctant to share their financial data. They were initially unwilling to disclose the actual funding allocated on safety. On the other hand, they have been supportive about the ways to remove concerns on safety concerns in competitive bidding by enabling any sums payable for carrying out safety measures to be identified in the construction contract.

Table 4: The case study: five high-rise building projects

No	Projects	Descriptions	Construction periods
1	Bldg A: apartments/ residences	Two towers, twenty-four floors	16 months
2	Bldg B: business park/ offices	One tower, twenty-one floors	15 months
3	Bldg C: office	Two main towers (11 and 4 floors), plus one parking of sixteen floors	21 months
4	Bldg D: multi-use/office/ hotel/mall/ apartments	Three towers (38, 39, and 40 floors)	15 months
5	Bldg E: apartments/ residences	Three towers (42, 34, and 22 floors)	36 months

Table 5: The comparisons of the allocated and the simulated costs of OSH-MS

No	Projects	Contract value USD	Actual costs allocated for OSH-MS in percentage to the construction cost	Simulated costs for OSH-MS in percentage to the construction cost
1	Building A	10.7 million	0.57%	1.92%
2	Building B	19 million	0.41%	0.76%
3	Building C	26 million	0.09%	0.75%
4	Building D	31.3 million	0.46%	1.29%
5	Building E	70 million	0.27%	0.58%

The respondents who participated in the development of the specification of OSH-MS cost components as propositioned in Table 2, were involved in five high-rise on-going building projects located in Jakarta and vicinity. A brief description of the case study projects is shown in Table 4. Data regarding the actual costs allocated for OSH-MS in those cases were collected. Using the specification of OSH-MS cost components (Table 3) and the unit costs used by the contractors, the estimated total cost of eighteen payable items was simulated to the five cases (Marbun, 2014). The cost comparison is as shown in Table 5.

Discussions

It is not surprising that projects spent much less on OSH-MS. The percentage costs were lower as the contract values increased, varied around 0.1%-0.6%. In Hong Kong, this figure is about 2%. The main distinction is on the quality/specification of the safety equipments which significantly differ in term of cost. For example, PPE (helmet, vest, shoes, mask, gloves, goggles) are provided for every worker, however these are generally low-quality cheap items. There is no specific standard and when there is a standard the enforcement is weak.

The study also found that the biggest expenses were for: safety officer, safety supervisors, security personnel, and vertical safety nets. In all five projects, vertical safety nets were lacking in quantity and quality. They were considered expensive items, so contractors tried to minimize in purchasing them. Safety supervisors on all projects were also insufficient.

The calculations in Table 5 were shown to the project managers. Their general comments were encouraging, they agreed that the thirteen cost components are in fact relevant and essential. They suggested that the maximum allocation for OSH-MS of 1% of the contract value would be accepted by the industry, provided that the regulation is enforced nation-wide. While the manager for Building C project allocated very minimum funding, he admitted that the project should implement better safety. He argued that the safety related items should be specific in terms of quantity and quality and identified in the bill of quantity/contract document.

The costs are naturally contingent to the number of workers, the project duration, and the complexity of the structures (whether single or multiple towers). Accordingly, the simulated costs (using the specification of OSH-MS cost components) have been analyzed, and the unit cost variations for the five cases are shown in Table 6.

Table 6: Variations of OSH-MS costs: number of workers, duration, towers

Projects	Simulated cost/worker (USD)	Simulated cost/ tower (USD)	Simulated cost/ month (USD)	Simulated cost/ worker/month (USD)	Simulated cost/ worker/ month/tower (USD)
Building A	745	102,478	12,810	47	23
Building B	581	145,244	9,683	39	39
Building C	973	97,290	9,266	46	23
Building D	806	134,263	26,853	54	18
Building E	2,013	134,223	11,185	56	19

Based on these five cases, the patterns for simulated costs are vague. However, there is a correlation with the number of towers, i.e., the unit cost per worker per month per tower is consistently decreasing with the addition of towers within a project. Several high cost items are fixed, such as safety officer and security personnel (do not vary with the number of towers).

As an illustration, buildings with three towers (i.e., Buildings D and E) should allocate about 18-19 USD per worker per month per tower for its OSH-MS programs. Buildings with two towers (i.e., Buildings A and C) about 23 USD per worker per month per tower, while Building B with on one tower requires to allocate more around 39 USD per worker per month.

While more data are necessary, this study has provided initial illustration on the rough estimate. Owners can start allocating minimum funding for safety items based on the number of towers, project duration, and the average number of workers involved in a high-rise construction projects. The payable items are separately listed in the BQ, and the specifications of such payable items should also be provided in the bidding documents.

CONCLUSION

National safety performance can be improved through better regulations but also supported with the continuous research to refine Construction Site Safety Manual/Handbook and Management System. A more innovative approach, such as Hong Kong's PFSS, is relevant for Indonesian construction industry. Based on interviews with project managers and government personnels, thirteen specific cost components have been identified. The simulated costs of OSH-MS were much higher than the actual funds spent on five cases. The percentage of actual costs were lower as the contract values increased, varied around 0.1%-0.6%. Based on only limited cases, the patterns for simulated costs are still unclear. However, there is a correlation with the number of towers; the unit cost per worker per month per tower is consistently decreasing with the addition of towers within a project. Also, it is recommended that owners set aside 1% of the contract value for OSH-MS with PFSS scheme. This study has provided initial overview of the feasibility of such scheme. Thus, the government (i.e., MPWH) should resume with nation-wide assessment and promotion to all stakeholders.

REFERENCES

BP Konstruksi (2012). Study on Cost of Occupational Safety and Health Management Systems in Public Works Projects. Final Report. Ministry of Public Works – Republic of Indonesia (unpublished).

Chan D.W.M., Chan A.P.C., Choi T.N.Y. (2010). "An empirical survey of the benefits of implementing pay for safety scheme (PFSS) in the Hong Kong construction industry", Journal of Safety Research, Volume 41, Issue 5, October 2010, 433-443.

Choi T.N.Y., Chan D. W.M., Chan A.P.C. (2011). "Perceived benefits of applying Pay for Safety Scheme (PFSS) in construction – A factor analysis approach," Safety Science, Volume 49, Issue 6, July 2011, 813–823.

ETWB (2000). Chapter 12 – Pay for Safety Scheme. Hong Kong: Environment, Transport and Works Bureau, Hong Kong SAR Government. http://www.devb.gov.hk/

filemanager/en/content_191/chapter12.pdf, accessed on October 4, 2013.

Marbun, I.K. (2014). Identification of Cost Components on Occupational Safety and Health Management Systems – High-Rise Building Projects, Master's Thesis, Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, Indonesia (unpublished).

Markkanen, P.K. (2004). Occupational Safety and Health in Indonesia, Working Paper 9. April 2004. International Labour Organization.

Worksafe Australia (1996). Health and Safety Management Systems - An Analysis of System Types and Effectiveness, http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/acrr1996healthandsafetymanagementsystems, accesed on December 19, 2014.

A CSV CONCEPT TO ADDRESS HEALTH AND SAFETY ISSUES AND ACHIEVE FIRM COMPETITIVENESS IN THE HONG KONG CONSTRUCTION INDUSTRY

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The Hong Kong construction industry has both contributed to and benefited from the growth and development of the last decades. However, health and safety related issues pose significant constraints to the continued growth of firms. Recent studies suggest that construction firms can embrace a 'Creating Shared Value' (CSV) concept to convert H&S related issues into business opportunities and achieve long-term competitiveness. Despite this recognition, no effort has been made to investigate the CSV concept in construction management. Thus, this paper aims to explore and understand the CSV concept in construction management. It identifies the potential means of shared value strategies, specifically related to health and safety issues in Hong Kong construction firms. It also establishes a fundamental link between the CSV concept and firm competitiveness using strategic management theory. Empirical data are collected from documents review and semi-structured interviews from four different companies. Data are analysed qualitatively and case examples are presented. The results show that construction firms are unknowingly applying the CSV concept to address health and safety related issues, while also achieving competitiveness.

Keywords: competitiveness, health and safety, CSV, strategic management.

INTRODUCTION

Over the past few decades, the construction industry in Hong Kong (HK) has experienced rapid economic, social, and infrastructure development. Although the industry has both contributed to and benefited from the growth and development, health and safety (H&S) issues pose significant constraints to the continued growth of the firms (Tang 2001; HKCA and Construction Industry Group 2012). H&S related issues remain in the form of health hazard, personal injuries and fatal accidents.

Recent studies suggest that construction firms can embrace the 'Creating Shared Value' (CSV) concept in order to address H&S related issues and achieve long-term competitiveness: business success, and future growth and development (Porter and Kramer 2011; Awale and Rowlinson 2014). The CSV concept or 'shared value' is an alternative strategy that simultaneously creates both social and business values by reconceiving products/markets, redefining productivity in the value chain, and enabling local cluster development (Porter and Kramer 2011; Porter et al. 2012). It can help firms to better respond to societal, environmental, and market needs as well as business activities. According to Hills et al. (2012), companies in other sectors (food, beverages, agriculture, pharmaceutical, health care, financial services, extractives, and natural resources) are embracing the CSV concept and scaling up their business horizon. Despite this recognition, management or organizational fields, especially, construction management is silent on this topic. No effort has been made to investigate the CSV concept in construction management. In this respect, a study is needed to explore and understand

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the CSV concept in construction management. Hence, the key question is: How can construction firms achieve competitiveness by implementing the CSV concept?

This research builds on previous study on the CSV concept and firm competitiveness (Awale and Rowlinson 2014). Hence, the CSV concept is used as a point of departure (Charmaz 2014). The specific objective is to explore and understand the CSV concept in construction management. In particular, this study identifies the potential means of creating 'shared value', specifically related to H&S issues in HK construction firms. It also establishes a basic link between the CSV concept and firm competitiveness using strategic management theory.

FIRM COMPETITIVENESS IN CONSTRUCTION

Competitiveness is a multi-dimensional concept (Momaya and Selby 1998), and can mean different things to different firms at different times (Barney 1986). According to Flanagan et al. (2007), competitiveness in construction management can be analysed at country, industry, firm, and project level. Various models, factors, measurement concepts, and indexes of competitiveness have also been explored using different approaches. Such approaches can be categorized as short-term view (e.g. project efficiency: time, cost or quality), medium-term view (e.g. impact on customer: functional performance, stakeholder needs, or client satisfaction), and long-term view (e.g. securing business success, and preparing for future growth and development) (Shenhar et al. 2001; Walker and Rowlinson 2008).

Companies mainly focus on achieving economic values but they fail to integrate the social dimensions in their competitive process (Taatila et al. 2006). Organization and management scholars, especially construction managers give relatively less priority to social and environmental issues while accessing their competitiveness (Walsh et al. 2003). Porter and Kramer (2011) argue that firms' competitiveness based on economic dimension alone would be incomplete and those firms that fail to integrate social dimensions while accessing their competitiveness may not succeed in achieving business target and future growth. Therefore, the recent view of construction firms on competitiveness is mainly short- to medium-term focused whereas long-term goals are overlooked (Shenhar et al. 2001; Walker and Rowlinson 2008). Hence, firm competitiveness needs to be operationalized as: 1) achieving business success, and 2) preparing for the future growth and development (Shenhar et al. 2001; Walker and Rowlinson 2008), which can be attained by addressing critical social and environmental issues of the firm (Porter and Kramer 2011; Porter et al. 2012).

STRATEGIC MANAGEMENT IN CONSTRUCTION

Strategic management in construction management research emphasizes on how construction firms compete within a particular business or market and position themselves among the competitors (Langford and Male 2001). It includes four generic processes - strategic analysis, strategic formulation, strategic implementation, and performance evaluation and control. The decision makers make both strategic 'what shall we do?' as well as tactical 'how shall we do it?' decisions to formulate and implement the strategy (Langford and Male 2001). Various theories exist for conducting the corresponding strategic management functions that assist firms to achieve long-term competitiveness (Green et al. 2008). For example, Porter's (1980; 1985) competitive theories postulate that a firm's competitive advantage comes from the competitive strategy adopted to cope with the competitive environment. Resource-based view (Wernerfelt 1984; Prahalad and Hamel 1990; Barney 1991) suggests that competitive advantage can be achieved from the possession and utilization of firm-specific resources, capabilities and competencies. Kay's (1993) distinctive capabilities theory proposes that companies can improve their strength through distinctive structure of relationships with employees, customers, suppliers, contractors and subcontractors. Such distinctive capabilities include capacity to innovate, key internal and external relationships, and corporate branding and reputations. Lastly, Porter's (1990; 1998) cluster development approach emphasizes on the enhancement of related and supporting companies and institutions in the location where the company operates to achieve competitive advantage. Above theories focus on various success factors or competitive dimensions.

However, from a strategic management perspective, these dimensions can mainly be linked to three significant views: the market-based view (Porter's competitive theories), the resource-based view (resources-based theories), and the relational view (distinctive capabilities theory, and cluster development approach) (Martinuzzi 2011) as shown in figure 1.

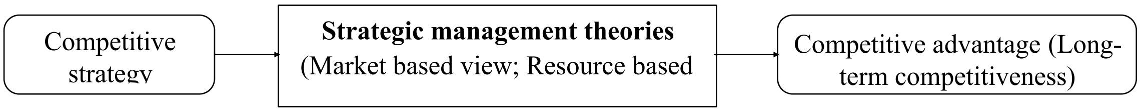

Figure 1: Application of strategic management theories in construction management

RESEARCH DESIGN

This research builds on our previous study on the CSV concept and firm competitiveness (Awale and Rowlinson 2014), and uses multiple case studies (Yin 2009) to gather empirical evidences. The multiple case studies focus on understanding the CSV manifestation within the multi-organizational settings (Eisenhardt 1989).

The research setting: H&S related issues in the HK construction industry

The industry is often characterized by poor H&S performances with high rate of injuries, accidents and fatalities. For example, the number of accidents has increased yearly from 2009 to 2013 and about 76% of all the industry fatalities between 2004 and 2013 occurred in the construction industry (Labour Department 2014). According to the labour department, fall from height and striking against or struck by moving object are the two major causes of both the industrial accidents and the fatalities. Besides these, injuries while lifting or carrying, slipping, tripping or falling on the same level is also significant among the workers in the HK construction industry (Labour Department 2009-2014).

Currently, the majority of large-scale infrastructure projects have entered into the late construction phase. However, those projects in pipeline and the new ones recently announced by the HK Government will increase the total construction workload. This trend is likely to increase the number of site accidents and injuries. If such situation persists, it may undermine the sustainable development and hence, the long-term competitiveness of the construction industry in HK (GovHK 2015).

Research method

Data collection involves review of organization documents such as latest sustainability and annual reports, homepage, publications and press releases, etc. of four companies. In this phase, H&S related issues and potential strategies adopted by the companies to address those issues were explored. The main purpose of the documents review was to generate case examples (Bowen 2009; Eisenhardt 1989; Yin 2009). A thorough, systematic review of the documents also provided good source of background information of the companies (Charmaz 2014). Since the review of the organization documents might not represent the actual practice of the company, semi-structured interviews with corresponding company practitioners were also conducted. The purpose was to get further clarifications, substantiate evidences, and determine the accuracy of information in the documents (Guba and Lincoln 1981; Jick 1979). Interviewees were from the strategic or management teams at the business level, who have either direct involvement or responsibility to make decisions for the development of the business strategies in their respective firms. Table 1 below depicts summary of the companies and the corresponding interviewees. Written consents were obtained from all participants prior to interviewing. Each participant was asked identical questions, which were mainly related to the anatomy of the CSV concept. All interviews were audio-recorded and verbatim. Outputs were analysed qualitatively.

Table 1: Summary of companies and corresponding interviewees

Company	Company profile	Participants (Total 12)
General Contractor: Company A	Largest construction company in Hong Kong (HK) in terms of market share with a strong turnover of US 1,471 million and US$ 1,592 million in 2012 and 2013 respectively	Total 5: Division commercial manager; Senior commercial manager; Senior environmental manager; Director - health, & safety and sustainability; Manager - CSR & sustainability
Client: Company B	Power company in HK with a turnover of US$ 1,354 million and total earnings before interest, taxes, depreciation and amortization (EBITDA) of US$ 993 million in 2014	Total 1: System operations manager
Client: Company C	Largest railway corporation in HK with a turnover of US$ 4,989 million and total EBITDA of US$ 1,856 million in 2013	Total 2: Manager - innovation and knowledge management; Senior manager - corporate responsibility
Building Contractor: Company D	Housing developer and building contractor in HK with a turnover of US$ 691 and US$ 622 million in 2012 and 2013 respectively	Total 4: Deputy general manager(a); Deputy General Manager(b); Construction manager; and CSR manager

Empirical findings: case examples

Case example 1: Development of semi-automatic breaker rack

Injuries during lifting or carrying and operating in awkward gesture under prolonged operation are serious H&S issues in Company A. Mishandling (manually handling) hand held tools, for example electric breaker, is the main reason for these problems. Traditionally, the electric breaker is very heavy and difficult to move around due to its clumsy design. This can lead to a pre-disposition for the development of carpal tunnel syndrome, and the condition known as white finger. Hence, Company A innovated a wheeled rack called ‘the semi-automatic breaker rack’ in order to address the above issue and improve company’s efficiency. This ergonomic rack is designed to carry the hand held electric breaker effortlessly, so as to avoid sprain injury and operations in awkward gesture under prolonged operation. Although, the design looked small and simple, it helped Company A to reduce possible injuries and in return improved the work efficiency and productivity significantly. This design also won the Innovation Competition 2014 award.

Case example 2: Bore pile head trimming method and modified casings extractor

There is always a high risk to workers working at height and workers getting injured from the direct contact with construction machineries. Traditionally, bore pile head trimming method and the casings extractors require workers to work at height. The formal even requires workers to use hand-held breakers during pile trimming. Both the activities are not only unsafe but are also time consuming and costly. Hence, instead of using the hand-held breakers to trim the concrete pile heads, company A came up with the innovate idea of removing the pile head by split and lift method. By de-bonding the vertical starter bars of the pile head, the pile head can be split apart from the bored pile easily by hydraulic splitter. It subsequently reduced the amount of in-situ pile head trimming. This innovative method saved direct cost of HK$ 10 million in one of the project and half the time in contrast to the traditional trimming method. Most importantly, the risk to workers such as working at height and the environment impacts are also minimized. Similarly, with the aim to eliminate the risk of working at height and increasing the productivity, Company A generated an innovative idea to redesign the casing extractor without the working platform. In this modified casings extractor, the jack core was reversed with the forces acting on ground. Therefore, working at height is no longer required. The extraction productivity has also made incredible improvement from 2 minutes per metre to 1 minute per metre.

Case example 3: Local supplier and subcontractor development programs

The HK construction industry is fragmented and affected largely by the presence of multi-layered subcontracting. Almost all the construction works in HK are subcontracted to small and medium enterprises (SMEs). Incompetency and incapability of these SMEs, subcontractors and suppliers have led to fatal construction accidents, poor quality, unsecure supply of materials and services, reduction in productivity, and have finally caused delays in project delivery. Hence, the ability of the SMEs, subcontractors and suppliers to perform every activities in a safe environment is very essential for main companies to remain profitable, reputable, and competitive. Moreover, the companies must have a safe work force with superior technical skills to compete successfully in the global marketplace. This signifies that the companies must make a major effort to improve the H&S and quality of all the parties in the location they operate. Hence, all the four companies have upgraded their workforce by organizing free H&S trainings and workshops to all their subcontractors and suppliers in the supply chain. Contrarily, Company A has pioneered the contractor's safety development program in order to improve the H&S of the entire construction industry working in collaboration with the construction industry council and the housing authority of HK.

Case example 4: 'Worker health and well-being month' program

Ageing and unknown health history of construction workers is the serious H&S issue in HK. To address these issues, Company C has initiated 'worker health and well-being month' program once every year at various construction worksites. This program conducts on-site health screening and improves the health awareness among construction workers. The main purpose of this program is to explore serious common diseases (e.g. heart and lung diseases, cholesterol, blood pressure, diabetes, etc.) and investigate alcohol consumption among the construction workers, and later educate them about the preventive measures.

Analysis of the case examples

Table 2 below depicts potential strategies that companies are implementing to address H&S related issues in the HK construction firms. It was surprising to notice that these companies were unknowingly implementing such strategies, which generated both social and business values simultaneously. Interviewees also cited these strategies as potential reasons for companies being able to achieve long-term competitiveness.

Table 2: Potential strategies to address health and safety related issues

Case example	Health and safety related issue	Potential strategy	Business opportunity		Competitiveness	
			Social value	Business value	Business success	Prepare for the future
1	Injuries during lifting and due to mishandling of hand tools	Development of innovative product or modification of equipment and tools *	Reduction in accident rate and injuries from lifting or carrying	Improved work efficiency and productivity, safety excellence awards	1) Improved profitability	(2) Scalability of the product, (3) leaders in innovative safe product, (4) recognition and reputation
2	Risk of worker falling from height, injuries from the direct contact with machineries	Development of innovative construction method or modification of construction process *	Reduced accident rate and less injuries	Cost savings increase in productivity, Safer and cheaper method	(5) Improved profitability, (6) win more contracts or projects	(7) Leaders in innovative safe process i.e., championing new practice
3	Risk of worker falling from height, injuries from the direct contact with construction machineries	Local supplier and subcontractor development programs #	Safer industry, safe working environment, improved and capable sub-contractor and suppliers	Secure supply, commercial gain (e.g. contractors or suppliers quote less price for same quality service/ product), good relationship		(8) Access to competitive and capable subcontractors and suppliers, (9) improved external relationship, (10) attraction of new comers

4	Ageing and unknown health history of construction workers	On-site health screening of workers to explore serious common diseases #	Improved H&S of workers, less site accidents and injuries, safe working environment	Improved reputation, and markings, good relationship with labour department and clients, access to workforce	(11) Win more contracts or projects, (12) gain in market share	(13) Retention of workers, (14) improved external relationship and higher public acceptance

*Note: * implies first means of the CSV concept i.e., reconceiving product or service, and # implies third means of the CSV concept i.e., local cluster development*

DISCUSSION

Table 2 above provides a notion of the firms using alternative strategies (potential strategies) to create tangible business opportunities by tackling H&S related issues. In fact, there is a shift in companies' focus towards developing innovative approaches that have addressed the H&S related issues in profitable ways. These companies may not have achieved both social and business values and competitiveness if they have approached the issues through compliance, philanthropic, volunteering, corporate giving, ethical or responsible mind-set (Porter and Kramer 2006). Such approaches not just become defensive (Berns et al. 2009) but also largely fail to deal with key challenges in business-society relationship (Frynas 2009). Instead, the companies have focused and prioritized the critical issues that have significant impact on their business operation, and proactively developed the potential strategies to address them. These potential strategies have emerged from companies' motive to solve the H&S issues and simultaneously obtain social and business benefits to remain competitive. There is also a manifestation of a compelling business case for a value creation (Berns et al. 2009) and a long-term sustainability (Porter and Kramer 2011). Hence, such potential strategies can be considered as in line with the CSV concept (Porter and Kramer 2011; Awale and Rowlinson 2014).

A CSV concept: an alternative strategy

The CSV concept 'shared value' is defined as policies and operating practices that creates business values by tackling social issues or converting social issues into tangible business opportunities by using three means: (i) reconceiving products/services and markets, (ii) redefining productivity in the value chain, and (iii) enabling local cluster development (Porter and Kramer 2011). The first means of shared value focuses on meeting the unmet needs and reaching unserved or underserved customers by designing and determining new products/services. It also helps companies to identify new markets, opportunities, and reposition in the current markets. Reconceiving products and markets focuses on revenue growth, expansion of market share, and profit along with improvements in cost, input access, quality, and productivity. The second pillar includes new approaches to energy and resources use, logistics, distribution, and productivity. It helps address H&S related issues and in turn improves the efficiency of business operations. Lastly, the third pillar focuses on improving the external environment of the company; enhancing available skills through the education and training of workers; and strengthening local suppliers, contractors, institutions and infrastructures. It helps in achieving secure supply, reducing accident rates, improving H&S, distribution infrastructure, workforce access, and education, skills and competencies (Porter and Kramer 2011; Porter et al. 2012).

In this sense, the CSV concept is a new way of thinking in management – an alternative strategy to achieve long-term competitiveness that focuses on integration of a social purpose into companies' business operations. Figure 2 below demonstrates the CSV concept for achieving firm competitiveness (Awale and Rowlinson 2014).

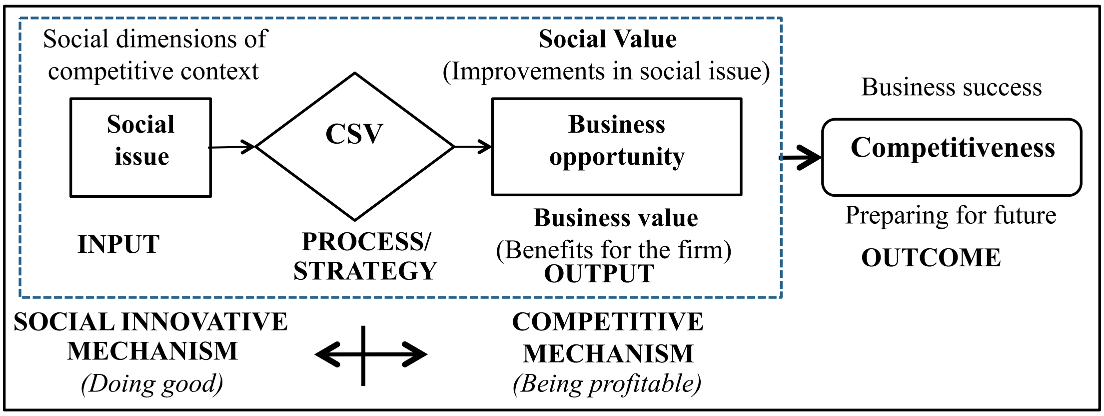

Figure 2: A CSV-competitiveness Model (Awale and Rowlinson 2014)

Differences between traditional CSR and the CSV concept

Corporate social responsibility (CSR) and the CSV concept are both based on the same overlapping concept - "doing good by doing well". However, the former is about being responsible, whereas the latter is about creating new values (Porter and Kramer 2006; 2011). CSR is generally successful in achieving project efficiency and client satisfaction but it does not necessarily lead to business success and facilitate future growth and development of the firm. CSR states that companies should be profitable, obey laws, be ethical, and be a good corporate citizen (Carroll 1991). These perspectives are reactive, defensive and lack active strategic choices within companies (Frynas 2009). Hence, CSR is limited to react against external pressure, mainly to satisfy stakeholder's needs and maintain the firm's reputation (Kanter 2011; Porter and Kramer 2006). It is typically an afterthought on how businesses operate and often remains at the periphery of business operation. In contrast, the firms embracing the CSV concept advance business operations in proactive ways and place critical issues at the core of their business operations (Awale and Rowlinson 2014). Hence, the CSV concept is a proactive business strategy to achieve long-term competitiveness.

Linkage between the CSV concept and firm competitiveness

Based upon the strategic management theory, the competitive dimensions in Table 2 above are re-arranged as shown in Table 3, which provides a basic linkage between the CSV concept and firm competitiveness.

Table 3: Basic relationship between the CSV concept and the long-term competitiveness

Competitive theories: the strategic management perspective	Long-term competitive dimensions
Market-Based View (Porter 1980; 1985)	(1), (2), (3), (5), (6), (7), (11), (12)
Resource-Based View (Wernerfelt 1984; Prahalad and Hamel 1990; Barney 1991)	(8), (10), (13)
Relational View (Porter 1990; Kay 1993; Porter 1998)	(4), (9), (14)

CONCLUSIONS

This study explores different means of shared value strategies, specifically related to H&S issues in the HK construction organizations. It unfolds the anatomy of the CSV concept using a qualitative methodology. It also establishes a link between the CSV concept and firm competitiveness using strategic management theory. Although the companies are unaware of the CSV concept, they are unknowingly applying the CSV concept. The overall result shows that construction firms can adopt the CSV concept to convert H&S related issues into business opportunities and achieve long-term competitiveness. For this, companies must integrate a social perspective into their core competitive frameworks and develop business strategy.

The construction industry is still unaware of the CSV concept. The tools to jointly measure social and business values do not exist in the construction industry. The CSV concept is difficult to quantify, probably due to lack of a robust process to implement the CSV concept. Hence, the priority of the future research could be to develop a robust tool and process to measure and implement the CSV concept respectively. Moreover, a detail study is needed to analyse the strategic link between the CSV concept and firm competitiveness. However, this study opens avenues for further research. It is expected that the findings will enhance our understanding of shared value creation and emphasize the joint measurement of both social and business values particularly in the construction industry.

REFERENCES

Awale, R and Rowlinson, S (2014) A conceptual framework for achieving firm competitiveness in construction: A 'creating shared value' (CSV) concept. In: Raiden, A B and Aboagye-Nimo, E (Eds) “30th Annual ARCOM Conference” 1-3 September 2014, Portsmouth, UK. Association of Researchers in Construction Management, 1285-1294.

Barney, J B (1986) Types of competition and the theory of strategy: Toward an integrative framework. “The Academy of Management Review”, 11(4), 791-800.

Barney, J B (1991) Firm resources and sustained competitive advantage. “Journal of Management”, 17(1), 99-120.

Berns, M, Townend, A, Khayat, Z, Balagopal, B, Reeves, M, Hopkins, M S and Kruschwitz, N (2009) The business of sustainability: what it means to managers now. “MIT Sloan Management Review”, 51(1), 20-26.

Bowen, G A (2009) Document Analysis as a qualitative research method. “Qualitative Research Journal”, 9(2), 27-40

Carroll, A B (1991) The Pyramid of Corporate Social Responsibility: Toward the moral management of organizational stakeholders. "Business Horizons", 34(4), 39-48.

Charmaz, K (2014) “Constructing Grounded Theory”. 2ed. London: SAGE Publications, Inc.

Eisenhardt, K (1989) Building Theories from Case Study Research. "Academy of Management Review" 14(4), 532-550.

Flanagan, R, Lu, W, Shen, L and Jewell, C (2007) Competitiveness in construction: a critical review of research. "Construction Management and Economics", 25(9), 989-1000.

Frynas, J G (2009) “Beyond corporate social responsibility: Oil multinationals and social challenges”. UK: Cambridge University Press.

GovHK (2015) “Press Releases on LCQ1: Measures to tackle problem of shortage of skilled workers in construction industry”. The Government of Hong Kong, Hong Kong SAR

Green, S D, Larsen, G D and Kao, C C (2008) Competitive strategy revisited: contested concepts and dynamic capabilities. “Construction Management and Economics”, 26(1), 63-78.

Guba, E G and Lincoln, Y S (1981) "Effective evaluation". San Francisco: Jossey-Bass.

Hills, G, Russell, P, Borgonovi, V, Doty, A and Lyer, L (2012) Shared value in emerging markets: How multinational corporations are redefining business strategies to reach poor or vulnerable populations. Retrived April 11, 2013, from www.fsg.org: http://sharedvalue.org/sites/default/files/resource-files/Shared_Value_in_Emerging_Markets.pdf

HKCA and Construction Industry Group (2012) “Hong Kong’s construction industry vision 2020: Building a city, building a society”. A report jointly prepared by the Hong Kong Construction Association (HKCA) and the Construction Industry Group of the British Chamber of Commerce, Hong Kong SAR.

Jick, T D (1979) Qualitative and quantitative methods: triangulation in action. "Administrative Science Quarterly", 24(4), 602-611.

Kanter, R M (2011) How great companies think differently. "Harvard Business Review", 89(11), 66-78.

Kay, J A (1993) “Foundations of corporate success: how business strategies add value”. Oxford: Oxford University Press.

Labour Department (2009-2014) “Occupational safety and health statistics 2008 – 2013”. Occupational Safety and Health Branch, Labour Department, Hong Kong SAR.

Labour Department. (2014) “Occupational safety and health statistics 2013”. Occupational Safety and Health Branch, Labour Department, Hong Kong SAR

Langford, D and Male, S (2001) “Strategic management in construction”. 2ed. Malden, Mass.: Blackwell Science.

Martinuzzi, A (2011) Responsible competitiveness - linking CSR and competitive advantage in three European industrial sectors. “Zeitschrift für Umweltpolitik & Umweltrecht”, 3, 297-337.

Momaya, K and Selby, K (1998) International competitiveness of the Canadian construction industry: a comparison with Japan and the United States. "Canadian Journal of Civil Engineering", 25, 640-652.

Porter, M E (1980) “Competitive Strategy: techniques for analyzing industries and competiors”. New York: Free Press.

Porter, M E (1985) “Competitive advantage: creating and sustaining superior performance”. New York: Free Press.

Porter, M E (1990) Competitive advantage of nations (Cover story). “Harvard Business Review”, 68(2), 73-93.

Porter, M E (1998) Clusters and the new economics of competition. “Harvard Business Review”, 76(6), 77-90.

Porter, M E, Hills, G, Pfitzer, M, Patscheke, S and Hawkins, E (2012) Measuring share value: How to unlock value by linking social and business results. Retrieved April 05, 2013, from www.fsg.org: http://www.mesacc.edu/other/engagement/2013Conf/Measuring_Shared_Value.pdf

Porter, M E and Kramer, M R (2006) Strategy & society: The link between competitive advantage and corporate social responsibility. “Harvard Business Review”, 84(12), 78-92.

Porter, M E and Kramer, M R (2011) The big idea: Creating shared value - How to reinvent capitalism and unleash a wave of innovation and growth. “Harvard Business Review”, 89(1/2), 62-77.

Prahalad, C K and Hamel, G (1990) The core competence of the corporation. “Harvard Business Review”, 68(3), 79-91.

Shenhar, A J, Dvir, D, Levy, O and Maltz, A C (2001) Project success: a multidimensional strategic concept. “Long Range Planning”, 34(6), 699-725.

Taatila, V P, Suomala, J, Siltala, R and Keskinen, S (2006) Framework to study the social innovation networks. “European Journal of Innovation Management”, 9(3), 312-326.

Tang, H (2001) “Construct for excellence: report of the construction industry review committee”. The Government of Hong Kong, Hong Kong SAR.

Walker, D H T and Rowlinson, S (2008) (Eds) “Procurement Systems: A cross-industry project management perspective”. London: Taylor and Francis.

Walsh, J P, Weber, K and Margolis, J D (2003) Social issues and management: Our lost cause found. “Journal of management”, 29(6), 859-881.

Wernerfelt, B (1984) A resource-based view of the firm. “Strategic Management Journal”, 5(2), 171-180.

Yin, R K (2009) "Case study research: design and methods". 4ed. Los Angeles, California: Sage Publications.

QUANTITIVE ASSESSMENT OF THE IMPACT OF REWORK PREVENTION ON SAFETY

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There have been limited studies that have examined the relationship between quality and safety performance. In addressing this issue, this paper examines the impact a 'Rework Prevention Program' had on reducing the number of safety incidents in an AU$375 million program alliance, which delivered 129 water infrastructure projects over a five-year period. The statistical characteristics of incidents (n=380) are examined prior to and after the introduction of a 'Rework Prevention Program'. The analysis revealed that there was a statistical significant difference in the number of incidents per month for pre and post introduction of the program. Moreover, the analysis revealed the number of incidents was increasing as the project progressed prior to the introduction of the program. Thus, the introduction of the 'Rework Reduction Program' significantly decreased the rate of incidents, which resulted in an improvement in safety performance.

Keywords: incidents, rework, safety, water infrastructure projects.

INTRODUCTION

Poor quality and safety performance can adversely influence the cost and schedule of a project. When rework occurs during construction, there is an increasing propensity for safety incidents and/or accidents to occur (Wanberg et al. 2013). Explaining incidents and accidents in appropriate context helps in understanding the importance of safety in project success. Safety incidents are undesired or unexpected events, while accidents are unplanned or unanticipated event that causes injury, illness, damage, or loss. The quality and safety literature is replete with studies that have examined 'how' and 'why' rework (e.g. Josephson et al. 2002; Hwang et al. 2009); and incidents and accidents occur (e.g., Choudhry and Fang 2008; Jitwasinkula and Hadikusumoa 2011). However, there have been limited studies that have sought to examine the relationship between rework and safety incidents. According to Love and Edwards (2013), the causal nature of rework and safety incidents are akin and therefore strategies to contain and reduce their occurrence share a symbiotic relationship. The causes of rework and safety incidents can be traced back to organizational influences, unsafe supervision, preconditions for unsafe acts, and the unsafe acts themselves (Reason 1997). Fundamentally, however there is a proclivity for an array of pathogens to trigger these events.

Pathogens are latent conditions and lay dormant within a system until an error comes to light. Before they are apparent, team members often remain unaware of the impact upon project performance that particular decisions, practices, or procedures can have during construction. Pathogens can arise because of strategic decisions taken by senior management or key decision-makers. Such decisions may be mistaken, but they also may be deliberate in the form of strategic misrepresentation. Latent conditions can lay dormant within a system for a considerable period of time and thus become an integral part of everyday work practices. Meanwhile once they combine with active failures then

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omission errors can arise and the consequences of which may be significant. Active failures are essentially unsafe acts committed by people who are in direct contact with a system. Such acts include: slips, lapses, mistakes and procedural violations. Active failures are often difficult to foresee. As a result, they cannot be eliminated by simply reacting to the event that has occurred. Latent conditions, however, can be identified and remedied before an adverse event occurs.

This paper aims to examine the impact of a 'Rework Prevention Program', introduced within a program alliance that was responsible for delivering 129 water infrastructure projects over a five year period on safety performance. Openly recognizing rework had become a problematic issue, the alliance changed its underlying culture to one that focused on 'error management'. At the heart of this newly adopted culture was its ability to learn and implement continuous improvement strategies to simultaneously ameliorate quality. A detailed description of the 'how' and 'why' the alliance adopted and implemented this new culture can be found in Love et al. (2015). This paper builds upon and compliments this earlier work by providing the quantitative evidence to support the impact that a 'Rework Prevention Program' had on not only reducing rework, but also safety incidents. In the next section of this paper, an overview of the case study is presented and the safety incidents that arose during the alliance's duration are analysed.

CASE STUDY

Rework is considered to be 'taboo' within construction and engineering infrastructure projects, and is often eschewed by management. In spite of its negative connotation, a program alliance openly recognized it was an on-going problem and adversely impacting safety; it had been observed by a Site Supervisor that when rework arose the number of incidents on the projects they were managing increased. In examining this issue, a case study is used to understand 'why' and 'how' the program alliance went about preventing rework through a process of context-specific learning that was engendered by authentic leadership, engagement and empowerment and a strong focus on continuous improvement. A case study of this nature provides a line of inquiry that can be used as an exemplar to demonstrate 'best practice'.

Case Study: Water Infrastructure

The program alliance was established in 2009 to deliver 129 water infrastructure projects, comprising of pipelines, water treatment plants, pump stations, tanks, storages and channel works throughout a regional area of Victoria in Australia. After an extended period of drought in 2008/2009 and significant growth in the region, the demand for water increased. As a result there was a need to up-grade existing and construct additional infrastructure to meet this demand. The alliance team was comprised of three organizations, the Owner Participant (OP) who was responsible for delivering water to its customers over an area of 8100km2 to five municipalities and 275,000 customers; an engineering consultancy who provided design, environmental and stakeholder management expertise; and a contractor who provided commercial and construction capabilities. The program of works to be undertaken was $375 million over a five-year period.

In 2011, approximately 2.5 years into the five-year program, the Alliance Leadership Team (ALT) and Alliance Management Team (AMT) became aware that a number of projects were incurring unnecessary cost and time delays due to rework. This coincided with the first batch of projects, which reached the end of their two years 'Asset Proving Period' (i.e. defects liability). An average of a three-week delay per project was being experienced due to rework issues, which, at the time equated to in excess of AU$1 million in costs to the alliance alone (e.g., management and supervision). Over the life of the program, if things had remained the same, then the costs that would have been incurred by the alliance would have been in excess of AU$3 million. The costs borne by contractors due to this rework were estimated to be at least five times this estimation. Noteworthy, the costs of rework did not vary between the project types. Yet, the number of product quality non-conformances formally raised and reported by contractors was zero, although it was clearly known this was not a reflection of reality, due largely to the fear of blame and damage to the organization's reputation. Moreover, rework was deemed to be a 'norm' and thus 'business as usual'. It was not until the contractors became aware of the problem that they began to work with the alliance to prevent its future occurrences.

The ALT and AMT knew that there were quality issues as a result of their inspections, but at the time felt the alliance lacked the systems, contractual power, relationships and culture to support and enable the contractors to identify errors and mistakes which could lead to rework. A concerted effort had been made within the alliance to report safety and environmental incidents, which improved over time, but the existing processes in place were inadequate to equally capture quality assurance (QA) and potential rework. Furthermore, no effort had been made to account for rework, as there was a perception it was a result of poor work practices and demonstrated failure. The alliance recognized that safety was being jeopardized as a result of a number of rework incidents. On average, 10 incidents/near misses (of all types) were occurring per month, particularly during months of November and December where 30 incidents/near misses befell due to several issues such as fatigue and stress. Initial analysis of events revealed that there was a direct relationship between the number of incidents and rework. In fact, it was propagated that the likelihood of a person being injured while attending to rework was nine times greater when compared to normal work activities. This was of a great concern to the alliance as it was contradictory to their underlying value system that had been developed at the onset of the project. Responsively recognizing the problem at hand, the ALT and AMT, collectively with the Non-Owners-Participants (NoP), embarked on a targeted safety improvement program to alleviate significant Health, Safety and Environment (HSE) issues that had been consistently emerging. In addition, they developed a rework prevention initiative to not only address project performance issues but also those relating to safety. A quantitative assessment of the impact of the 'Rework Prevention Program' is presented in the next section of this paper.

In implementing this program the ALT/AMT changed the culture that had prevailed within the alliance by changing behaviours, its climate, providing a motivation to learn and re-examine the way performance was measured. This change was undertaken as the original Key Result Areas (KRA), which had three to four Key Performance Indicators (KPIs) that were not aligned and thus the alliance team found it difficult to understand and implement them. Values were re-defined and aligned to performance objectives, for example, safety was aligned to 'no harm' and the delivery quality outcomes alliance. Essentially, safety and quality were aligned. An explicit feature in creating the new climate was 'learning' through interaction and participation between alliance and its contractors. Particular emphasis was placed on feedback and knowledge acquisition derived from work processes, information, reflection and discussion between alliance members and its contractors.

RESULTS

A total of 380 incidents were identified in the 129 projects that were delivered by the Alliance. Figure 1 provides the 'best fit' distribution of incidents per month that occurred over the five year period. The mean (M) number of incidents per month was 6.5, with a minimum of 0 and maximum of 15. The number of incidents per month was observed to be not normally distributed. The probability distribution was found to have a skewness 0.13229 and kurtosis -0.7964. Determining the 'best fit' distribution enables the probability of their occurrence to be determined. The Kolmogorov-Smirnov (K-S) test revealed a D-statistic of 0.0883 with a P-value of 0.71628 for the 380 incidents occurred over the 58 month period for the water infrastructure projects. The KS-test accepted the H0 for the sample distribution's 'best fit' at $\alpha = 0.2$, $\alpha = 0.1$, $\alpha = 0.05$, $\alpha = 0.02$, and $\alpha = 0.01$. A continuous uniform distribution was found to be the 'best fit' as presented in Figure 1 and 2. This distribution is derived from a family of symmetric probability distributions such that each member possesses intervals of the same length for the distribution's that are equally probable. The support is defined by the two parameters, a and b, which are its minimum and maximum values. In this instance, the parameters were found to be a = -0.26316 , b =15.253. The PDF is expressed as (Figure 1):

$$f(x) = \begin{cases} \dfrac{1}{b-a} \\ \\ 0 \\ \end{cases}$$

Eq.1

The CDF is expressed as (Figure 2):

$$F(x) = \begin{cases} 0 & for \quad x < a \\ \\ \dfrac{x-a}{b-a} & for \quad a \leq x < b \\ \\ 1 & for \quad x \geq b \end{cases}$$

Eq.2

The probability, for example, that the alliance in this case would incur less than a mean of 5 incidents per month is (P (x < x1) = 0.38). The probability of the alliance experiencing between a 5 and 10 incidents per month, for example, is 35% (P(x1< x< x2) = 0.35).

Hand (35%) and leg (13%) injuries to the body accounted for a significant proportion of those that were incurred. In addition, the major types of incidents that arose were damage to services (19%), environmental incidents (17%), and damage to property (14%) and first aid injuries (14%), which were deemed of low severity. Injuries of low severity were to be those that inconvenienced individuals such as minor cuts or sprains, but allowed a person to continue with their or alternate duties for one full shift or more. Human injuries of higher severity, that is, Alternate Work Injury (AWI), Loss Time Injury (LTI) and Medical Treatment Injury (MTI) comprised of only 3% of total incidents. Notably, 22% of total incidents involved only the reporting of unsafe acts or conditions.

A total of 43.5% of the incidents occurred between 1000 and 1200hrs and 1500 and 1600hrs. At 1000hr, site workers tend to have their morning break and therefore may become distracted and lose their concentration. In addition, there is a propensity for site workers blood sugar levels to drop at this time of day due to physical demands of the work that they undertake, which may contribute to a loss concentration. A chi-square test ($\chi 2$) was undertaken to determine if there was significant difference between H0 (i.e., Null hypothesis that assumes there is no relationship between two measured phenomena): Incidents occurring during (breaks - not during breaks) = 0; and H1 (i.e, Alternative hypothesis that assumes there is a relationship): Incidents occurred during (breaks - not during breaks) $\neq$ 0). It was revealed that a significant difference between incidents occurring during break time and non-break time ($\chi 2$ (2, n=360) = 142.379, p =0.00, at 99% significance. Furthermore, a greater rate of incidents occurs during break time (158 incidents in a three-hour period) than non-break time (202 incidents in the remaining five-hour period).

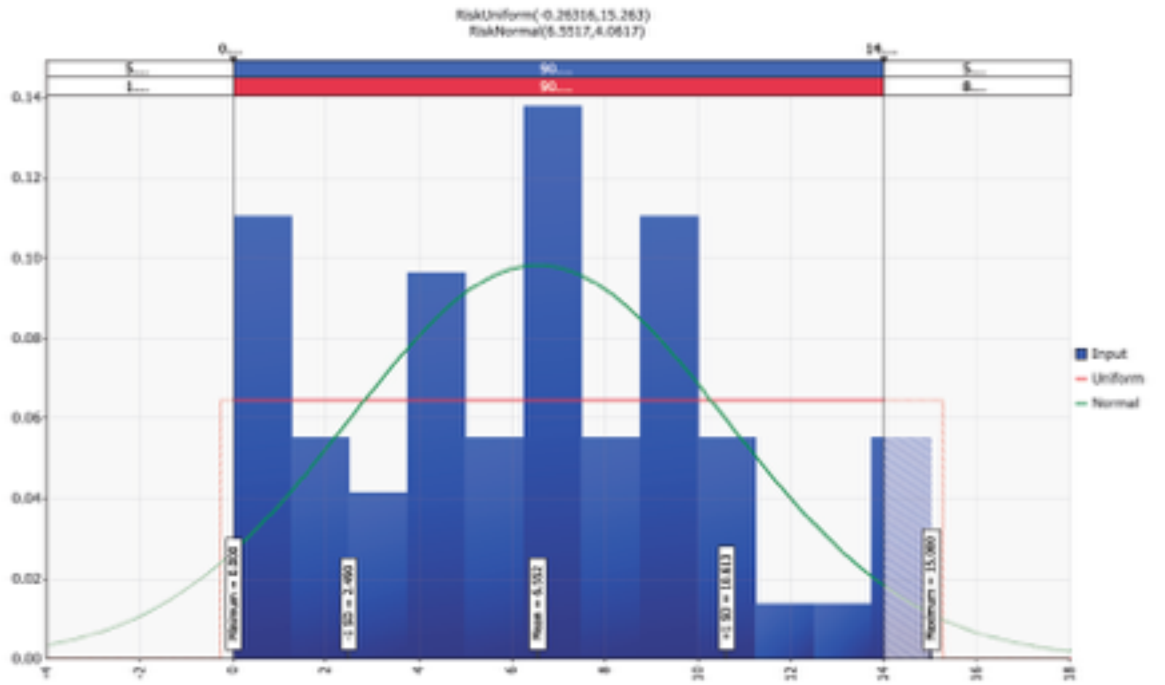

Figure 1: Best 'fit' distribution with PDF for incidents per month

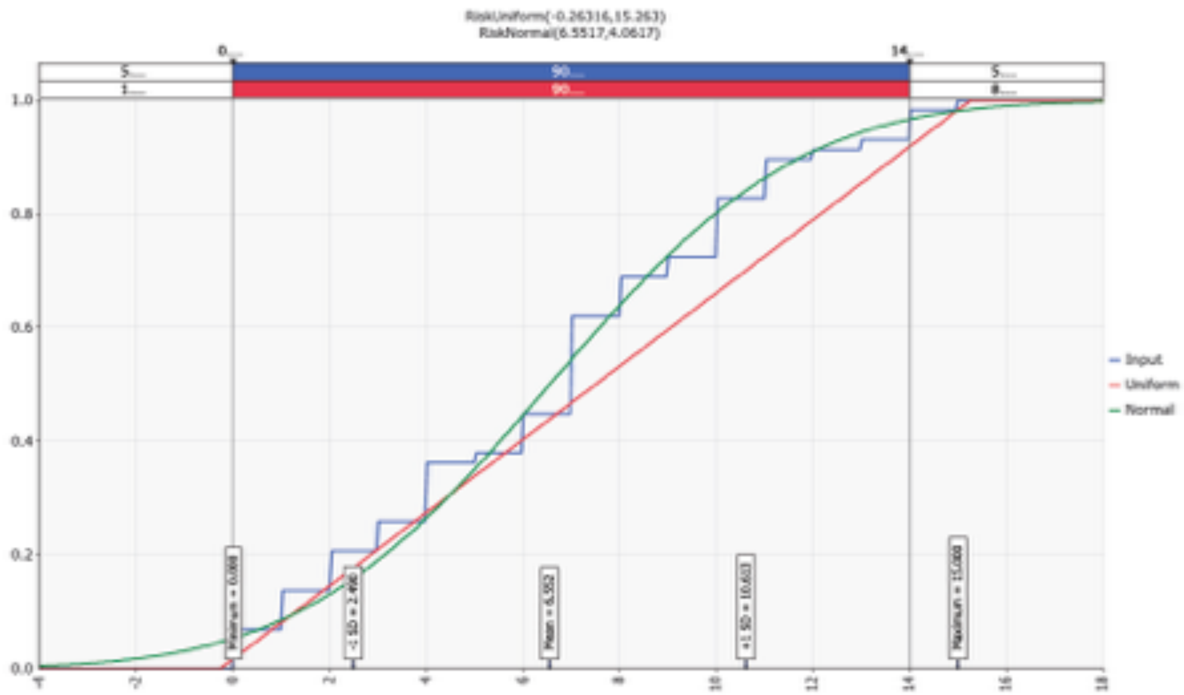

Figure 2: CDF for incidents per month

Impact of Rework Prevention Program on the Frequency of Incidents

A specific 'Rework Reduction Program' was instigated in May 2013, as the alliance leadership team observed that rework had become a problem and was having a negative financial impact on the performance of the projects that they were undertaking. In fact, it was observed that a significant amount of rework was occurring when incidents had arisen and it was estimated that it was four times greater for incidents to occur during rework than when compared to normal work activities (Love et al. 2015). To address the problem at hand, the alliance adopted and implemented an error management culture and instigated an initiative that realized a drive from individual to a collective learning environment. As noted above, specific details about the case are presented in Love et al. (2015). Table 1 identifies the proportion of incidents by type that occurred when rework was being undertaken. However, there were no significant differences between the type of incidents and rework at p =0.00, at 99% significance.

Table 1: Percentage of incidents occurring during rework

Incident Type	Rework	Non-Rework
Actual injuries	39%	61%
Unsafe acts/ conditions and near misses	35%	65%
Property damage	32%	68%
High potential incidents (1p/2p)	42%	58%
Low potential incidents (3p)	28%	72%
Total Incidents	29%	71%

As a result of implementing the ‘Rework Reduction Program’ in May 2013, the mean number of incidents decreased from approximately eight to five incidents per month. Figure 3 highlights the fluctuation of incidents over the five year period and after the introduction of the program. Furthermore, tests reveal that the difference in the occurrence of incidents between the period before and after the program is significant (Table 2).

Introduction of Rework Prevention Program

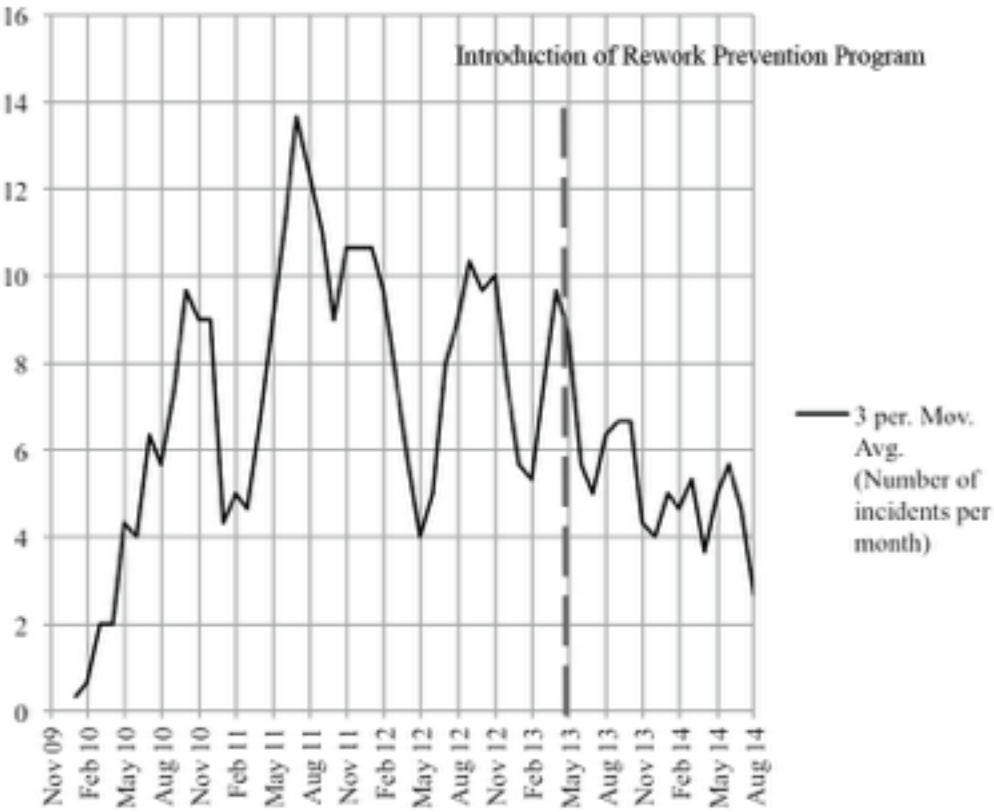

Figure 3: Impact of the 'Rework Prevention Program' on incidents per month

Table 2: Statistics of incidents pre and post introduction of the rework program

	Intervention	Total number of incidents	Number of months	Mean incidents per month	Std. Deviation	Std. Error Mean
Incidents	Pre	304	42	7.24	4.264	0.658
Occurrence per month	Post	76	16	4.75	2.864	0.716

The independent samples t-test (Table 3) and Mann-Whitney U test (Tables 4-6) were carried out to determine if there was a significant impact of the 'Rework Prevention Program' on the frequency of incidents occurring. The p-value was less than 0.05 ($t(56) = 2.150$, $p = 0.036$), and therefore the H0 that there is no difference in the number of incidents occurring per month pre- and post-intervention is rejected. The results of the independent samples t-test demonstrate that there is a statistical significant difference in the number of incidents per month for pre- and post-introduction of the program. The test results indicate a negative direction and significant at 95% two tailed, $z = -2.202$, $p = 0.028 < 0.05$. From Table 5, the pre-introduction period had an average rank of 32.50, while the post-introduction period had an average rank of 21.63. The test results reject the H0 and conclude a lower number of incidents per month on the average post-introduction than pre-introduction at 95% significance level.

Table 3: Independent samples T-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Incidents Occurrence per month	Equal variances assumed	2.399	.127	2.15	56	0.036	2.488	1.157	1.170	4.806
	Equal variances not assumed			2.559	40.482	0.014	2.488	0.972	0.524	4.453

Table 4: Mann Whitney U test – Descriptive statistics

Number of months	Mean number of incidents per month	Std. Deviation	Minimum	Maximum
58	6.55	4.062	1	15
58	0.28	0.451	0	1

Table 5: Mann Whitney U test – Ranks

	Rework Prevention Program	N	Mean Rank	Sum of Ranks
Incident Occurrences	Pre	42	32.50	1365.00
	Post	16	21.63	346.00
	Total	58		

Table 6: Mann Whitney U test – Test statistics (a)

	Incidents Occurrence
Mann-Whitney U	210.000
Wilcoxon W	346.000
Z	-2.202
Asymp. Sig. (2-tailed)	0.028

(a) Grouping Variable: Rework Prevention Program

Comparison between Pre and Post ‘Rework Prevention Program’

A non-parametric Spearman’s correlation test was undertaken to determine if there was significant relationship between the number of incidents occurring pre and post introduction of the ‘Rework Prevention Program’. The Spearman's correlation coefficient of prior to the introduction of the program rs, is 0.438, and statistically significant at 99% level ($p = 0.004 < 0$). This indicates a significant positive relationship between the month/year and number of incidents prior to the introduction of the program; that is, the number of incidents was increasing as the project progressed. However, in the post-introduction period, the correlation coefficient, rs, is -0.329, and $p = 0.213$. The results indicate no significant relationship (though in a negative direction). This suggests that the ‘Rework Reduction Program’ has altered the increasing trend of the frequency of incidents that occurred in the program Alliance. The results indicate that a symbiotic relationship exists between safety and quality performance. Thus they are interdependent and depend on employees' actions and therefore cannot be considered in isolation especially as they use similar documentation, improvement and standardization and decision-making processes.

CONCLUSIONS

Rework had been causing significant delays to projects, which were much undesired by the communities that they serviced. The ‘Rework Prevention Program’ had focused on changing the culture and behaviour of alliance members and the contractors that were delivering the various types of water infrastructure projects. New processes and procedures were established; and alliance members and contractors were encouraged to openly share their knowledge and experiences about the rework events that had occurred. Lessons learnt workshops focusing on rework were regular held with the alliance team and contractors.

While rework was explicitly reduced, the significant impact that the program had on safety performance was unexpected. In demonstrating the effect of the ‘Rework Reduction Programs’, the statistical characteristics of frequency incidents prior to and after its introduction was examined. A continuous uniform distribution was found to be the best overall distribution fit for the monthly incidents, which can be used to calculate the probability of their occurrence and used in future water infrastructure projects that are delivered using a program alliance. It was revealed that as a result of implementing the ‘Rework Reduction Program’, there was a statistical significant difference in the number of incidents per month for pre and post introduction of the program. Moreover, the analysis revealed the number of incidents was increasing as the project progressed prior to the introduction of the program. Thus, the introduction of the ‘Rework Reduction Program’ significantly decreased the rate of incidents, which resulted in an improvement in safety performance.

REFERENCES

Choudhry, R M and Fang, D (2008) Why operatives engage in unsafe work behavior: Investigating factors on construction sites. "Safety Science", 46(4), 566–584.

Hwang, B, Thomas, S R, Haas, C and Caldas, C (2009) Measuring the impact of rework on construction cost performance. "ASCE Journal of Construction Engineering and Management", 135(3), 187-198.

Jitwasinkula, B and Hadikusumoa, B H W (2011) Identification of important organizational factors influencing safety work behaviours in construction projects. "Journal of Civil Engineering and Management", 17(4), 520-528.

Josephson, P-E, Larsson, B and Li, H (2002) Illustrative benchmarking rework and rework costs in Swedish construction industry. "ASCE Journal of Management in Engineering", 18(2), 76–83.

Love, P E D and Edwards, D J (2013) Curbing rework in offshore projects: Systemic classification of risks with dialogue and narratives. "Structure and Infrastructure Engineering", 9(11), 1118-1135.

Love, P E D, Teo, P, Ackermann, F and Morrison, J (2015) From individual to collective learning: Enacting rework prevention in a program water infrastructure alliance. "ASCE Journal of Construction Engineering and Management", Doi:10.1061/(ASCE)CO.1943-7862.000101, 05015009.

Reason, J T (1997) "Managing the Risks of Organizational Accidents". Farnham, UK: Ashgate.

Wanberg, J, Harper, C, Hallowell, M R and Rajendran, S (2013) Relationship between construction safety and quality performance. "ASCE Journal of Construction Engineering and Management", 139(10), 04013003.

EFFECTIVENESS OF CLIMATIC HEAT STRESS MANAGEMENT: A CULTURAL INSTITUTIONAL PERSPECTIVE

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[The paper presents results of a field study on climatic heat stress management in Chongqing, China. A one-day data collection protocol is developed for data collection, which integrated health and fitness testing, real-time heart rate monitoring, non-participant observation and semi-structured interviews. Data are analysed with a triangulation approach. Work activities are video recorded, coded and analysed in three trades, i.e., plasterer, concretor and formworker. Taxonomies are developed from the analysis for metabolic rates for major work activities in the three trades. The results and methods are compared with an earlier study in Hong Kong. Contents of two existing guidelines are examined against their effectiveness during implementation on construction site management. The study finds that site-specific weather surveillance system and regional and occupational specific guidelines are necessary. Meanwhile the impact of national culture and its interplay with society's institutional environment are discussed.]

Keywords: [climatic heat stress; institutional interventions; culture; institutional environment].

INTRODUCTION

[Construction work conducted in hot summer poses safety risks on construction project management, resulting in heat illnesses or accidents (e.g. Chi et al., 2005; Rowlinson et al., 2014). Institutional interventions specific to heat stress management have been developed for decades in the ergonomics field, e.g., the annually updated TLVs® by American Conference of Governmental and Industrial Hygienists since 1970s (ACGIH, 2013), yet understanding of their effectiveness on construction site is relatively undeveloped. Heat illness is a special type of accident that starts with a hazard in the natural environment, stems from personal health disorder and leads to a safety consequence that can be serious, even fatal. But unlike a catastrophic event, its spread to uninvolved personnel is limited. This provides a reasonably simplified event for understanding the systemic and institutional factors contributing to construction accidents. A previous study in Hong Kong construction sites by the research team has identified institutional factors at individual, job, team, project, organization, industry, society and ecosystem levels that are influencing climatic heat stress management. Being aware that the finding from a region-specific sample is bounded by national culture, the research presented in this paper extends the sample into Chongqing region of China. Through an initial comparative study, the research identifies institutional factors at national cultural level as well as improved methodologies.]

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AN INSTITUTIONAL PERSPECTIVE

Institutions are socially constructed laws, structures, rules, regulations, cultures, norms, routines, cognitive frames and established practices that explicitly or implicitly govern individual and organisational decision-making behaviours (Schmidt, 2008). The concept of institution constitutes the base for an overarching methodology to examine how elements of a system are organized and function in certain ways. Referring to the Loughborough Construction Accident Causality framework (Gibb et al., 2006; Haslam et al., 2005), heat stress starts from a hazard among the workplace conditions located at the level of immediate circumstance (Table 1). This is added by extra heat at construction site released from machines or vehicles, or by concrete after being casted. Moreover, metabolic heat generated by continuous physical work constitutes a significant amount of heat stress within the human body. In this sense the heat hazard encompasses all of the four categories of immediate circumstance, which implies the effective control of it is widely connected with the shaping factors and the originating influences in the upper stream of the supply chain.

Table 1: A summary of the Loughborough ConAC framework (Haslam et al., 2003; 2005)

<table>
<tr><th colspan="2" rowspan="2">Immediate accident circumstances</th><th rowspan="2">Shaping factors</th><th colspan="2">Originating influences</th></tr>
<tr><th>Proximal</th><th>Distal</th></tr>
<tr><td>1.Workplace</td><td>Layout/space; lighting/ noise; hot/cold/wet; local hazards</td><td>Site constraints; work scheduling; house keeping</td><td rowspan="4">Permanent works design; project management; construction processes; health & safety culture; risk management</td><td rowspan="4">Client requirements; economic climate; construction education</td></tr>
<tr><td>2. Work team</td><td>Actions; behaviour; capabilities; communication</td><td>Attitudes/motivations; knowledge/skills; supervision; health/fatigue</td></tr>
<tr><td>3. Material</td><td rowspan="2">Suitability; usability; condition</td><td rowspan="2">Design specification; supply/availability</td></tr>
<tr><td>4. Equipment</td></tr>
</table>

At organizational level, Ju and Rowlinson (2014) reported how safety initiatives are twisted from their intended goals as construction organizations try to cope with external OHS institutional demands under production pressure. Moreover, stakeholders of a construction project have diverse interests in the project as accountability defines their roles, therefore decisions on reconciling or prioritising goals are not value-free (Dekker, 2006). Rowlinson and Jia (forthcoming) analyse heat illness incidents on construction site and identify institutional factors as acted by different stakeholders (Table 2).

Table 2: Institutional factors contributing to heat illness incidents (Rowlinson and Jia, 2015)

Levels of actors	Identified institutional factors
Ecosystem	Geographical characteristics of site; Local weather; Regional climate; Climate change
Society level	Sustainability concerns; Client organizations; Market mechanism; Policy & legislation; Power of Workers' Union; Pre-tertiary OSH education; Societal culture
Industry level	Industrial coordination; Training/licensing system; Project-based organisations; Client contract strategies; Norms of occupation; Pyramid subcontracting system; Supply chain coordination
Organization	Business model; Organisational culture; Training; Integration of safety/ production
Project level	Production strategy; Project leadership; Management infrastructure; Risk management system; Training
Team level	Team leadership; Team culture; Team practice; Team knowledge
Job unit level	Temporal and spatial characteristics of work; Psycho-social environment; Financial incentives; Daily working hours; Workload, work pace, continuous working time
Individual level	Mindfulness; Ageing status, fitness, latent illness, and acclimatisation status; Surface-to-mass ratio; Fitness; Ethnicity; Lifestyle; Personal priorities; Fatigue status; Psychological stress; Risk perception; Knowledge; Work skills

INSTITUTIONAL INTERVENTIONS FOR OCCUPATIONAL HEAT STRESS

Existing international guidelines on heat stress management focus on control of individual acclimatization, water intake, and engineering controls of environmental heat. Moreover, the guidelines suggest environmental thresholds to benchmark heat exposure, matched with work-rest regimen to control the exposure (ACGIH, 2009; ISO 7243, 1989). These guidelines are widely referred to in global industrial standards (AIOH, 2003). Whilst these standards provide basic policy environments for managing occupational heat stress, these experimentally determined thresholds do not seems to be working in industries other than military, sports, or steel mills where heat exposure can be easily controlled by centralized decisions. In most industrial contexts where numerous decisions are to be made by frontline staff in responses to changing situations and diverse short-term goals, the guidelines are found to be over-conservative and counter-productive (Budd, 2008). In this study we explore the effectiveness of heat stress management guidelines as institutional interventions in the specific societal cultural environments by frontline staff on construction sites in Chongqing (CQ) Municipality and Hong Kong (HK) SAR of China.

METHODOLOGY

Regional climate can be seen as a player in the institutional environments of heat stress management in that it prescribes a law on the establishment of environmental thresholds that may work in one region but not another. Before adopting any thresholds or guidelines for construction industry, two fundamental understandings of climatic heat management need to be established, i.e., an understanding of the characteristics of local climates in the sense of how they affect construction production practice and an understanding of the socio-managerial context of construction site practices in the sense of how they can be intervened to be productive and safe in hot weather. On these concerns, a 360-degree, mixed-methods approach to data collection and a triangulation, case study approach to analysis were adopted to enable us to triangulate sources of information and derive valid conclusions (Fellows & Liu, 2008; Yin, 2013). To understand the context, a profile of metabolic rate is needed as an element of heat stress in construction work. Traditional method for collecting data of metabolic rate is through Douglas bag method (Rosdahl et al., 2010), which, however, interferes with work activities, putting in doubt whether the data are measuring what it is intended to. To minimize this bias, Rowlinson and Jia (2014) develop an extended Predicted Heat Strain model (PHS model) (ISO 7933, 2004; Malchaire et al., 2001) for analysing the variance of consequences of heat stress in a dynamic workplace (ePHS model). Through utilization of the equations suggested by ISO 8996 (2004), metabolic rate data can be converted from heart rate data. Continuous recording with sports heart rate monitor is a non-intrusive method that can keep the naturalistic setting of the study. This method however has a limitation in that data recorded during summer make a systematic overestimation on of metabolic rate. An improved methodology was thus tested in the CQ study in which heart rate data were recorded during non-hot season. Socio-managerial and cultural contexts of the projects were analysed through triangulation of questionnaire, interview and site observation data.

A one-day data protocol was developed and tested in the CQ study. Within a normal working day, researchers in a team of three met participants in a pre-work morning session and a post-work evening session. Between the two sessions workers performed their daily work wearing a heart rate monitor. A heat stress monitor and a video camera were set up at the workplace to obtain a continuous record of environmental parameters and working activities. During the course researchers administered questionnaires to managers and conducted informal interviews with site workers and managers. In the evening session, workers went back to complete a YMCA 3-minute Step Test. Researchers went through the data collection sheet on risks and interventions with workers on semi-structured interviews.

METHODOLOGY

The cases

Cases were constructed at both individual levels and project levels through triangulation of questionnaire analysis, content analysis of semi-structured interviews, observation and coworker and supervisors' report, statistical analysis of lifestyle and physiological data. The sample included six workers and nine managers from two construction sites, including two plasterers working in indoor environment, two formworkers working in shaded area and two concreters working on rooftop. All the six worker participants are within the normal range of blood pressure except one marginally falls into the hypotension category; all are within the normal range of Body Mass Index (BMI) except one falls into the range of underweight. Four of the six workers were smokers, smoking 10 to 40 cigarettes per day. The ages of the workers range from 21 to 61. The mean age of the sample is 38.8.

Ages of the managers sample range from 21 to 60. Mean age is 34.9. Their experiences of working in the construction industry range from one year to 24 years (Mean = 8.8 years). Their positions included Site Coordinator, Safety Supervisor, Construction Manager, Quality Supervisor, Construction Supervisor, Senior Engineer, and Site Engineer.

Institutional interventions

Known as a region of extremely hot summer, Chongqing Municipality issued a regional guidelines in 2007 (Document No. 205, 2007), defining the warning of a hot weather day and suggesting three levels of safety measures (see Table 7 for more details) based on forecasted daily maximum temperature. In 2012 a formal national guideline was in force in mainland China, the Notice for Administering Heat Stress Prevention Measures (Document No. 89, 2012). Accountability is assigned to employers for provision of a safe working environment. However, during the field study, it was found that none of these was implemented. There are other three Chinese national standards applied to "hot work", including GBZ 2.2 (2007), GBZ/T 189.7 (2007) and GBZ/T 229.3 (2010). These standards adopt WBGT as heat stress measurement, being identical to the specification by ACGIH (ACGIH, 1976, 2012) and ISO 7243 (1989), but are not applied to construction work.

Table 3: Comparison of Chongqing's 2007guidelines and China's 2012 national Guidelines

Daily max-temperature	2007 CQ guidelines	2012 national guidelines
≥ 40°C	Stop work or control workplace temperature under 37°C	Stop all outdoor work
≥ 37°C, <40°C	Daily work hours ≤ 6 hours Stop work during 12 pm to 4 pm. High temperature allowance	Daily outdoor work ≤ 6 hours Stop work during hottest hours
≥ 35°C, <37°C	Preparation	Work rotation Pay high temperature allowance

Institutional interventions

CQ is of an inland sub-tropical climate (CQMB, 2008), with summer ranged from May to August where daily maximum temperature often exceeds 33oC while relative humidity is between 70% to 80% (CMA, 2014). Descriptive statistics of this study is shown in Table 4.

Table 4: Descriptive statistics of recorded environmental parameters

	Ta (°C)	Tg (°C)	RH (%)	Va (m/s)	$WBGT_{in}$ (°C)	$WBGT_{out}$ (°C)
Mean	24.5	26.0	48.4	0.5	18.4	23.2
Median	22.7	23.4	54.2	0.4	18.6	25.1
Minimum	16.8	16.8	19.9	0.0	16.3	16.7
Maximum	37.4	48.5	72.4	2.3	20.3	27.9
Std. Deviation	4.7	7.8	15.4	0.5	0.9	4.0

Work routines

General work routines of the two studies are compared in Table 5. Regimens in the HK construction sites were rather homogeneous, while in the CQ study a clear difference existed between local and migrant workers. The two sites were residential building projects under a large private developer. Site A was at completion stage of the project. The two plasterers were working on finishing work in indoor environment. Site B was at structural building stage. The two carpenters were working in the façade inside and outside of the building, whilst the two concretors were working outdoor on the rooftop. The local workers worked for 22 to 25 days a month, having the autonomy of choosing their days off, and practiced daily routine. The migrant workers from the greater Chongqing region lived in site-based air-conditioned dormitories and worked daily without weekends or public holidays. The carpenters were paid a lump sum for certain volume of work, which drove them to voluntarily work overtime to complete the work for the next job. The concretors were paid by daily wage with unpredictable working hours. In one occasion they spent a whole morning idling in the workplace waiting for the concrete pump. In another case they worked continuously for 48 hours to meet work progress demand.

Table 5: Work routines of the sample

	Plasterers	Formworkers	Concretors
Identity	Local	Migrant workers	Migrant workers
Accommodation	Home	Onsite dormitories	Onsite dormitories
Contract	Monthly salaries	Lump sum	Daily wages
Work days	Work 22-25 days a month, flexible leave	Work everyday. No weekend or public holidays	Work every day. No weekend or public holidays
Daily working hours	9 am – 6 pm	Start with sunrise, finish with sunset	By work demand and availability of concrete pump
Work regimen	Self-paced	Self-paced	Paced by concrete pumps.
Lunch break	11.30 a.m. – 1 p.m.	11.30 a.m. – 1 p.m.	11.30 a.m. – 1 p.m.

Trade specific metabolic profiles

Video clips were indexed and coded by two researchers (Spielholz et al., 2001) and confirmed that the two codebooks agreed with all coding of major activities (Kivi & Mattila, 1991). Heart rate data were converted into metabolic rates and synchronized with video record of work activities. Initial analysis indicated that heart rate slightly lags behind the equivalent activity being performed. For this reason the minimum time range for a code is set as five minutes to ensure the synchronization between metabolic rates and activities (Oglesby et al., 1989). Typical activities of each trade were summarized in Table 6. The coded activities were then further combined into two essential categories: effective work (em) and idling (im). Results of the mean metabolic rate for plasterer is 201 W/m2, for formworker is 185 W/m2 (em) and 159 W/m2 (im), for concreter is 174 W/m2 (em) and 166 W/m2 (im). Except for the plasterers' metabolic rate profile marginally falls into the category of heavy workload, during which no rest or idling were observed, the metabolic rates of both work and rest for the other two trades fall into the moderate workload category (ISO 7243, 1989).

Table 6: Typical activities of three trades

Trade	Plasterer	Carpenter	Concreter
Categories of activities	1. Mixing powder and water, including carrying them 2. Walking with empty bucket 3. Carrying working platform 4. Plastering the ceiling 5. Plastering the wall 6. Idling/rest	1. Looking for materials (used formwork) on site 2. Knocking down concrete from used formwork 3. Sawing formwork 4. Drilling concrete 5. Fixing formwork 6. Idling/rest	1. Splashing water 2. Harrowing concrete 3. Paving concrete with a handheld machine; 4. Guiding concrete pipe to pour concrete 5. Idling/rest

Results of comparative analysis

To understand the uniqueness of the characteristics of CQ context and its influence on physical work, results of the CQ study was compared with a previous study the research team did in Hong Kong. The HK study was a research project commissioned by HK Construction Industry Council with an aim of developing a heat stress guidelines for the construction industry. The new guidelines (CIC, 2013), as an outcome of the HK study, has been issued in 2013 and is being used in construction contracts by major clients. The sample is 216 workers from 37 trades and 95 managers on 37 job titles from 26 construction sites. More details of the HK study have been reported in separate papers (Jia et al., forthcoming; Rowlinson & Jia, 2014). To compare the perceptions of risks and interventions in the two different samples, means of ratings of perceived risks and effectiveness of interventions are calculated and ranked from larger to smaller values as presented in Table 7. Comparisons of perceived risks and interventions between the two studies are presented as follows.

Table 7: Comparison of perceived risk factors and effective interventions

Risks	*Workers' sample*	*Managers' sample*
CQ study	1.Ambient temperature 2.Work pace 3.Long working hours (fatigue) 4.Solar radiant heat 5.Wearing PPE 6.Lack of ventilation	1.Solar radiant heat 2.Ambient temperature 3.Heavy workload 4.Long working hours (fatigue) 5.Workers' physical health 6. Lack of break
HK study	1. Lack of ventilation 2. Ambient temperature 3. Lack of break (continuous working time) 4. Solar radiant heat 5. Worker's physical health 6. Work pace	1. Lack of ventilation 2. Solar radiant heat 3. Humidity 4. Ambient temperature 5. Worker's physical health 6. Lack of break (continuous working time)
Interventions	*Workers' sample*	*Managers' sample*
CQ study	1. Ageratum Liquid 2. Air conditioned room 3. Provide drinking water 4. First Aid 5. Health screening 6. Ventilation	1. First aid 2. Ageratum Liquid 3. Provide shaded resting place 4. Toolbox talk 5. Ventilation 6. Remind workers to drink water
HK study	1. Provide shaded resting place 2. First aid 3. Remind workers to drink water 4. Inform supervisor of early symptoms 5. Mechanical aids 6. Buddy system	1. Prohibit alcohol 2. Arrange regular breaks 3. Inform supervisor of early symptoms 4. Encourage fluid intake 5. Provide shaded resting place 6. Training for workers

DISCUSSION

The finding that the mean metabolic rates of idling/rest are similar to those of the major work activities reflects both the self-paced nature of the legitimate work and the restlessness during breaks. During the study, the concreters were idled for a whole morning waiting for the pump truck. As shown in the metabolic rate profile, the concreters idling on rooftop wondering around and smoking were not taking effective rest. The evidence shows that idling caused by poor planning or supply chain coordination contribute to neither productivity nor safety.

The ranking result of the risk factors is generally consistent with the rational model, which focuses on six factors of air temperature, humidity, solar radiation, metabolic heat and clothing effect. In addition, except the CQ workers sample, managers in both studies and HK workers recognize personal heat as a top risk factor in heat. Of the result of effective interventions, all participants in the CQ study rated Ageratum Liquid as a top important measure for heat stress prevention. In an extreme case, a worker emphasized that the most prominent heat risk on site is inadequate provision of this medicine. The Ageratum Liquid is a Chinese medicine known to have effect of calming down digestive system to prevent vomiting and improving immune system. However, its ingredients contain alcohol, suggesting potential side effect. Its equivalent in HK is the herbal tea (Leung Cha), a traditional Cantonese drinks believed to have the effect of cooling down the body. Medical advice suggests it helps improve body's sweating system. Such vernacular interventions developed from local lifestyle, climate and population are often cheaper and more effective options for safety. However imposition of formalized universal institutions often eliminate options of preventions that are unique to the local culture. In HK it was observed that herbal tea was provided on some sites, but was in a progress of being replaced by modern bottled drinks.

Of the four samples, prohibition of alcohol was ranked as a top effective intervention by the HK managers' sample but was not recognized by workers and managers in the CQ study. In CQ, no construction sites were found to prohibit alcohol or smoking. One worker participant reported that he drank a bottle of beer during lunch in summer for "cooling down the body". Researchers observed that drinking beer in street food court during lunch was a norm among workers. However, when being asked whether alcohol should be prohibited on site, the frequent drinker strongly support prohibition and gave his reason as, "Drinking is good for me but not good for the whole." In contrast, his manager strongly objects the idea of banning alcohol on site, because "it is their hobby. We cannot forbid people's hobby." Whilst the result indicates a lack of safety knowledge among the workforce in CQ, a strong Confucianism benevolent value is manifested on which the worker was willing to sacrifice his 'hobby' for the benefit of 'the whole' while the manager was looking after his workers as spoiled children. In Hong Kong, while the formal rule of banning alcohol on site was in force, informal practice was decoupled from the rule. A worker reported he had to do social drink with his boss, a subcontractor, to secure his job in the next project. A manager accepted steel benders drinking on site, because "this is their trade norm." In the case of HK, a strong pragmatism culture is manifested. In both studies, informal cultural institutions overwhelmed formal rules.

CONCLUSIONS

The study analysed individual cases of six construction workers and nine managers in Chongqing and compared their perceived prominent risks and interventions with a previous study in Hong Kong. Based on the research team's experience of HK study, a one-day data collection protocol was developed and tested. Video record and task analysis of working activities produced initial benchmarks of metabolic rates in three trades of concreter, plaster and formworker. The comparative analysis indicates that in CQ, both managers and workers rely heavily on reactive interventions such as first-aid and medicine, while a formal safety management infrastructure is not in place. Results of the study confirmed that regional and construction occupational specific heat stress guidelines are needed in China, from both a scientific point of view and the feedback of frontline personnel. Existing international or national standards and threshold systems provide reference institutional infrastructure for heat stress management. However, for these interventions to be effective, they need to be integrated with a site safety management system organically generated from local context. The issues embedded in heat stress management on construction site are widely connected to organizational and societal levels of institutions, which provides a focal point to understand how a safety management system works. Future studies are needed for cross cultural and climatic regional comparisons.

REFERENCES

ACGIH. (1976). Threshold Limit Values for Chemical Substances and Physical Agents. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists.

ACGIH. (2009). Heat Stress and Heat Strain: TLV® Physical Agents 7th Edition Documentation Cincinnati: American Conference of Governmental Industrial Hygienists.

ACGIH. (2012). 2012 TLVs® and BEIs® - Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. American Conference of Governmental Industrial Hygienists: Publication #0110.

ACGIH. (2013). 2013 TLVs® and BEIs® - Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. Cincinnati: American Conference of Governmental Industrial Hygienists.

AIOH. (2003). Heat Stress Standard & Documentation Developed for Use in the Australian Environment (Developed by Ross Di Corleto, Gerry Coles and Ian Firth). Tullamarine: The Australian Institute of Occupational Hygienists Inc.

Budd, Grahame M. (2008). Wet-bulb globe temperature (WBGT) - its history and its limitations. Journal of Science and Medicine in Sport, 11, 20-32.

Chi, Chia-Fen, Chang, Tin-Chang, & Ting, Hsin-I. (2005). Accident patterns and prevention measures for fatal occupational falls in the construction industry. Applied Ergonomics, 36, 391-400.

CIC. (2013). Guidelines on Site Safety Measures for Working in Hot Weather (Version 2). Hong Kong: Construction Industry Council.

CMA. (2014). China Meteoreological Data Sharing Service System. http://cdc.cma.gov.cn/dataSetLogger.do?changeFlag=dataLogger, accessed 24 Jan 2015, China Meteorological Administration.

CQMB. (2008). Chongqing climate in general. http://www.cqmb.gov.cn, accessed on 24 Jan 2015 , Chongqing Meteorological Bureau.

Dekker, Sidney. (2006). The Field Guide to Understanding Human Error (Rev. Ed.). Aldershot, England: Ashgate

Document No. 89. (2012). Notice for Administering Guidelines on Climatic Heat Stress Prevention Measures. Beijing: State Administration of Work Safety, Ministry of Health, Ministry of Human Resource and Social Security, All China Federation of Trade Unions.

Document No. 205. (2007). Measures of Labour Protection in Hot Weather in Chongqing Municipality (Vol. 2007年5月16日). Chongqing: Chongqing Municipality Government.

Fellows, Richard, & Liu, Anita. (2008). Research Methods for Construction (3rd ed.). Oxford: Wiley-Blackwell.

GBZ 2.2. (2007). Occupational exposure limits for hazardous agents in the workplace Part 2： Physical agents (in Chinese) Beijing: Ministry of Health.

GBZ/T 189.7. (2007). Measurement of Physical Agents in Workplace Part 7: Heat Stress (in Chinese). Beijing: Ministry of Health, P. R. China.

GBZ/T 229.3. (2010). Classification of Occupational Hazards at Workplaces Part 3: Occupational Exposure to Heat Stress (in Chinese). Beijing: Ministry of Health, P. R. China.

Gibb, Alistair, Haslam, Roger, Gyi, Diane, Hide, Sophie, & Duff, Roy. (2006). What causes accidents? Civil Engineering, 159(November 2006), 47-50.

Haslam, Roger A, Hide, Sophie A, Gibb, Alistair G F, & Gyi, Diane E. (2003). Causual factors in construction accidents. UK: Health and Safety Executive (Research Report 156).

Haslam, Roger A, Hide, Sophie A, Gibb, Alistair G F, Gyi, Diane E, Pavitt, T, Atkinson, S., & Duff, A R. (2005). Contributing factors in construction accidents. Applied Ergonomics, 36, 401-415.

ISO 7243. (1989). Hot Environments - Estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature). Geneva: International Standard Organisation.

ISO 7933. (2004). Ergonomics of the thermal environment Analytical determination and interpretation of heat stress using calculation of the predicted heat strain. Geneva: International Standard Organisation.

ISO 8996. (2004). Ergonomics of the thermal environment. Determination of metabolic rate. Geneva: International standards Organisation.

Jia, Yunyan Andrea, Rowlinson, Steve, & Ciccarelli, Marina. (forthcoming). Climatic and psychosocial risks of heat illness incidents on construction site. Occupational and Environmental Medicine, under review.

Kivi, P., & Mattila, M. (1991). Analysis and improvement of work postures in the building industry: application of the computerised OWAS method. Applied Ergonomics, 22(1), 43-48.

Malchaire, J., Piette, A., Kampmann, B., Mehnert, P., Gebhardt, H., Havenith, G., . . . Griefahn, B. (2001). Development and validation of the Predicted Heat Strain model. Annals of Occupational Hygiene, 45(2), 123-135.

Oglesby, Clarkson H., Parker, Henry W., & Howell, Gregory A. (1989). Productivity Improvement in Construction. New York: McGraw-Hill.

Rosdahl, Has, Gullstrand, Lennart, Sailer-Eriksson, Jane, Johansson, Patrik, & Schantz, Peter. (2010). Evaluation of the Oxycon Mobile metabolic system against the Douglas bag method. European Journal of Applied Psysiology, 109, 159-171.

Rowlinson, Steve, & Jia, Yunyan Andrea. (2014). Application of the Predicted Heat Strain Model in development of localized, threshold-based heat stress management guidelines for the construction industry Annals of Occupational Hygiene, 58(3), 326-339. doi: 10.1093/annhyg/met070

Rowlinson, Steve, & Jia, Yunyan Andrea. (2015). Construction accident causality: an Institutional analysis of heat illness incidents on site. Safety Science, 78, 179-189.

Rowlinson, Steve, Jia, Yunyan Andrea, Li, Baizhan, & Ju, Chuanjing Carrie. (2014). Management of climatic heat stress risk in construction: a review of practices, methodologies, and future research. Accident Analysis and Prevention, 66, 187-198.

Schmidt, Vivien A. (2008). Discursive Institutionalism: The Explanatory Power of Ideas and Discourse. Annual Review of Political Science, 11, 303-326.

Spielholz, Peregrin, Silverstein, Barbara, Morgan, Michael, Checkoway, Harvey, & Kaufman, Joel. (2001). Comparison of self-report, video observation and direct measurement methods for upper extremity musculoskeletal disorder physical risk factors. Ergonomics, 44(6), 588-613.

Yin, Robert K. (2013). Case Study Research: Design and Methods (5th ed.). Los Angeles: SAGE.

HEALTH, SAFETY AND WELFARE: EXCUSES USED TO ARGUE, FUSS AND TO GET AWAY WITH DOING LITTLE OR NOTHING?

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The film *The Good, The Bad and The* Ugly referred to different kinds of people in this world. Eli Wallach, who played the role of Tuco Ramirez, said "*in this world, there are two kinds of people*". Tuco used this analogy for a number of scenarios throughout the film and gave examples that depicted roles within his circle of colleagues. Tuco himself played the role of a bandit and was the "Ugly" within the title. Within Health, Safety and Welfare, there are many *ugly* sides. Anecdotal evidence suggests that some people, whether by nature, nurture or life experience can and do use illegitimate excuses related to health, safety and welfare to deliberately reduce production.

This research was the result of a small scale study completed on 12 highly-trained crews carrying out work associated with electricity overhead networks. The study showed that variables such as *deviations* from compliance with Job Site Safety Plans (JSSPs) and *production* in terms of work completed in a given time are straightforward to measure. A deviation is regarded as not complying with the JSSP. The JSSP involves 3 checklists that include a site specific risk assessment, plant and equipment, and a permit to dig. Part of the study involved interviewing each crew whilst health, safety and welfare audits were being carried out.

Within the study, it was found that there was a wide range of reasons for deviations. The reasons can be categorised into three groups with 1) Perceived Legitimate Reasons; 2) Perceived Ambiguous Reasons; and 3) Perceived Illegitimate Reasons. The study also shows that there was a correlation between *deviations* and *production*, with the crew having the greater number of deviations achieving up to 25.1% higher production than the average production rates. The study also showed that the crews which gave the highest level of both Ambiguous Reasons and Illegitimate Reasons had the lowest overall production rates.

Keywords: controls, excuses, health, safety, welfare, behaviour, risk.

INTRODUCTION

The objective of this study was to investigate whether a wider study that relates to attitudes towards "working safely" and the link to production needs to be carried out. The people who are involved in the management of health and safety and assessing the reasons for 'deviations from compliance with Job Site Safety Plans (JSSPs) need to understand the difference between:

- Perceived Legitimate Reasons
- Perceived Ambiguous Reasons
- Perceived Illegitimate Reasons

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People use illegitimate excuses referred to as 'reasons' related to health, safety and welfare to deliberately reduce production. Situations like this are counterproductive in many ways due to:

- Monetary losses
- Frustration for those who do not use illegitimate excuses
- Ethical issues due to non-cooperation

This research is the result of a study completed on 12 highly-trained crews carrying out work associated with electricity overhead networks in Ireland. To-date, no current literature exists which interrogates health, safety and welfare as an excuse (or reason) to inhibit work production rates. This in itself is a problem in terms of a lack of understanding of the area of attitudes towards "working safely" and the link to production. Therefore, this is a legitimate reason for starting the discussion.

LITERATURE REVIEW

The Health and Safety Executive (HSE) (2012) has a webpage entitled "Ridiculous 'elf and safety excuses exposed by watchdog". The webpage provides accounts of what it refers to as 10 ridiculous health and safety "excuses". The excuses range from charity shops refusing to sell knitting needles to schools banning yo-yos. The webpage also explains why these "excuses" used were not regarded as legitimate when considering current health and safety legislation.

When making choices relating to what is regarded as safe or unsafe, there can be uncertainty. Blockley (2013) provides the top 10 issues/questions for civil engineering systems with Question 5 asking "*How do we categorise uncertainty?"*. In answering this question, Blockley (2013) refers to the question by Plato "*Where is the wisdom to know that we do not know?*". However, when it comes to health, safety and welfare, the consequences of failure through not knowing can unfortunately be fatal.

Petroski (2006) discusses success through failure and refers to the complexity of design coupled with the faults associated with human nature and warns that people should beware of the lure of success and listen to the lessons of failure. The faults associated with human nature is reference to the "differences" in behaviour as individuals which also affect the way work crews operate in terms of making decisions. Differences in people exist. According to Belbin (1996), successful groups consist of individuals who fulfil a number of roles. The nine team roles identified are as follows:

- Plant
- Resource Investigator
- Co-ordinator
- Shaper
- Monitor-Evaluator
- Team Worker
- Implementer
- Completer
- Specialist

Belbin (1993) provides strengths and allowable weaknesses for each of the above nine team roles. It could be argued that the literature review for this research should provide a detailed account of human behavioural patterns linked to health and safety as there are many studies on worker behaviour. It also could be argued that given the sample size involved, the study should be widened with the crew monitoring designed around human behaviour. There was insufficient data collected in this study to provide a meaningful discussion related to the behavioural aspects of health and safety linked to previous studies. This is the rationale for not carrying out an in-depth analysis of previous worker behaviour studies.

METHODOLOGY

The research was the result of a study completed on 12 highly-trained crews carrying out work associated with electricity overhead networks. The rationale for using 12 crews was to use the total crews from one company to avoid random selection. This was a “small scale study” to investigate the need for a wider study. When assessing water discharges from domestic appliances Butler (1991) compared results obtained with 4 other large scale surveys and concluded that this small scale study was reasonably reliable and that useful information can be obtained from small scale studies.

All crews carry out the same work type which involves erecting wooden poles in new-build electricity network. New networks can cross or run parallel to existing live networks and the crews are also trained to work in live electricity networks. The production was measured in the amount of “digs” achieved per month. Part of the study involved interviewing each crew while health, safety and welfare audits were being carried out. Each crew was audited once per month. All audits were carried out by the same certified auditor. All audits were based on a bespoke checklist that the company wishes to keep confidential for competition reasons.

The audits recorded deviations from the JSSP and from the approved Health & Safety Plan for the work. Since this study was completed, “commendable actions” were also recorded on the audits but were not recorded as part of this research. The production achieved by each crew in terms of work completed or digs completed were also recorded from production work sheets for each month. Each dig relates to the erection of a pole where 1 pole = 1 No., 100 poles = 100 No.

Results & discussion

Examples of deviations found during audits are shown in Table 1.

Table 1: Examples of deviations found during audits

Examples of Deviations Found During Audits			
Documents	**Not identifying Physical Problems**	**Behaviour**	**Plant & equipment**
JSSP not completed	Poor Ground	Not following JSSP	Not certified
Not following methods	Damaged Network	Not following briefings	Damaged
Crew training not current	Extreme Weather	Not using PPE	Missing
	Farm Animals		
	Existing Services		

It is not suggested that any of the deviations given in Table 1 directly affect production. For example, not completing paperwork or checklists correctly and not having certified plant/equipment does not necessarily impact on the ability of a crew to complete work, however, these deviations can impact on the ability to complete work operations safely.

The results from the audits over a 7.5 month period (January to mid-August) are shown in Table 2.

Table 2: Deviation totals per crew

Crew ID	Jan	Feb	Mar	Apr	May	June	July	Aug	Total	Avg
1	2	1	2	1	0	4	1	0	11.00	1.375
2	0	2	0	1	0	0	2	1	6.00	0.750
3	3	1	2	NA	2	1	NA	3	12.00	2.000
4	2	1	3	2	1	2	1	1	13.00	1.625
5	1	1	0	1	2	0	0	0	5.00	0.625
6	4	3	NA	2	2	1	2	1	15.00	2.143
7	2	0	2	3	1	2	NA	3	13.00	1.857
8	1	3	1	2	0	2	2	1	12.00	1.500
9	1	1	1	1	3	1	1	2	11.00	1.375
10	3	2	1	4	2	1	1	1	15.00	1.875
11	1	2	4	2	2	4	NA	2	17.00	2.429
12	1	0	1	2	1	0	0	NA	5.00	0.714
The Average Deviations per audit/month based on all 12 crews										**1.522**

Notes: NA = crew was not available for audit or was not working.

Figure 1 gives the graphical results of Table 1. It can be seen from Figure 1 that Crew 5 had the lowest amount of deviations at 0.625 per audit and Crew 11 had the highest average deviations at 2.429 per audit.

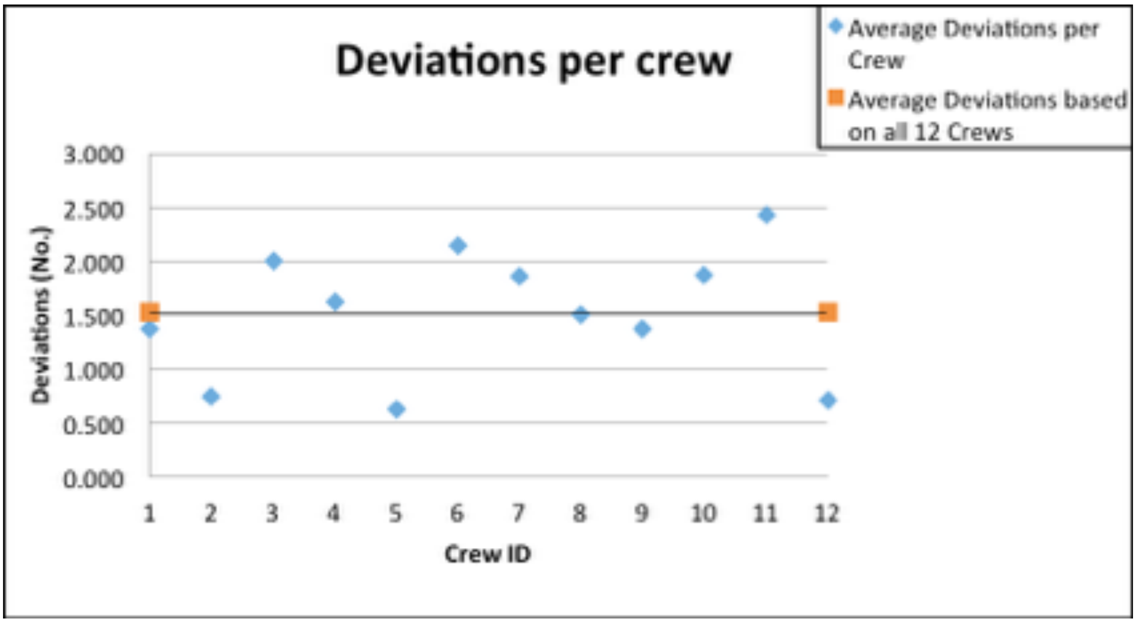

Figure 1: Deviations per crew

From Figure 1, it can be seen that Crews 3, 4, 6, 7 10 and 11 had above average deviations per audit. With the exception of Crew 7, the aforementioned crews also had above average production rates as shown in Table 3 and Figure 2. While Crews 1 and 9 were both close to the overall deviation and production averages.

Table 3: Production totals per crew

Crew ID	Jan	Feb	Mar	Apr	May	June	July	Aug	Total	Avg
1	98	112	88	126	96	127	116	62	825	103.1
2	136	108	123	152	125	119	106	71	940	117.5
3	167	151	159	NA	133	109	NA	77	796	132.7
4	111	91	153	150	142	120	139	57	963	120.4
5	97	105	90	101	89	78	94	44	698	87.3
6	143	157	NA	134	129	131	155	79	928	132.6
7	102	138	95	111	118	110	NA	66	740	105.7
8	137	90	144	127	97	122	128	52	897	112.1
9	141	113	166	120	107	132	115	45	939	117.4
10	108	147	135	124	130	163	117	57	981	122.6
11	154	122	148	171	169	161	NA	81	1006	143.7
12	87	82	99	80	75	72	89	NA	584	83.4
The Average production per audit/month based on all 12 crews										**114.9**

Notes: NA = crew was not working for the full month; August data where applicable is based on 2 weeks production.

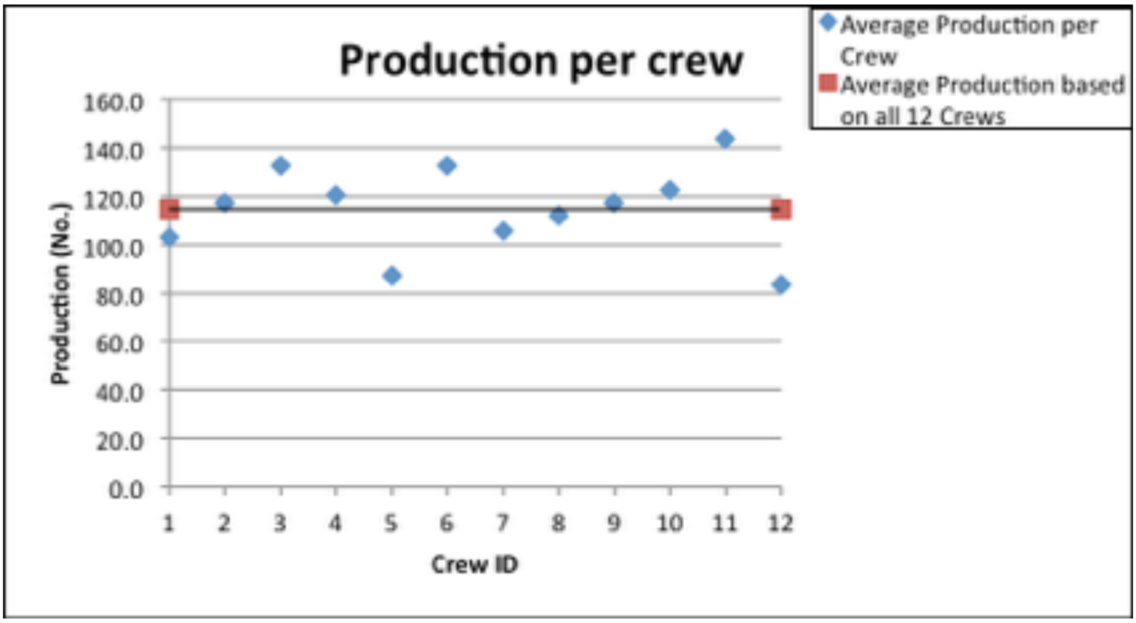

Figure 2: Production per crew

From Table 2 and Figure 1, it can be seen that Crews 5 and 12 had below average numbers of deviations with Crew 12 having the lowest number of deviations out of all crews followed closely by Crew 5. From Table 3 and Figure 2, it can be seen that Crews 5 and 12 had substantially below average production with Crew 12 having the lowest production out of all crews at 83.4 digs per month, closely followed by Crew 5 at 87.3 digs per month. However this trend was not present in the analysis of Crew 2. Crew 2 had below averages deviations at 0.75 (similar to Crews 5 and 11) with the average for all crews at 1.522 deviations per audit. The production rate for Crew 2 at 117.5 digs per month was above the average of 114.9 digs per month. This demonstrates that low deviation numbers may not always result in low production rates for the sample analysed.

During the audits, it was found that there is a wide range of reasons for deviations and reasons for work not being carried out according to plan. The reasons for the latter can be categorised into three groups with 1) Perceived Legitimate Reasons; 2) Perceived Ambiguous Reasons; and 3) Perceived Illegitimate Reasons. Table 4 summarises reasons given by the crews for the inability to progress with work operations. The reasons regarded as "legitimate" reasons are reasons that relate to physical or plant/equipment issues. The reasons regarded as ambiguous reasons are where the reasons were questionable in terms of stopping work operations with illegitimate reasons regarded as "excuses" not to carry out work. The results show that the reasons perceived to be illegitimate were only given by Crews 5 and 12 and did not include Crew 2. This offers some explanation as to why Crew 2 had above average production rates whereas Crews 5 and 12 had significantly below average production rates.

Table 4: Reason types

No.	Legitimate Reasons	Ambiguous Reasons	Illegitimate Reasons (Excuses)
1	High winds	Too wet to work	Too cold to work
2	Defect found in plant	Not sure of method *	Too hot to work
3	Switch out needed		Monetary complaints≈
4	Poor Ground conditions		Out Late last night
5	Other physical conditions		

Notes *Trained member of staff; ≈ Crew or crew member complaining about salary when they are being paid what was agreed and paid above statutory rates.

Categorisation of the reasons is something that needs further research on a wider scale as the current categorisation is based on the judgment of the first author, having first-hand experience of each crew through the data collection. For example, some of the ambiguous reasons may become legitimate based for changes in conditions. However, the first author's judgment in this study is that the given "conditions" do not undermine the categorisation of the "reason types" in this study. In a wider study variability in terms of risk threshold would need to be considered.

The small scale study showed that a link was established between Illegitimate Reasons and below average production rates. The research found that there can be an ugly side to Health, Safety and Welfare in terms of crew arguments relating to roles and responsibilities with Crew 12 also openly ridiculing their employer and expressing jealously at the employer (for example) having a big house. Crew 5 also displayed hostility towards their employer in terms of negative comments and made reference to making their employer "*far too much money*". Crew 5 also made reference to another Crew receiving a new van and expressed disapproval as their own (Crew 5) transport which happened to be a Mitsubishi Pajero jeep that was 2 years old. This type of hostility was not shown by Crew 2 who appeared to hold their employer in high regard and had no complaints about their plant or equipment.

The excuses given were generally linked with perceived misunderstanding in control measure choices. The choice of control measures can be linked to what is reasonable or what is reasonably practicable. The definition of Reasonably Practicable in relation to the duties of an employer means that an employer has exercised…

> *"all due care by putting in place the necessary protective and preventative measures, having identified the hazards and assessed the risks to safety and health likely to result in accidents or injury to health and the place of work concerned and where the putting in place of any further measures is grossly disproportionate having regard to the unusual, unforeseeable and exceptional nature of any circumstance or occurrence that may result in an accident at work or injury to health at that place of work".*
>
> (HSA, 2005, P.15)

From the given Reasonably Practicable definition, the specifying protective and preventative measures are dependent on variables. It appears that the subjectivity in the choice of adequate controls is an issue and can be used as an excuse to produce less output.

LIMITATIONS

There have been limitations to this study as follows:

1. While the work operations being carried out by each crew were similar it was not identical as each "dig" location varied in terms of geographical location.
2. The data set is small and an in-depth statistical analysis would serve no purpose.
3. The information gathering should have included a questionnaire for each crew in order to better determine attitudes.
4. Categorisation of the "reason types" is something that needs further research on a wider scale.

CONCLUSIONS

This small scale study showed that variables such as "defects" in terms of deviations from complying with JSSPs and "production" in terms of work completed in a given time are straightforward to measure.

This study shows that there is a correlation between deviations and production, with the crew having the greater number of deviations achieving up to 25.1% higher production than the average production rates. However, it is recognised that due to the scale of the study, a deeper statistical interrogation would not assist the discussion at this point.

The study showed that the crews which gave the highest level of both Ambiguous Reasons and Illegitimate Reasons had the lowest overall production rates. A clear correlation was established between perceived Illegitimate Reasons for deviations and below average production rates.

Eli Wallach who played the role of Tuco Ramirez in the film the Good, the Bad and the Ugly said "in this world, there are two kinds of people". In reality there are many different kinds of people in this world. This research also shows that there can be an ugly side to Health, Safety and Welfare in terms of arguments and jealousy with crew members. This is something that needs to be investigated further.

Whilst the sample size in the study has been a limitation, Butler (1991) demonstrates how small scale studies can provide reasonably reliable and useful information. This paper is a starting point which demonstrates that questionable excuses are being used as excuses to not do work. It can be argued that in the process of "doing less", health, safety and welfare are used as excuses to argue, fuss and to get away with doing less work. This study has highlighted that further work is required.

Recommendations for further work

The reality is that there is inadequate research insofar as the following area remains unconfirmed as outlined in the primary recommendation for further research: A wide/large scale study with the objective of investigating attitudes towards "working safely" and the link to production. In the wider study variability in terms of risk threshold, working conditions and individual behaviour would need to be investigated further.

REFERENCES

Belbin, R.M., (1996) How to Build Successful Teams. London. Butterworth Heinemann.

Blockley, D. (2013) Do civil engineering systems need systematising? Tackling complexity–top 10 issues for civil engineering systems. Civil Engineering and Environmental Systems, 30(3-4): 199-210.

Butler, D. (1991) A small-scale study of wastewater discharges from domestic appliances, Journal of IWEM, 5, 2, April, 178-185.

Health & Safety Authority (HSA) (2005) Safety, Health and Welfare at Work Act 2005. Dublin: Oireachtas Publications.

Health & Safety Executive (HSE) (2012) Ridiculous 'elf and safety excuses exposed by watchdog [Online] Accessed at: http://www.hse.gov.uk/press/2012/hse-myth-busting.htm, Accessed on: 16/04/2015.

Petroski, H. (2006) Success Through Failure: The Paradox of Design. New Jersey: Princeton University Press.

INQUIRY INTO THE HEALTH AND SAFETY MANAGEMENT PRACTICES OF CONTRACTORS IN VIETNAM: PRELIMINARY FINDINGS

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Despite the socio-economic significance of the Vietnamese construction industry, the industry continues to have a poor reputation in terms of occupational health and safety (H&S). Whilst it is evident that improvement is needed, there is a dearth of research in this area to drive and guide improvement efforts. Particularly in the area of H&S management, there is little available documented insight into the H&S management practices being implemented by contractors (i.e. construction companies). As the awareness of these practices is an important milestone to gaining understanding into areas that need improvement, this study provides preliminary insight into the H&S management practices of contractors in Vietnam. The study employed a questionnaire survey of contractors and it presents preliminary findings from the responses of 42 contractors. Within three of the key elements of H&S management (i.e. policy, organising for H&S, and risk assessment) the survey findings suggest that whilst some practices are commonplace amongst contractors, there are also practices that are less implemented by contractors. Amongst the less implemented practices are: provision of health and safety guides/manuals, undertaking risk assessments for work packages/operations, reviewing and updating risk assessments, and assessing the competence of workers/subcontractors. Whilst not conclusive given the limited number of responses, the findings presently provide preliminary indication of the aspects of H&S management that are weak amongst contractors and may thus need attention.

Keywords: health and safety, health and safety management, survey, Vietnam.

INTRODUCTION

The construction industry is regarded as a highly hazardous industry and it is usually the greatest contributor to industrial fatalities in many developing countries including Vietnam (Tutesigensi and Phung, 2011). Construction also accounts for a significant number of occupational related ill health and absence from work. The high injury and illness records in construction have been attributed to a host of factors including extended hours of working in ergonomically difficult positions; unsafe worker behaviour, exposure to the harsh weather, dust, noise and fumes; regular working at height; working in confined space, features of construction projects, and prevalent human-machine interactions on site (Griffith and Howard, 2001; Haslam et al., 2005; Manu et al., 2014). The poor state of health and safety (H&S) in construction calls for better H&S management in construction considering the socio-economic benefits that are derived from this industry in many countries. Despite improvement realised in developed countries through health and safety management, developing countries such as Vietnam have not been able to achieve similar improvements (Tutesigensi and

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Phung, 2011). Work related fatalities remain high and is predicted to increase due to the ever increasing spate of industrialisation which has led to increased construction activities (Hämäläinen et al., 2009; MOLISA, 2012).

HEALTH AND SAFETY IN THE VIETNAMESE CONSTRUCTION INDUSTRY

H&S performance in Vietnam has historically been reported as being among the worst in the Asian region with an estimated industrial fatality of up to 26 per 100,000 workers (Hämäläinen et al., 2009). This is significantly poor when compared to developed countries where fatalities rates are much lower (e.g. 0.44 fatalities per 100 000 workers in the UK for 2013/14 (Health and Safety Executive (HSE), 2014)). Vietnams Ministry of Labour Invalids and Social Affairs (MOLISA) reported as high as 5951 accidents which affected up to 6337 people, 2553 injuries and 621 fatalities based on national safety records in 2007 (MOLISA, 2008). More recent records are still worrying with about 152 fatal accidents recorded within just the first 6 months of 2013 (MOLISA, 2014). The cost of accidents to the Vietnamese economy was estimated at 58,528 billion Vietnamese dong (VND) (GB £1.65 billion, based on average 2014 interbank rate) with a loss of 382,313 working days due to accidents and work-related illness in 2007 (BSW, 2008). More recent data indicates losses of up to 19.23 billion VND (GB £545,315 based on average 2014 interbank rate) as compensation to accident victims and a loss of 19,109 working days due to ill-health in the first half of 2013 (MOLISA, 2014). The construction industry in Vietnam contributes significantly to the poor H&S record and is thus considered as one of the most dangerous industries (Tutesigensi and Phung, 2011). According to BSW (2008) up to 28% of accidents and 44% of industrial fatalities are attributable to construction activity in Vietnam. Consequently, the Vietnamese construction industry has been in the spotlight due to its contribution to ill health and accidents. Forecast for 2010 to 2015, is that 170,000 people will suffer from occupational accidents, of which 1,700 fatalities will occur at the prevailing rate (MOLISA, 2012). This could result in losses of over 2,000 billion VND per year (MOLISA, 2012) (GB £56,715,063 based on average 2014 interbank rate). Given the huge cost associated with the poor H&S performance of the Vietnamese construction industry, efforts towards improvement are much needed.

HEALTH AND SAFETY MANAGEMENT

Effective H&S management gives improvements in the reduction of construction accidents (Lingard and Rowlingson, 2005; Fewings, 2013). The lower accident and fatality rates recorded in developed countries is partly attributable to H&S management practices instituted through the adoption of H&S management systems (Fewings, 2013). Owing to this, adoption of H&S management systems and their associated practices by contractors is increasingly becoming important (Fewings, 2013). According to Griffith and Howarth (2001) an effective H&S management system recognises H&S as a major contributor to organisation performance in general. Gallagher (1997) identified the following practices as important in delivering effective H&S management: high level of senior management commitment; occupational health and safety (OHS) responsibilities known; encouragement of supervisor involvement; active involvement of a H&S representative who has a broad role; effective OHS committees; planned hazard identification, risk assessment and hazard elimination control; and comprehensive approach in inspections. According to Fewings (2013) these practices can be more effectively institutionalised within a management framework with key areas/elements categorised as follows: H&S Policy, organisation for its management, risk assessment, planning and implementation, measuring performance and an effective review system for feedback. This system is after BS OHSAS 18001: 2007 (BSI, 2007), the UK Health and Safety Executive (HSE) guidance for H&S management (HSE, 1997; 2013), and is also similar to other models of H&S management such as the model by the International Labour Organisation (i.e. ILO OSH 2001) (ILO, 2001). According to the Royal Society of Chemistry (2014), the BS OHSAS 18001:2007 remains the most widely used model. The description of the above areas/elements and examples of practices are given in Table 1 below. As BS

OHSAS 18001:2007 is the widely used framework and it also closely related to the models by HSE (1997, 2013), Table 1 is structured around these models of H&S management.

Table 1: Key H&S Management Elements

Management Practice Area/ Element	Management Practice sub-area/ element *	Description and examples of practices*
Plan	Policy	Written in-house H&S policy statement reflecting management's concern for H&S and detailing principles of actions to achieve H&S objectives e.g. policy document
	Planning	Planning for effective resource allocation e.g. Pre-project H&S plans.
Do	Organising	The structural system to manage health and safety e.g. human, financial and equipment; communication.
	Risk Assessment	Evaluation of risks and establishing necessary H&S measures to avoid accidents e.g. pre-project risk assessments.
	Implementation	Actual implementation of programmes e.g. training.
Check	Measuring Performance	Verification of the extent to which goals are achieved e.g. performance measurements metrics to include H&S targets such as number of accidents.
Act	Management review/Auditing	Reviewing in order to improve entire system e.g. External consultant reviews.

*Sources: (HSE, 1997; Griffith and Howard, 2001; Lingard and Rowlinson, 2005; BSI, 2007, Boyle, 2008; Kheni et al., 2008; Cheng et al., 2012; Fewings 2013; Hinze et al., 2013, HSE, 2013)

The importance of H&S management in construction is also reflected in the extant literature by the extent of research work around the subject. Several studies have examined the use and importance of H&S management practices in both developed and developing countries (e.g. Kheni et al., 2008; Cheng et al., 2012; Manu et al., 2013; Agumba et al., 2013; Hinze et al., 2013). However, in the specific context of Vietnam, there is a paucity of research on H&S management practices. The limited construction H&S research literature on Vietnam has focused on other issues such as worker attitude towards H&S (Tutesigensi and Phung, 2011) and also government reports have mainly highlighted the poor state of H&S affairs and the vision for its management (Pham, 2002; BSW, 2008; MOLISA, 2012). There is therefore the need for research into H&S management by contractors in Vietnam to gain an understanding into the elements/practices that need improvement. To this end, this research provides preliminary findings on the H&S management practices implemented by contractors in Vietnam.

RESEARCH METHOD

A quantitative approach was adopted for this study with the main reason being its suitability for obtaining a generic view or snapshot of a phenomenon (Fellows and Liu, 2008). Again, this approach is suitable for this study which sought to answer a research question relating to "what" (i.e. what H&S management practices are used by contractors in Vietnam?) (Fellows and Lui, 2008). In order to investigate the H&S management practices of Vietnamese contractors, contractors' personnel in management roles (e.g. H&S managers, project managers, site managers, engineers, and company directors/managers) were targeted as such personnel are most likely to possess the relevant knowledge and experience relating to the management of H&S in their organisations. Drawing on the literature review (particularly the elements and practices of H&S management (Table 1)) a questionnaire survey was designed for the data collection. The questionnaire included closed questions to obtain company information (e.g. size of company), company H&S management practices, and open ended questions requesting for general comments about difficulties/challenges faced in managing H&S. It is estimated that there are circa 50,000 registered contractors in Vietnam (Mai and Van, 2012). According to Denscombe (2007), decisions on sample size may be done on the basis of prior knowledge, familiarity and good judgment. Consequently, due to time and resource constraints a decision was made to progress the study in a pragmatic and systematic way by breaking Vietnam into 2 main regions (Northern and Southern) and then focusing on the Northern region in a first preliminary phase which is the focus of this paper. Contractors operating in the northern part of Vietnam were thus targeted. The developed questionnaire was translated into Vietnamese and administered to 60 contractors. Accompanying the questionnaire was a letter requesting for a personnel in construction management related role (e.g. company director, H&S manager, site manager, project manager, and civil engineer) to complete the questionnaire. The contractors were obtained from information provided by local departments of construction in provinces/cities, and also from the lead researcher's industry connections. As acknowledged in Gibb et al. (2002), obtaining participation in construction H&S research can be very difficult and as such using industry connections/contacts to enhance participation can be useful (Manu, 2012). The survey yielded a total of 47 responses. However, following screening of the responses, 5 were excluded due to excessive missing data. The closed questions were analysed using frequency (%), and thematic analysis was used for the open responses.

FINDINGS & DISCUSSION

The first section of the survey sought to find out the background of respondents and their companies. The majority of respondents were site managers (28.5%) and civil engineers (23.3%). Company directors who responded to the survey also constituted 21%. 2.4% held H&S specific designation. All together the respondents constituted a good number of respondents with management level roles within the companies. 21.4% of the respondents had less than 5 years of experience within the construction industry. The remaining majority possess more than 5 years of experience.

With regards to the background of the companies, the majority are medium size (42.9%) or small size (40.5%) companies. This classification of firm size is based on Vietnamese Regulation of Business Registration. Similar to the construction industry of other countries, in Vietnam a single firm can provide different types of construction services. A majority of the companies are however involved in public works (76.2%) or civil engineering related construction (78.5%). Most of the firms (66.7%) do not have a specific budget for H&S management. The background details of the surveyed firms are presented in Table 2 below.

Table 2: Background of Respondents and Companies

		No.	*%*
Respondents role	Site Manager	12	28.5
	H&S Manager/Supervisor	1	2.4
	Company Director	9	21.4
	Civil Engineer	10	23.8
	Project Manager	6	14.3
	Other	4	9.5
Respondents experience	Less than 5 years	9	21.4
	5 to 15 years	24	57.1
	Over 15 years	9	21.4
Company size	Small (less than 50 employees)	17	40.5
	Medium (51 to 150 employees)	18	42.9
	Large (more than 150 employees)	7	16.6
Areas/Sectors of companies operations	Public sector works	32	76.2
	Private sector works	20	47.6
	Buildings	23	54.7
	Civil	33	78.5
	New build	23	54.7
	Refurbishment	9	21.4
	Demolition	21	50.0
	Other	14	33.3
Budget for H&S management	No budget	28	66.6
	Less than 300 million VND*	7	16.7
	More than 300 million VND*	7	16.7

*300 million VND = GB £8,507 based on average 2014 interbank rate.

H&S Management Practices by Vietnamese Contractors

The findings and discussion presented here focus on practices within the policy, organisation and risk assessment areas/elements of H&S management. The findings are summarised in Figure 1 below.

Figure 1: Level of Implementation of H&S Management Practices

H&S Policy

The survey revealed that a majority of firms have a formal health and safety policy statement (74%). All the companies also have H&S as part of company director responsibilities.

Organising for H&S

All the firms have site supervisors with H&S responsibilities. 86% alluded to communicating H&S information to their workers through outlets such as newsletters and leaflets, while 60% engage with their workers on various H&S issues (e.g. having H&S meetings). 79% of the companies network with other organisations (e.g. government authorities) on H&S issues. Whilst health and safety posters are displayed by most of the companies (i.e. 71%), only 55% of them openly display their company's health and safety policy on sites, company websites or head office branch. 80.95% of the companies provide health and safety annual reports. 67% of the firms surveyed share their H&S practices with external stakeholders such as clients. 52% of the companies perform assessment for the H&S competence of workers and subcontractors. While 52% have a designated H&S manager role, a lesser proportion of companies (42%) provide training for their H&S managers. On the other hand only 24% of the participating firms have a designated health and safety department and 17% of them provide health and safety guides and manuals for workers.

Risk Management

Most of the firms (88%) alluded to informing their employees about hazards on site and 74% undertake overall project risk assessments before projects starts. However, only 38% of them undertake risk assessment for individual work packages and operations before they begin. 48% review and update risk assessment during construction while 62% of them design site rules and measures in order to mitigate assessed risks.

Borrowing from the concept/practice of academic degree classification (e.g. UK masters, ≤ 49% = weak; 50-69% = pass to merit; 70% + = very good/ distinction), the level of implementation of the H&S management practices in Figure 1 could be categorised as: low (i.e. 0 - 49%); moderate (i.e. 50 - 69%); and high (70% +). From the results it is clear that some efforts are being made by Vietnamese contractors in relation to practices adopted to manage H&S as 9 practices show a high level of implementation (i.e. 70% +) across the companies. According to Lancaster et al. (2003) smaller companies are more likely to be affected by red tape making them less capable of dealing with the complexities associated with H&S compliance. In spite of this, although a majority of the companies are small and medium size, the results suggest that some efforts are being made by Vietnamese contractors especially in the area of H&S policy. Within the element of organising for H&S, 3 practices and 5 practices have a low level of implementation and a moderate level of implementation respectively. In terms of risk assessment, 2 practices and 1 practice have a low level of implementation and a moderate level of implementation respectively. These lower levels of implementation within these elements could partly be responsible for the poor H&S record of the construction sector in Vietnam (see MOLISA, 2012). A key practice within organising for H&S which is significantly lacking is the provision of health and safety manuals/guides with only 17% of firms practicing this. This could be explained by the following statement from the open ended questions on the questionnaire: "H&S training documents are not officially standardized by government, there is a lack of official framework of H&S training programmes and they have not been deeply evaluated. Documents which are being issued are not effective and helpful" [Company Director]. Similarly only 24% of firms actually have an H&S department/unit. Given that majority of the companies are small and medium size, this is unsurprising as small and medium companies are noted to have limited resources (see Fabiano et al., 2004) and as such may not be able to adequately finance and resource a unit/department designated for H&S.

Safety Attitude and Behaviour and Practices

Workers H&S attitude and behaviour is an indication of how well H&S is managed/H&S performance (Tutesigensi and Phung, 2011). In order therefore to help gauge the effectiveness of the management of H&S by the contractors, their assessment of workers' H&S attitude and behaviour was sought. From the survey, more than a half of the respondents were of the view that site workers have poor attitude and bad behaviour in terms of H&S as indicated in figure 2. According to Duc (2014), site workers in small construction projects (which often tend to be managed by small and medium size contractors) often lack appropriate working contracts and H&S training. This may be reasons for the poor H&S attitude and behaviour among workers of the responding firms which are mainly small or medium size (i.e. 83.4%).

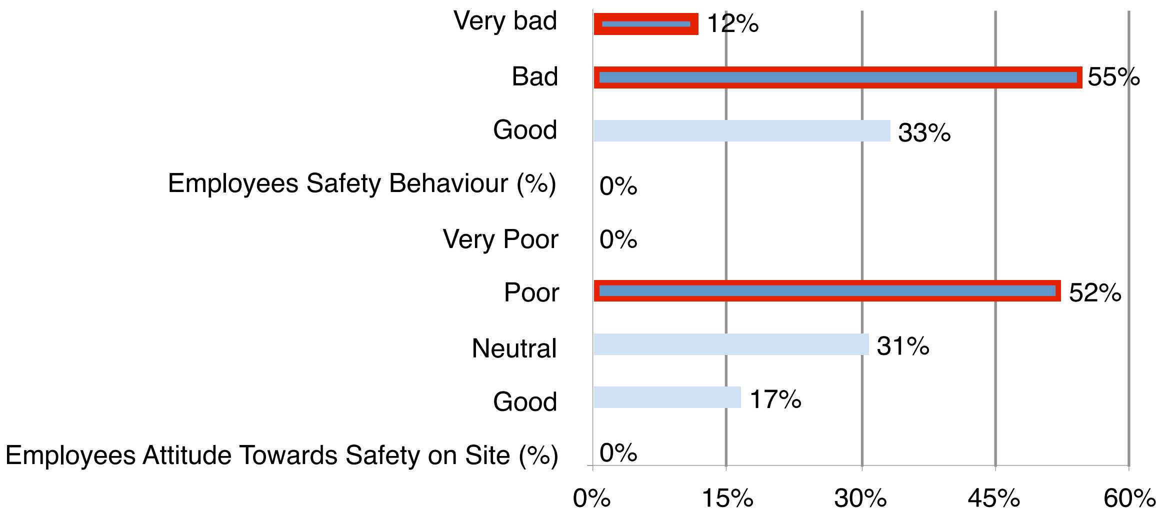

Figure 2: Workers behaviour and attitude towards safety

From the respondents open responses, worker H&S attitude and behaviour were also noted as a challenge for H&S management. A selection of the open ended comments regarding attitudes and behaviour are given below:

"Poor attitude of both employer and site workers; poor cultural behaviour causes poor execution "[Project Manager].

"Site workers do not follow site regulations, do not use personal protective equipment" [Site Manager]

"Need to have methods to improve the attitude towards occupational health and safety in construction for site workers" [Site manager]

"Need to build a culture of occupational health and safety in construction industry, start from employers and expand it to site workers" [Health and safety supervisor].

"Opening mandatory training programmes for site workers, improving the attitude and behaviour towards occupational health and safety practices" [Civil Engineer].

Thus workers' attitude and behaviour continue to be an issue with H&S management. This may be attributable to several factors such as the casualization and the temporary nature of employment of workers. Such a situation often creates a gap between firms and workers which prevents effective extension of internal safety practices to these workers.

CONCLUSIONS

This study has provided insight into the H&S management practices by Vietnamese contractors. Within three of the key elements of H&S management (i.e. policy, organising for H&S, and risk assessment) the findings suggest that there is a lower level of implementation of practices in the areas of organising for H&S and risk assessment especially amongst small and medium size contractors as the vast majority (i.e. 83.4%) of the participating companies are small and medium size contractors. The practices with low levels of implementation therefore need to be carefully considered in order to contribute towards improvement in the poor H&S performance in the Vietnamese construction industry. Also the poor attitude and behaviour of workers towards H&S need attention to promote H&S improvement. By highlighting the practices that have a low and moderate level of implementation and also by flagging H&S attitude and behaviour as being an issue, the results of this study could prompt relevant state authorities to design training and awareness programmes to help improve these areas of concern. However, as the findings only reflect the situation in Northern Vietnam, further study is required to cover the Southern part to provide a more comprehensive picture of the status of H&S management amongst contractors in Vietnam.

REFERENCE

Agumba, J., Pretorius, J.H and Haupt, T. (2013) Health and safety management practices in small and medium enterprises in the South African construction industry. Acta Structilia 2013, 20(1), pp 66-88.

Boyle. T. (2008) Health and Safety: Risk Management, 3rd edition, IOHS Services Limited Publishing.

BSI (2007) BS OHSAS 18001:2007 Occupational health and safety management systems - Requirements. London: BSI.

BSW (2008) Report 2007 Occupational Accident Situation. See http://www.antoanlaodong.gov.vn/Reports-Statistics/Reports_Statistics/Report_2007_occupational_accident_situation/ (accessed 17/05/2010).

Cheng, E.W.L., Ryan, N and Kelly, S (2012) Exploring the perceived influence of safety management practices on project performance in the construction industry. Safety Science, 50 (2), pp. 363–369

Denscombe, M. (2007) The good research guide, 3rd edition. McGraw-Hill Education.

Duc, T. (2014) An Toan Lao Dong Tai Cac Cong Trinh Xay Dung Bi Xem Nhe (translation: Occupational safety in construction work was overlooked), Available online at http://congannghean.vn/phap-luat/201403/an-toan-lao-dong-tai-cac-cong-trinh-xay-dung-con-bi-xem-nhe-461852/ (translation available at http://tinyurl.com/osoukl3) , Access on 18 April, 2014.

Fabiano, B., Curro, F. and Pastorino, R. (2004) A study of the relationship between occupational injuries and firm size and type in the Italian industry. Safety Science, 42 (7), pp.587-600.

Fellows, R. & Liu, A. (2008) Research Method for Construction. 3rd edition. West Sussex: Blackwell Publishing.

Fewings, P. (2013) Construction Project Management – An Integrated Approach, 2nd ed. Routledge Publishing.

Gallagher, C. (1997) Health and Safety Management Systems: An Analysis of System Types and Effectiveness, National Key Centre in Industrial Relations, Monash University - Melbourne Publishing.

Gibb, A.G., Haslam, R.A., Gyi, D.E., Hide, S., Hastings, S. and Duff, R. (2002) ConCA-Preliminary results from a study of accident causality. In: Rowlinson, S. (ed.) Proceeding of Triennial Conference CIB W099, May 2002. University of Hong Kong, Hong Kong.

Griffith, A., and Howarth, T. (2001) Construction Health and Safety Management. Longman Publishing.

Hämäläinen, P., Saarela, K. L. and Takala, J. (2009) Global Trend According to Estimated Number of Occupational Accidents and Fatal Work-Related Diseases at Region and Country Level. Journal of Safety Research, 40(2), pp.125–139.

Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, D.E., Pavitt, T., Atkinson, S. and Duff, A.R. (2005) Contributing factors in construction accidents. Applied Ergonomics, 36(4), pp.401– 415.

Hinze, J., Hallowell, M. and Baud, K (2013) Construction-Safety Best Practices and Relationships to Safety Performance. Journal of Construction Engineering and Management, 139 (10).

HSE (1997) Successful health and safety management - HSG65, 2nd edition. Suffolk: HSE Books.

HSE (2013) Managing for health and safety- HSG65, 3rd edition. Suffolk: HSE Books.

HSE (2014) Health and Safety Statistics 2013/14. Health and Safety Executive. Available at http://www.hse.gov.uk/statistics/overall/hssh1314.pdf [accessed 19 December 2014]

ILO (2001) Guidelines on occupational safety and health management systems, ILO-OSH 2001. Geneva: ILO.

Kheni, N.A., Dainty, A.R.J and Gibb, A. (2008) Health and safety management in developing countries: a study of construction SMEs in Ghana, Construction Management and Economics, 26(11), pp. 1159-1169.

Lancaster, R., Ward,R., Talbot, P. and Brazier, A., (2003), Costs of compliance with health and safety regulations in SME's, HSE publishing.

Lingard, H. and Rowlinson, S. (2005) Occupational Health and Safety in Construction Project Management. Spon Press Publishing.

Mai, P. T. and Van, L. H. (2012) Vietnam country report. In: 18th Asiaconstruct Conference, 10-11 October 2012, Marina Bay Sand, Singapore. Asiaconstruct Conference.

Manu, P. (2012) An investigation into the accident causal influence of construction project features, PhD thesis. School of Technology, University of Wolverhampton.

Manu, P., Ankrah, N., Proverbs, D., and Suresh, S. (2013) Mitigating the health and safety influence of subcontracting in construction: The approach of main contractors. International Journal of Project Management. 31(7), pp. 1017–1026.

Manu, P., Ankrah, N., Proverbs, D. and Suresh, S. (2014) The health and safety impact of construction project features. Engineering, Construction and Architectural Management, 21 (1), pp. 65-93.

MOLISA (2008) Health and Safety State in Construction Industry. MOLISA, Hanoi, Vietnam.

MOLISA (2012) National Programme on Occupational Safety and Occupational Health in Period of 2011- 2015. MOLISA, Hanoi, Vietnam.

MOLISA (2014) Accident report 2013. MOLISA, Hanoi, Vietnam.

Pham, H.D (2002) Employment Law 2002. Labour Press, Hanoi, Vietnam.

Royal Society of Chemistry (2014) Occupational health and safety management systems. Royal Society of Chemistry.

Tutesigensi, A and Phung, B.N. (2011) Vietnamese construction workers' attitude to health and Safety Management. Proceedings of the Institution of Civil Engineers Management Procurement and Law, 164(1), pp.41–47.

AN EXPLORATORY STUDY INTO PROMOTING CONSTRUCTION HEALTH AND SAFETY IN GHANA THROUGH PUBLIC WORKS PROCUREMENT

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The construction industry is commonly associated with high or increasing levels of work-related hazards with ensuing injuries and fatalities. Studies have shown that procurement can further promote good construction H&S practice as it occurs throughout the life cycle of a project. However, the use of procurement as an instrument to promote H&S practices in construction has received little attention till date especially in developing countries. For this reason, the research aimed to explore practical measures to improve construction H&S through public works procurement in Ghana. Qualitative data was collected through semi-structured interviews. Seven respondents (procurement managers, consultants and Quantity surveyors), selected through a non-probabilistic purpose sampling from public institutions participated in the survey. In Ghana, the Public Procurement Act, Act 663 which was introduced in 2003 to ensure sanity and value for money in public procurement provides guidelines for the procurement of public works. In view of this, a case study of the H&S management of project procured using the Act 663 was also carried out. This was done to ascertain how public works is carried out in the Ghanaian public sector setting by determining the various stakeholders involved, the processes the project underwent and the various considerations looked at especially under H&S. The results however indicated that the Act 663 has no clause that addresses construction H&S. The paper also finds that, H&S does not form part of the criteria for evaluating tenders. To address the constraints so as to improve upon construction H&S, certain recommendations are offered. These include the inclusion of non-ambiguous H&S requirements as criteria for evaluating tenders and the pricing of H&S items in bills of quantities. Additionally, practical measures to improving construction H&S in Ghana at the key stages of works procurement are also provided. It also includes the specific roles and involvements of other stakeholders in the procurement process.

Keywords: Ghana, Heath and Safety, Public Procurement, Public Procurement Act.

INTRODUCTION

Health and safety (H&S) has become a major concern to governments and private individuals. As a result, there have been efforts all over the world to promote H&S especially H&S at work. The International Labour Organisation (ILO) estimates that 6,300 people die every day as a result of work-related diseases and injuries which is more than 2.3 million deaths per year (ILO, 2013).

The construction industry is not left out of this plague. H&S is a major concern for the construction industry (Hislop, 1999; Teo et al., 2005). About 60,000 fatal accidents occur on construction sites around the world every year (Wells and Hawkins, 2011). In 2005, the industry was the special focus of the World Day for H&S (ILO, 2005). This is because the industry is largely labour intensive and

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employs a large number of people such as contractors, architects, engineers and labourers, and these construction workers are involved in an inherently dangerous occupation because of the potential for exposures to multiple hazards (Lew and Lentz, 2010).

Why is H&S an issue for procurement to consider? According to Hawkins and Wells (2011), procurement procedures can further promote or inhibit good Occupational Health and Safety (OHS) practice. If the government at all levels, integrates H&S into all the stages of the procurement process, contractors will need to demonstrate their abilities to meet those requirements.

Research problem

In many developing countries (including Ghana), accurate statistics of injuries and fatalities in the construction industry are hard to come by because many of these accidents go unreported (Boakye et al., 2010). Nevertheless, the available statistics in some of these countries underscore the evidence that the construction industry is fraught with hazard and risk (Fugar et al., 2010). In the Ghanaian construction industry for example, the rates of accidents have been increasing steadily every year as indicated in table 1. In 2004, the number of accidents was 8 and this rose to 28 in 2009 (250%).

Table 1: Number of Fatal Construction Accidents from 2004 to 2009 (Boakye et al, 2010)

Year	Number of Accidents Per Year	Index
2004	8	100
2005	21	362.5
2006	29	362.5
2007	20	250
2008	30	375
2009	28	350

In developed countries, there are efficient, independent bodies in charge of H&S at the workplace, for example, the Health and Safety Executives (HSE) in the United Kingdom. Such bodies do not only enforce H&S laws, but also prosecute employers or companies when the laws are breached. That is not the case in Ghana. Ghana, like many other developing countries, cannot boast of any comprehensive national H&S policy (Bruce, 2009). Meanwhile the country is geared towards industrialization as one of the fastest growing economy of the world (Solari et al., 2012) especially after the recent oil discovery. A report by the Ghana Health Service in 2007 indicated that, Ghana's challenge of mainstreaming Occupational H&S (OHS) practices in its national developmental agenda is certainly mitigated by lack of national OHS policy. Though the nation has different agencies under different jurisdictions which monitor different industries for workplace and employee H&S including the Department of Factories Inspectorate (DoFI), there is no national body, policy nor process that govern occupational H&S in Ghana. The problem is not so much as the lack of H&S laws or policies. In the absence of these laws, the existing laws should deal with the situation. One of such laws that can greatly help improve H&S standards in the country is the Public Procurement Act, Act 663. To address the issue of in the procurement of works in Ghana, it is imperative to look at how the procurement Act addresses issues of H&S in the procurement of works and to explore the changes necessary to improve the present situation. The paper aims to explore practical measures to improve construction H&S through public works procurement in Ghana. The study focuses on only public works procurement.

UNDERSTANDING GHANA'S CONSTRUCTION INDUSTRY

Procurement can be classified into public procurement and private procurement. Public procurement generally refers to the use of public or state funds to purchase goods, services and works. Brammer and Walker (2007) pointed out that public procurement is a significant phenomenon which is understudied

Procurement of construction contracts in Ghana alone consumes over 60% of the National Budget Expenditure according to the Public Procurement Authority in 2010. Therefore, an efficient system could ensure value for money in government expenditure which is essential to a country facing enormous developmental challenges (Ameyaw et al., 2012).

The construction industry holds the key to the development of the nation through the provision of employment opportunities, and also its contribution to the nation's GDP. The African Economic Outlook (2012) report notes that the industry contributes 8.6% to the total gross domestic product (GDP) of Ghana and employs over 1.4% of the country's labour force. The sector has grown significantly from around 4.5% of GDP in the 1980s to become one of Ghana's most important industries. The Economic Outlook Report (2013) described the construction sector as one of the sectors that have sustained the industrial sector of Ghana. According to Ashiboe-Mensah (2012) and Agbojah (2008), the stakeholders in the Ghanaian construction industry are as follows: the client (GoG Agencies and ministries, corporate organisations and individuals), the project execution team which involves the design and construction teams, end-users and financiers.

In Ghana, the growth of construction has led to the increasing severity of risks on construction sites (Kheni et al., 2008). Laryea and Mensah (2010) reported that, there is a lack of strong and appropriate H&S legislation for governing construction work and site operations in construction in Ghana. They identified two(2) Acts in Ghana (the Labour Act, 2003 and the Factories, Offices and Shops Act, 1970) that provide some form of regulatory instruments for ensuring H&S on construction sites. However, these are not strongly enforced and many contractors are not even aware of their H&S obligations under these Acts. Regulatory bodies responsible for ensuring compliance are not properly resourced to carry out their statutory responsibilities under the two legislations. This depicts that there is a big problem with construction H&S in Ghana. Most workers interviewed in the course of the study indicated that injuries and accidents are common on sites and often they have to go through long periods of frustration and pleading with employers before they are provided with their some form of compensation for injuries and accidents (Laryea and Mensah, 2010). Accident statistics show that, construction accounted for 1,108 out of a total of 6,064 accidents reported to the Labour Department in 1975. This translates into 18% of accidents in the country's occupational setting and over 1,500 accidents per 100,000 workers. Again, out of the claims reported, only 10% were settled, amounting to 150,000 US Dollars (Kheni et al., 2010).

INTEGRATING H&S INTO WORKS PROCUREMENT

According to the Victorian government (2010), there are a number of profitable benefits associated with including H&S principles into procurement which are improved productivity, reduced costs, innovation in design and construction, and better estimation and management of production and operational costs over the lifecycle of the project. Wells and Hawkins (2011) assert that many measures are needed to improve OHS, including an appropriate legal framework, an effective inspectorate, training of workers and supervisors, restrictions on working hours and wide availability of occupational health services. If these other measures are in place, procurement procedures and contract documents have the potential to act as important mechanisms to remind the parties to the contract of their obligations under the law. When these other measures are lacking, an appropriate use of procurement procedures and contract documentation has the potential to raise the standard of OHS on individual projects. Hence procurement is a direct way for clients and donors to make a real difference to OHS in their area of influence (ibid). Wells and Hawkins (2011) argued two reasons why OHS is a serious issue to consider during the process of works procurement. First; H&S legislation is increasingly holding clients responsible for the H&S of the workforce on their construction projects. This responsibility may to some extent be passed on to consultants and to contractors and subcontractors. Hence the terms on which these services are procured are critical in ensuring that the responsibility is taken seriously by all parties and that the interests of the client are safeguarded.

Second; while it is often argued that the monitoring and enforcement of H&S regulations is the responsibility of regulatory authorities, the large number and wide dispersion of construction sites means that it is practically impossible to inspect all. In this context the procurement process and the terms and conditions of the contract can be seen as complementary mechanisms for ensuring compliance with existing legislation and/or the terms and conditions of project finance. The Government of Australia (2006) revealed that certain considerations are required to integrate H&S into procurement. The considerations needed are principles, processes and application. The principles and processes refer to the reasons and steps respectively for considering H&S in procurement. It is relevant to note that, a considerable number of studies have been carried out on this topic in developed countries. However, there is still a knowledge gap on how procurement can help to improve H&S in developing countries more specifically Ghana.

RESEARCH METHOD

Semi structured interviews were conducted with seven respondents who are involved in construction procurement from the following public institutions: the Kumasi Metropolitan Assembly (KMA), Public Procurement Authority (PPA), Urban Roads Department (URD), KNUST, Architectural and Engineering Service Limited (AESL) and Building, Roads and Research Institute (BRRI). Participants were chosen based on their experience and expert knowledge in the field of study. The study adopted a non-probabilistic purposive sampling in selecting the respondents for the interview. The reason for using purposive sampling lies in the selection of information-rich cases, with the objective of yielding insight and understanding of the phenomenon under investigation. The average tenure of the respondents in the industry is nine years and all of them have a Bachelor's degree or higher. The interviews took place face-to-face between the researcher and the respondents. The interviews were audio taped and on the average took between 30 to 45 minutes. Documentary analysis of a project procured using Act 663 was also carried out which involved the examining of documents, specifically tender and contract documents, site report minutes and tender evaluation report from the assembly and juxtaposed with a model for integrating H&S into procurement. This is to highlight the limitations of the Act 663 with respect to H&S.

Interview data were transcribed verbatim and then sorted into themes. The items that were identified as themes were items that captured something important about the data in relation to the research objective and their relevance was not based on their prevalence within the dataset (Braun and Clarke, 2006). The themes are: a) H&S provisions in the PPA Act 663, b) H&S challenges in the Procurement of works, c) Incorporation of H&S into the procurement process and d) Stakeholders' roles in promoting H&S in the procurement process.

RESULTS AND DISCUSSION

DOCUMENTARY FINDINGS

Documents analysed revealed the following: At the planning stage no H&S considerations were made. At design stage H&S considerations were made for only the end-users of the building and not the construction workforce. Potential contractors were not involved in the design stage. At the tender stage H&S did not form part of criteria for evaluating tenders. General clause in the conditions of contract placing all H&S obligations on the contractor at the contract stage. During construction, regular site meetings were carried out in accordance with the Act 663 but H&S did not form part of the discussion. Inspections out were solely for inspecting work done. There was no H&S report. At the post evaluation stage, financial audits were carried out but no audit was done on H&S

INTERVIEW FINDINGS

Limitations of Act 663 with respect to construction H&S

The Act 663 enacted in 2003 has established guidelines, principles and tender committees to take charge of its objectives, it is however not clear in addressing issues of health safety. This study therefore sought to outline the limitations of the Act with respect construction H&S. The emerging themes under the limitations are: H&S challenges that associated with the procurement of works and adequacy of H&S provisions in the Act 663.

H&S Provision in the Act 663

In response to the question “Does the Public Procurement Act address H&S issues in the procurement of works? How?”, all the respondents mentioned that there is no specific aspect of the Act 663 that gives details on H&S of issues in the procurement of works.

“I don't know of any specific H&S provisions in the Act.” (KNUST)

This confirms what was reviewed from literature that, there is no specific clause or section in the Act 663 that addresses H&S. A study by Amponsah-Tawiah and Dartey-Baah (2012) revealed that, the governments of Ghana, past and present, have not shown any political will, commitment and support for bold occupational H&S policies. The neglect of H&S provisions in the Act 663 is a barrier that affects H&S in the procurement of works as it does not make H&S mandatory.

“It is mostly donor-funded projects that insist on H&S measures in works procurement. For example, World Bank always talk about what we call the safeguards. Aside that, there isn't anything embedded in our construction procurement laws.” (KMA)

The results above indicate that there is a need to strengthen efforts to promote construction health and safety in the procurement of works. The Act 663 lacks portions on construction health and safety and needs to be amended to include a health and safety clause or provision in order health and safety mandatory.

Challenges Associated With H&S on Works Procured Under the PPA Act 663

As to the question on the H&S challenges associated with works procured under the PPA Act 663, the respondents raised the issues of inadequate enforcement and monitoring, training and inadequacy of the H&S laws as illustrated in the following quotations.

“H&S issue is a challenge in terms of implementation because it is not contractual.” (BRRI 1)

“The challenge has to do with enforcement, training and education. We are not doing much as a nation.” (KNUST)

This confirms the findings of Akorsu (2013), Kheni et al., (2008) and, Laryea and Mensah (2010) who revealed that, H&S regulations are not strongly enforced and many contractors are not even aware of their H&S obligations under these Acts. Akorsu (2013) stated that, “we tend to have fine laws, we tend to ratify labour standards as quickly as they are adopted by the ILO but we hardly enforce these.”

The respondent from PPA however mentioned that the challenge has to do with cost associated with H&S as seen in the quote below:

“There is a challenge of cost rising as a result of inclusion of H&S measures.” (PPA)

This confirms the findings of Wells & Hawkins (2011) who revealed that, improved H&S in construction comes with a cost. According to the researchers, the cost estimated in improving H&S is however less than the cost of lost time due to accidents.

The results indicates that making rules and regulation relating to health and safety of workers is one step ahead of causing a positive change in the sector but it does not end there. Going further to implement it; that is making sure individual contractors and consultants strictly adhere to these rules and regulations will make much of a difference in ensuring health and safety of workers.

Incorporating H&S into the various stages of Procurement

There are some specific processes that respondents mentioned that need to be followed when integrating H&S into procurement process. These processes are planning stage, design stage, tender stage, and tender evaluation, award of contract, construction stage and then evaluation (post).

Below are snippets of comments and views shared by respondents in relation to the various construction stages.

Planning stage -

"….. H&S will be considered through budgetary allocation. This means that the cost of construction will go up a little. For whatever the contractor does, he has to be paid and it's going to increase his preliminaries a little." (AESL)

"Thorough investigation to determine how risky the project is, H&S issues involved. And this could help those carrying out the documentation to know exactly what they need to incorporate in their documentation." (KNUST)

These are in line with the findings of the Government of Australia (2006) and Charles et al. (2007) who suggested that risk assessment, assigning of responsibilities is necessary at the planning stage in order to prevent accidents. Also it is emphasized that risk assessment carried out should be recorded in a register, out of which a H&S plan is developed and carried through tender (Wells and Hawkins, 2011).

Design stage -

"Design stage is involves putting together drawings Bills of quantities. Capture whatever H&S measure you envisage and incorporate it into the drawings and tender documents."(BRRI 2)

"At this stage ask yourself the type of safety measures that will be needed... Your designs must not conflict with the use of these equipment."(PPA)

Many H&S challenges encountered at the construction stage could be avoided if due consideration and effort was put into the planning and design stage (Charles et al., 2007; Hawkins and Wells, 2011).

Tender stage -

"H&S should be a pre-requisite in evaluating the tenders." (AESL)

"All stated conditions for the award of contract or for a firm to qualify must be strictly adhered to during evaluation….Awards should not be based on cost alone."(PPA)

The suggestions of the respondent from PPA are in conformity to the work of Wells and Hawkins (2011) who suggest that, per the rules of World Bank, contracts should be awarded to the 'lowest evaluated tender'. However, if a contractor fails to meet the requirements of the client in terms of H&S, the tender should be rejected as invalid or non-conforming even though his price may be lower.

Contract stage -

"You've set the rules so you go strictly by the requirement set in the tender document to evaluate them. Those who meet the requirements are then selected for the award." (KNUST)

Construction stage - All the respondents deemed the construction stage as a very important stage, as it is the stage where all the paper work done in the previous stages of procurement on H&S is implemented or actualizes.

"This is the implementation stage. At this level, there should be some inspectors, who will go round to make sure that, what is stated in the documents you've signed is provided for." (BRRI 2)

"This is where you make sure that the contractor complies with whatever provisions concerning H&S on the ground, and everything that has been indicated to promote H&S must actualise on the project site." (PPA)

Post evaluation stage -

"As-built drawings should be provided at the completion of the project by consultants. H&S manuals must also be provided as to how the building should be used. Accidents should be recorded."(AESL)

The respondent also suggested that, records of accidents should be kept by policy. This will serve as a yardstick or reference point in another project. Some also suggested that H&S audits should be carried after the project has been completed as illustrated in the following comment:

"H&S audits must be carried out before and after the project." (URD)

Wells and Hawkins (2011) advised that audits carried out after the completion of the project should not only be financial but also on H&S.

RECOMMENDATIONS AND CONCLUSIONS

The findings revealed the following: First, the Act 663 was not explicit on the issue of H&S. Secondly, H&S does not form part of the criteria for evaluating tenders. Also H&S audit is carried out before, during and after the project. There is also the use of traditional approaches where design is split from construction. This does not encourage contractor participation in the project. Lastly, there are also challenges with supervision, enforcement and monitoring of H&S measures.

To promote construction H&S at the various stages of procurement, the study recommends the following as indicated in Table 2. The recommendations are based strictly on data analysed.

Table 2: A Simplified Layout of Integrating H&S into the Stages of Construction Procurement.

Stages of Procurement	H&S considerations
Planning stage	- Scope the project. - Carry out risk assessment of the project to determine H&S issues involved. - Determine who to bring on board.
Design stage	- BOQ's to include itemised provision of H&S, architectural drawings which are H&S friendly. -Safe method statements.
Tender stage	- Inclusion of H&S as a requirement for evaluating tenders. - Evaluating and awarding tenders based on criteria set which includes H&S.
Contract stage	- Include health and safety clause in the contract. - Clearly defined roles and responsibilities of parties especially in the area of H&S.
Construction stage	- Carry out regular site visits. - Effective monitoring and supervision to ensure compliance. - Require monthly H&S reports.
Post Evaluation stage	- H&S audits should be carried out in addition to the financial audits after the completion of the project.

To address the limitations of the Act 663 in addressing construction H&S, it is recommended that H&S issues should form part of the requirements for evaluating tenders. Again, the Public Procurement authority could also amend the law to include a clause in the Act 663 specifically on

H&S. The PPA has Standard Tender Documents which most public institutions use. H&S items must therefore be priced and captured under the preliminary section of the bill of quantities of the tender document. Laws alone may not ensure effective H&S. A collaboration between all the parties involved in the process is therefore essential. Potential contractors must also be encouraged to participate in the design process to bring their expertise to bare on a project. H&S performance targets on all projects irrespective of the scope. Again, the GhIS, GIA, GIE, who form the professional body in construction in Ghana must champion the discipline of construction H&S in Ghana on sustained basis by providing training on H&S and certification of construction professional, and the establishment of codes of practice. Lastly, the Government of Ghana should equip the Department of Labour and the Department of Factories Inspectorate with the needed resources to strengthen the monitoring and enforcement of H&S laws.

The overriding importance of human life and health suggests that any project which is completed in accordance to its cost, quality and time objectives, but fails to fully ensure the H&S of the people associated should probably be regarded as a failure (Honu et al., 2013). Literature reviewed clearly shows that procurement is an important tool that can be used in achieving social objectives, in this case H&S. Therefore a successful integration of H&S in public works procurement is of benefit to the government, client, contractor and employees (workforce) as it will help minimize construction accidents, enhances contractor's corporate's image, and also help in savings on cost. The nation as a whole saves on cost since as an accident free site will help minimize the payment of compensations.

A follow up study into the private sector of Ghana's construction industry is proposed. The proposed study will adopt a similar methodological approach with the hope of generating results that are comparable to findings presented in this paper. Comprehensive recommendations can thus be made for the private sector of the country in relation to the integration of H&S practices as requirements for the procurement of works in construction.

REFERENCES

Akorsu, A. D. (2013) Labour Standards Application along Value Chains in Ghana: Reality Check and Policy Option Economics and Management of Networks Conference, Robinson Hotel and University Ibn Zohr Agadir, Morocco.

Ameyaw, C., Mensah, S. and Osei-Tutu, E. (2012) Public Procurement in Ghana: The Implementation Challenges to the Public Procurement Law 2003(Act 663). International Journal of Construction Supply Chain Management, 2 November, Volume 2, 55-56.

Ashiboe-Mensah, N.A. (2012) Photovoltaic Adoption in the Ghanaian Building Industry: Perceptions and Relational Dynamics of Innovation Adoption Decision Factors. Ph.D. dissertation, Kwame Nkrumah University of Science and Technology, Kumasi.

Boakye, N.A., Fugar, F.D.K. and Akomah, B.B. (2010) Ensuring the Health and Safety of Ghanaian Construction Workers by Decentralised Government Agencies: An Exploratory Study In: Laryea, S., Leiringer, R. and Hughes, W. (Eds) Procs West Africa Built Environment Research (WABER) Conference, 27-28 July 2010, Accra, Ghana, 295-304.

Brammer, S., and Walker, H. (2007) Sustainable Procurement Practice in the Public Sector: An International Comparative Study. University of Bath School of Management Working Paper Series.

Braun, V. and Clarke, V. (2006) Using Thematic Analysis in Psychology Qualitative Research in Psychology, 3 (2), 77-101.

Charles, M., Pillay, J. and Ryan, R. (2007) Guide to Best Practice for Safer Construction: Literature Review, From Concept to Completion. Icon.Net Pty Ltd.

Government of Australia (2006) Guidance on Occupational Health and Safety in Government Procurement.

Hislop, R. D. (1999) Construction Site Safety: A Guide for Managing Contractors. Illustrated. Taylor & Francis Group.

Honu, M., Laryea, S. and Smallwood, J. (2013) Conceptual Model for Integrating Health and Safety into Construction Procurement in Ghana. Accra, Ghana. Procs 5th West WABER conference.

International Labour Organization (2013) Safety and Health at Work. Available at: www.ilo.org/global/topics/safety-and-health-at-work/long--en/index.htm [Accessed 12-09-2013].

International Labour Organization (2005) World Day for Safety and Health at Work: A Background Paper. International Labour Office, Geneva.

International Labour Organization (2003) Safety in Numbers; Pointers for Global safety at work.ILO publications, Geneva.

Laryea, S. and Mensah, S. (2010) Health and Safety on Construction Sites in Ghana. Dauphine Université, Paris, COBRA (The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors).

Kheni, N. A., Dainty, A. R. and Gibb, A. G. (2008) Health and Safety Management in Developing Countries: A Study of Construction SME's in Ghana, Construction Management and Economics, 26(11), 1159-1169.

Kheni, N. A., Gibb, A. G. and Dainty, A. R., (2010) Health and Safety Management Within Small and Medium Sized Enterprises (SMEs) in Developing Countries: Study of Contextual Influences. Journal of Construction Engineering and Management, 136(10), 1104-1115.

Public Procurement Act, Act 663, 2003

Solari, G., O'Maonaigh N., Hesp, C., Sanchez, M., and Gutierrez, G. (2012) The Second Fastest-growing Economy in the World in 2011. Worldfolio (September 2012). A United World Supplement. Available at: http://www.worldfolio.co.uk/region/africa/ghana/joseph-samuel-annan-deputy-minister-of-trade-ghanan1589#sthash.FmoDpEYB.dpuf [Accessed 22-02-2014]

The Government of Australia, (2010) Health and Safety in Construction Procurement. A Handbook for the Public Sector. Edition 1.

Wells, J. D. and Hawkins, J. (2011) Promoting Construction Health and Safety through Procurement: A briefing Note for Developing Countries. Procs of the ICE-Management, Procurement and Law. 1-12.

ENGAGING WORKERS: BUILDING ON THE FOUNDATIONS OF WORKER INVOLVEMENT

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Involving construction workers in the day-to-day management of health and safety, such as involving them in risk assessments, can improve health and safety performance and is legally required in many jurisdictions. Construction companies may therefore already use worker involvement as one foundation for maintaining and improving health and safety performance. Sometimes these practices are referred to as worker engagement.

Engagement can also be viewed as a continuum of approaches, one of which is worker involvement. In this model, involvement is a stepping stone to higher levels of engagement. The aim of this paper is to examine how a construction company can work towards higher levels of engagement and what changes this might promote in health and safety performance. A literature review was undertaken in the fields of health and safety, organisational psychology and human resource management.

In the latter two disciplines, engagement refers to the thoughts and feelings of workers that direct them to behave in ways which support their organisation and its goals. Higher levels of engagement are realised when organisations care for workers' wellbeing, provide positive working conditions and use positive leadership practices.

High levels of engagement are associated with a number of organisational benefits which may extend to improved health and safety performance. There is a need for further research to understand the nature and extent of those improvements and whether construction companies should invest time and money to build on a foundation of effective worker involvement. As a minimum, they could seek to develop supervisors' and managers' soft skills.

Keywords: Construction, Engagement, Involvement, Safety, Worker

INTRODUCTION

Health and Safety legislation in various parts of the world (e.g. Australia, South Africa and most EU states) give workers the right to be informed about the dangers posed by their work and workplace and to influence how those hazards are managed (Safe Work Australia 2011, The Council of the European Communities 1989, The South African Department of Labour 2004).

In these countries, this manifests as a statutory duty on employers to consult with employees on matters of health and safety. Legislation, or associated guidance, sometimes extend the duty to consult and give workers other, practical opportunities to exert influence. For example, in the UK,

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employers are advised to involve workers in the risk assessment process (Health and Safety Executive 2014).

Organisations also seek to engage workers to improve health and safety performance (The European Agency for Safety and Health at Work 2012). 'Involvement' and 'engagement' can be used interchangeably in day-to-day speech. The Oxford dictionary (pg. 581) gives various definitions of 'engage' including "involve someone" and "to participate or become involved in." Academic papers have therefore used worker involvement in health and safety as one measure of employee engagement (Cheyne et al. 2013, Frazier et al. 2013). Dromey (2014) agrees that involving workers, and giving them a voice, is an important component of worker engagement.

Concepts of worker involvement and engagement are integral to health and safety management in the UK construction industry. For example, the Olympic Delivery Authority, the body responsible for creating the infrastructure for the 2012 Olympic Games, "recognised that effective consultation and engagement was a fundamental mechanism for achieving high standards of health and safety throughout the programme" (Healey and Sugden, 2012: 19).

The Construction (Design and Management) Regulations 2015 impose a statutory duty on Principal Contractors in the UK to consult and engage with their workforce (HSE 2015). The associated guidance discuss the important of involving workers in taking decisions about health and safety.

Rudd et al. (2006) conceptualised engagement as a continuum of different approaches: Inform - Consult - Involve - Collaborate - Empower. It is self-evident that simply informing workers that a deep excavation is about to commence will produce different levels of engagement and different outcomes compared to actively involving those workers in assessing the risks and impact on adjacent construction activities.

The purpose of this paper is to examine how construction companies might go beyond worker involvement in order to achieve higher levels of worker engagement and what the health and safety consequences might be.

METHODOLOGY

A literature review was performed using the Summons 2.0 database. This is a 'federated search' or 'meta search' facility and has the ability to reveal abstracts from sources that are not 'content partners' (Way 2010). However, it was found that research papers commissioned by the HSE were not available through this database and a specific search was performed on the HSE website (www.hse.gov.uk).

The use of the search term "employee engagement" returned an unmanageable number of articles (8711), including many drawn from grey literature. The Summons 2.0 database allows for numerous refinements to the search criteria. A search strategy was devised to increase the relevancy, currency and credibility of the articles returned.

Scholarly and peer-reviewed journal articles, published since 01/01/2010, were obtained from relevant disciplines. The search terms used and the total number of articles returned are shown in Table 1, below.

Table 1: Articles returned in Summons 2.0 by the search strategy

	Articles Returned
“employee engagement” safety	524
“worker engagement” safety	65
“worker involvement” safety	115
"employee involvement" safety	595

Articles were reviewed if they were available in English and were academic or scholarly articles referring to occupational health and safety within the abstract. Research sponsored by the HSE was also included. Articles were not included if they were from the body of grey literature.

Forward and backward chaining (Booth 2008) was also utilised and uncovered a number of additional, relevant articles. Earlier articles were also included if they helped explain the concepts and outcomes of worker involvement and engagement. Some of these articles were found in the body of grey literature but were so frequently cited that they have been included.

WHAT IS ENGAGEMENT?

Defining engagement is not a straightforward proposition. In their report to the UK Government, MacLeod and Clarke (2009) found over 50 definitions in use.

Within the fields of organisational psychology and human resources, there are fundamental disagreements about whether engagement describes what we do to our workers or how those workers respond (Truss et al. 2013). That response could be cognitive (e.g. intentions to stay with a company), behavioural (e.g. being an advocate of the company) or affective (e.g. feeling motivated and empowered at work) (MacLeod and Clarke 2009, Welch 2011). Truss et al. (2013) describe employee engagement as a ‘contested construct’.

None of these debates are particularly helpful for practitioners and researchers who may be considering the utility of worker engagement in improving safety outcomes (Fidderman and McDonnell 2010).

Shuck and Wollard (2010: 103) have synthesised a ‘working definition’ of engagement from the existing literature, and it will be adopted in this paper:

An individual employee’s cognitive, emotional, and behavioral state directed toward desired organizational outcomes.

If this definition is examined alongside the typology proposed by Rudd et al. (2006), it is possible to surmise that managers who simply inform workers of changes and issue instructions will generate limited changes in worker's perceptions about their work or employer. This approach would generate low levels of engagement. Involving, consulting and collaborating with workers may generate more notable changes in their thoughts, feelings and behaviours. It would be beneficial to examine these approaches before investigating how higher levels of engagement may be achieved.

WORKER INVOLVEMENT

The Oxford dictionary (pg. 921) defines involving as causing someone or something "to participate in an activity or situation." When applied to an occupational context, this manifests as giving workers an opportunity to influence their work and their working conditions (Strauss 1998). Involving workers in safety is one factor that contributed to the low accident and incident rates achieved during the ‘big build’ of the London Olympic Games 2012 (Lucy et al. 2011). Worker involvement may be partly predicated on the notion that workers possess valuable insights that employers need in order to maintain standards of safety, production etc.

Mechanisms for involving workers in health and safety include pre-task briefings, joint risk assessments, involving working in safety audits, observations and inspections, worker involvement in accident investigations, and use of near miss and hazard-reporting systems (Fidderman and McDonnell 2010, Frazier et al. 2013, Healey and Sugden 2012, Lucy et al. 2011, Wachter and Yorio 2014).

When workers collaborate in assessing risks and planning safe systems of work, they gain insights into risks and ownership of the controls, making compliance more likely (Vinodkumar and Bhasi 2010, Wachter and Yorio 2014). Fidderman and McDonnell (2010) and Lekka and Healey (2012) concur that collaboration is a key component of effective worker involvement. Collaboration of this sort produces higher levels of engagement than simply asking for opinions or feedback (Rudd et al. 2006).

Low-injury sites are characterised, in part, by the presence of formal health and safety committees in which employee representatives offer to investigate safety problems with management (Geldart et al. 2010). However, worker involvement can also include ad hoc, informal interactions between managers and employees in which information and views can be shared (Marchington 2015).

Put simply, consultation, involvement and collaboration in safety revolve around creating opportunities for workers to share safety-related information (e.g. hazard reporting or pre-task briefings) and participate in day-to-day safety management (e.g. assessing risks or solving safety problems). These approaches draw on and enhance workers' insights to generate better methods and improved organisation of work.

Involving workers in the day-to-day management of health and safety is not only a practical means of improving standards, it is legally required in many jurisdictions.

However, the degree of worker involvement appears to be influenced, in part, by the workers' own perceptions of the priority of safety (Cheyne et al. 2013). This corresponds with experiences in the workplace: Simply providing workers with opportunities to get involved offers no guarantees that they will be used appropriately. As one example, requiring workers to report a minimum number of hazards each month could lead them to find trivial hazards in the first few days of the month, and ignore subsequent and more significant hazards.

To effectively involve workers, and make the process genuinely collaborative, managers need effective ‘soft skills’ (Fidderman and McDonnell 2010, Lekka and Healey 2012). Corrective action and feedback is also needed in response to suggestions and hazard/near miss reports to maintain commitment to these schemes (Fidderman and McDonnell 2010, Lucy et al. 2011, Lunt et al. 2008).

HIGHER LEVELS OF ENGAGEMENT

The effect of engagement

It is worthwhile establishing whether the effort and cost of going beyond worker involvement, and seeking higher levels of engagement, are justified. Organisational benefits include reduced turnover, lower absenteeism, increased productivity and innovation, improved performance and better customer service (Bhuvanaiah and Raya 2014, Harter et al. 2002, MacLeod and Clarke 2009, Wollard and Shuck 2011). This leads to competitive advantages, higher profits, revenue generation and growth (Anitha 2014, MacLeod and Clarke 2009, Xu and Thomas 2011).

Engaged workers may perform core duties to a higher standard and/or undertake discretionary tasks (Christian et al. 2011, Macey and Schneider 2008, Saks 2006) which are known as Organisational Citizenship Behaviours (OCB) (Organ 1988).

Applying these concepts to construction, it is possible to surmise that engaged workers may contribute to defect-free construction and the achievement of production targets. OCB could manifest as workers volunteering for unpopular assignments, working extra hours to finish a task, rejecting offers to work for a rival firm or pro-actively raising potential problems (such as unclear design details).

Engaging workers

Using the definition of engagement proposed by Shuck and Wollard (2010) the practices that create higher levels of engagement are those that clarify the goals of the organisation and create the conditions whereby workers have conducive thoughts and feelings towards the organisation and it's goals.

Without reasonable working conditions, fair pay and work security it is unlikely that engagement will develop, and workers are unlikely to go above and beyond what is strictly required in the formal contract (Shuck and Herd 2012, Wollard and Shuck 2011). In the construction sector, providing reasonable working conditions could start with such basic measures as providing clean and comfortable welfare units.

Engagement is promoted by actively caring for workers' wellbeing and providing a supportive organisational culture, such as providing a good work life balance (Anitha 2014, Rich et al. 2010, Saks 2006, Wollard and Shuck 2011). The construction industry uses practical measures such as offering free health checks (in addition to health surveillance). Clark et al. (2014: 107) propose that "employees who feel that their organisation cares about their wellbeing are likely to return the favour".

High levels of engagement rely on perceptions of trust, justice, psychological safety and protection of psychological health (Kahn 1990, Saks 2006). This may take the form of employee assistance programmes, promotion of a reasonable work-life balance, a zero tolerance approach to bullying and a fair approach to investigations.

When workers share their organisation's vision and values they are more likely to be engaged (Dromey 2014, Wollard and Shuck 2011) perhaps because they understand and identify with the goals of the organisation and find more meaning in their work. Clear management expectations and providing feedback help clarify the organisation's goals and support engagement (Crawford et al. 2014, Wollard and Shuck 2011).

Transformational leadership is associated with engagement as these leaders display many of the preceding qualities (Christian et al. 2011, Macey and Schneider 2008). For example, a transformational style helps workers to identify with their leaders, and by extension their values and goals (Hansen et al. 2014, Hayati et al. 2014).

Engagement is facilitated by developing workers and providing them with personally meaningful work which uses their strengths and encourages autonomy (Shantz et al. 2014, Soane et al. 2013, Wollard and Shuck 2011). This aligns with the view that empowerment represents the highest level of engagement (Rudd et al. 2006), although it is clear that higher levels of engagement depend on much more than empowerment.

Fully autonomous working arrangements are difficult to envisage in the construction industry, where effective co-ordination and timing of activities are critical. However, a team of workers could determine the health and safety rules and targets for a project and set out how they (and their managers) will achieve this. Reasonable budgets might be delegated to this working party. They could, for example, set up and run a wellbeing or training event. Managers would act more as facilitators and coaches.

These conditions for engagement can be summarised as being positive human resources practices and effective, perhaps innovative, leadership approaches.

Engagement and health and safety outcomes

A meta-analysis revealed a significant relationship between engagement of business units (as measured by the Gallup Workplace Audit) and a range of beneficial outcomes, including fewer lost workdays due to accidents (Harter et al. 2002). Wachter and Yorio (2014) found that worker engagement significantly predicted the number of recordable and lost time incidents.

Improved core task performance is one behavioural outcome of engagement (Saks 2006). It may improve safety outcomes by manifesting as higher levels of attention to health and safety risks, error traps and procedures and ultimately lead workers to avoid or adapt unsafe working practices and comply with safe working procedures (Nahrgang et al. 2011, Wachter and Yorio 2014).

Therefore, both worker involvement and worker engagement could lead to better methods of working and improved compliance. This is valuable as a meta-analysis by Nahrgang et al. (2011) found a significant, negative relationship between compliance and adverse events, unsafe behaviours and accidents.

The other behavioural outcome of engagement, citizenship behaviours (Saks 2006), was conceptualised by Nahrgang et al. (2011) as 'safety participation'. This construct only explained 0-25% of the variance of safety outcomes.

Previous studies have highlighted the importance of safety-related citizenship behaviours (e.g. Hofmann et al. 2003). Potentially, these citizenship behaviours could take the form of more enthusiastic and diligent use of worker involvement opportunities (e.g. prompt reporting of hazards). Workers could also challenge co-workers who are working unsafely or take a new starter 'under their wing'.

Some worker involvement tools, such as suggestion or near-miss reporting schemes, encourage workers to pro-actively and voluntarily raise safety issues. However, worker involvement is largely driven by managers' agendas (e.g. asking for worker's insights into the risks and controls associated with a particular activity). A key conceptual difference of higher levels of worker engagement is that it is expected to evoke entirely pro-active and voluntary ideas and behaviours, alongside improved task performance. The highest level of engagement is therefore characterised by people setting their own agenda (Rudd et al. 2006).

No study has investigated the impact of engagement on a range of workers' safety-related citizenship behaviours (as envisaged by Hofmann et al. 2003). A swathe of beneficial behaviours, which might help explain the relationship between higher levels of engagement and improved safety outcomes, may be going 'under the radar'. No studies have investigated the impact of the full range of engagement practices (as envisaged in the literature review by Wollard and Shuck 2011) on safety behaviours.

Worker engagement may be a useful, but largely unexplored, mechanism for influencing safety behaviours and outcomes. It is worthy of further examination.

Barriers to engagement

The absence of engagement practices may just lead to the lack of engagement. However, interviews with workers revealed that when they feel uncared for or work in an aggressive environment, where competition was valued over collaboration, they can become disengaged, ultimately quitting their jobs (Shuck et al. 2010).

Organisations purporting to be "high performance" could promote aggressive management, leading to feelings of fear and anxiety, and cause workers to disengage.

Engagement could slip into unhealthy 'workaholism', and organisations should create the conditions that reduce workaholism (Caesens et al. 2014).

Each worker is a unique individual who will be more or less inclined to be engaged due to their individual personality traits (Akhtar et al 2015) and perceptions of their own worthiness and capabilities (Lee and Ok 2015).

Lee and Ok (2015) suggest that this might influence selection practices (i.e. selecting workers with a natural propensity to become engaged). This may not be a realistic proposal for many construction companies. At the very least it would be valuable to recognise that workers will not respond uniformly to engagement opportunities.

CONCLUSIONS

Worker involvement in health and safety can be a practical process, such as holding pre-task briefings, and is legally required in the UK and many other jurisdictions. As such, construction companies may already be using worker involvement as one of their foundations for effective health and safety management.

Workers who are involved will be, to some extent, engaged. In other words, they are more likely to have positive thoughts and feelings about their organisation, contributing to higher levels of task performance and proactive, voluntary behaviours. Involvement relies on positive leadership practices and a positive regard for the insights and perceptions of the workforce. Consequently, construction companies may benefit from developing the soft skills of supervisors and managers.

If worker engagement is viewed as a continuum, worker involvement is a stepping stone towards higher levels of engagement. These higher levels of engagement rely upon the employer caring for workers' well-being and working conditions. This will largely be driven by an organisation's human resources strategy and will require the organisation exceeding legal, minimum standards of worker welfare, rates of pay etc.

There is insufficient evidence at present to recommend that companies go beyond worker involvement and collaboration to improve health and safety performance. To date, no research has investigated the influence of the full array of engagement practices on safety behaviours, and whether those behaviours include safety compliance and/or safety-related citizenship behaviours. It is also presently unclear whether going beyond involvement makes a significant difference to safety performance. These are potentially interesting areas for future research.

REFERENCES

Akhtar, R, Boustani, L, Tsivrikos, D and Chamorro-Premuzic, T (2015) The engageable personality: Personality and trait EI as predictors of work engagement. "Personality and Individual Differences", 73, 44-49.

Anitha, J (2014) Determinants of employee engagement and their impact on employee performance. "International Journal of Productivity and Performance Management", 63 (3), 308 - 323.

Bhuvanaiah, T and Raya, R (2014) Employee Engagement: Key to Organizational Success. "Journal of Indian Management", October-December 2014, 61-71.

Booth, A (2008) Unpacking your literature search toolbox: on search styles and tactics. "Health Information and Libraries Journal", 25, 313-317.

Caesens, G, Stinglhamber, F and Luypaert, G (2014) The impact of work engagement and workaholism on well-being. "Career Development International", 19(7), 813-835.

Cheyne, A, Tomas, J and Oliver, A (2013) Multilevel Models in the Explanation of the Relationship between Safety Climate and Safe Behavior. "Spanish Journal of Psychology", 16, e54, 1-11

Christian, M, Garza, A and Slaughter J (2011) Work Engagement. A Quantitative Review and Test of its Relation with Task and Contextual Performance. "Personnel Psychology", 64, 89-136.

Clark, O, Zickar, M and Jex, S (2014) Role definition as a Moderator of the Relationship Between Safety Climate and Organizational Citizenship Behavior among Hospital Nurses. "Journal of Business Psychology", 29, 101-110.

Council of the European Communities (1989) Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. Available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0391:EN:HTML

Crawford, E, Rich, B, Buckman, B and Bergeron, J (2014) The antecedents and drivers of employee engagement, in C. Truss, R. Delbridge, K. Alfes, A. Shantz and E. Soane (eds.), "Employee Engagement in Theory and Practice". Oxon: Routledge.

Dromey (2014) "A system of safety management practices and worker engagement for reducing and preventing accidents". London: IPA.

European Agency for Safety and Health at Work (2012) "Worker and representation and consultation on health and safety". Luxembourg: Publications Office of the EU.

Fidderman, H and McDonnell, K (2010) "Worker Involvement in health and safety: what works?". Royal Society for the Prevention of Accidents.

Frazier, C, Ludwig, T, Whitaker, B and Roberts, D (2013) A hierarchical factor analysis of a safety culture survey. "Journal of Safety Research", 45, 15-28.

Geldart, S, Smith, C, Shannon, H and Lohfeld, L (2010) Organizational practices and workplace health and safety: A cross-sectional study in manufacturing companies. "Safety Science", 48, 562–569.

Hansen, A, Byrne, Z and Kiersch, C (2014) How interpersonal leadership relates to employee engagement. "Journal of Managerial Psychology", 29(8), 953-972.

Harter, J, Schmidt, F and Hayes, T (2002) Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: a meta-analysis. "Journal of Applied Psychology", 87(2), 268–279.

Hayati, D, Charkhabi, M and Naami, A (2014) The relationship between transformational leadership and work engagement in governmental hospitals nurses: a survey study. "SpringerPlus", 3:25.

Healey. N and Sugden, C (2012) "Safety Culture on the Olympic Park. RR942." HSE Books.

Hofmann, D, Morgeson, F and Gerras, S (2003) Climate as a Moderator of the Relationship Between Leader-Member Exchange and Content Specific Citizenship: Safety Climate as an Exemplar. "Journal of Applied Psychology", 88(1), 170-178.

HSE (2015) "Managing Health and Safety in Construction: Construction (Design and Management) Regulations 2015. Guidance on Regulations. L153." HSE Books. Available online at: http://www.hse.gov.uk/pubns/books/l153.htm

Kahn (1990) Psychological conditions of personal engagement and disengagement at work. "Academy of Management Journal", 33, 692-724.

Lee, J and Ok, C (2015) Drivers of work engagement: An examination of core self-evaluations and psychological climate among hotel employees. "International Journal of Hospitality Management", 44, 84-98.

Lekka, C and Healey, N (2012) "A review of the literature on effective leadership behaviours for safety". HSE Books.

Lucy, D, Tamkin, P, Tyers, C and Hicks, B (2011) "Leadership and worker involvement on the Olympic Park. RR 986." HSE Books.

Lunt, J, Bates, S, Bennett, V and Hopkinson, J (2008) "Behaviour change and worker engagement practices within the construction sector. RR60." HSE Books: HMSO.

Macey, W, Schneider, B (2008). The meaning of employee engagement. "Industrial and Organisational Psychology", 1, 3-30.

Marchington, M (2015) Analysing the forces shaping employee involvement and participation (EIP) at organisation level in liberal market economies (LMEs). "Human Resource Management Journal", 25(1), 1-18.

MacLeod, D and Clarke, N (2009) "Engaging for success: Enhancing Performance through employee engagement". Department for Business, Innovation and Skills.

Nahrgang, J, Morgeson, F and Hofmann, D (2010) Safety at Work: A Meta-Analytic Investigation of the Link Between Job Demands, Job Resources, Burnout, Engagement and Safety Outcomes. "Journal of Applied Psychology", 96(1), 71-94.

Organ, D (1988) "Organizational Ciizenship Behaviour: The Good Soldier Syndrome". Lexington: Lexington Books.

Oxford Dictionary of English, 2010. 3rd edition. Oxford: Oxford University Press.

Rich, B, LePine, J, and Crawford, E (2010) Job Engagement: Antecedents and Effects on Job Performance. "Academy of Management Journal", 53(3), 617-635.

Rudd, T., Colligan, F. and Naik, R (2006) "Learner Voice: a handbook from Futurelab". Bristol, Futurelab.

Safe Work Australia (2011) "Work health and safety consultation, co-operation and co-ordination code of practice". Safe Work Australia.

Saks, A (2006). Antecedents and consequences of employee engagement. "Journal of management Psychology", 21(7), 600-619.

Shantz, A, Alfes, K, Truss, C and Soane, E (2013) The role of employee engagement in the relationship between job design and task performance, citizenship and deviant behaviours. "The International Journal of Human Resource Management", 24(14), 2608-2627.

Shuck, B, Rocco, T and Albornoz, C (2010) Exploring employee engagement from the employee perspective: Implications for HRD. "Journal of European Industrial Training", 35(4), 300-325.

Shuck, B and Herd, A (2012) Employee Engagement and Leadership: Exploring the Convergence of Two Frameworks and Implications for Leadership Development in HRD. "Human Resource Development Review", 11(2), 156-181.

Shuck, B and Wollard, K (2010) Employee engagement and HRD: A seminal review of the foundations. "Human Resource Development Review", 9(1), 89-110.

Soane, E, Shantz, A, Alfes, K, Truss, C, Rees, C and Gatenby, M (2013) The Association of Meaningfulness, Well-Being, and Engagement with Absenteeism: A Moderated Mediation Model. "Human Resource Management", 52: 441–456.

South African Department of Labour (2004) "Republic of South Africa No.85 of 1993: Occupational Health and Safety Act as amended by Occupational Health and Safety Amendment Act, No. 181 of 1993".

Strauss, G (1998) Participation works – if conditions are appropriate. In F. Heller, E. Pusic, G. Strauss and B. Wilpert (eds.) "Organizational Participation: Myth and Reality", Oxford: Oxford University Press.

Truss, C, Shantz, A, Soane, E, Alfes, K, Delbridge, R (2013) Employee engagement, organisational performance and individual well-being: exploring the evidence, developing the theory. "The International Journal of Human Resource Management", 24(14), 2657-2669.

Vinodkumar, M, Bhasi, M (2010) Safety management practices and safety behaviour: Assessing the mediating role of safety knowledge and motivation. "Accident Analysis & Prevention", 42 (6), pp. 2082-2093.

Wachter, J, Yorio, P (2014) A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation. "Accident Analysis and Prevention", 68, 117-130.

Way, D (2010) The Impact of Web-scale Discovery on the Use of a Library Collection. "Serials Review", 38(4), 214-220.

Welch, M (2011) The evolution of the employee engagement concept: communication implications. "Corporate Communications: An International Journal", 16 (4), 328-346

Wollard, K, Shuck, B (2011) Antecedents to Employee Engagement: A Structured Review of the Literature. "Advances in Developing Human Resources", 13(4), 429-446.

OCCUPATIONAL SAFETY AND HEALTH IN THE CONSTRUCTION INDUSTRIES OF THE NEW MEMBERS STATES OF EUROPE AND TURKEY: A QUESTIONNAIRE SURVEY OF TRADES UNIONS AND DISCUSSION AT A A WORKSHOP

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A project entitled 'Decent Work for Workers in Construction Industry', launched by the Programme for Workers' Activities of the International Training Centre of the International Labour Office (ITC-ILO), in partnership with the European Federation of Building and Wood Workers (EFBWW) and the European Trade Union Confederation (ETUC), aims to increase institutional capacity of the EFBWW and the ETUC affiliates from New Member States and Candidate Countries to engage in constructive sectoral social dialogue at national and European levels. An important part of this project was a two-day Workshop "Occupational Safety and Health in the Construction Industry" held in Budapest in September 2014. Twenty-nine delegates representing 12 trades unions from 10 countries attended the Workshop, many of whom were senior officials.

In preparation for the Workshop, a questionnaire was devised that sought the views of these trades unions on a comprehensive range of topics on occupational safety and health in the construction industries of their countries. The purpose of the questionnaire was to begin the Workshop by bringing together the opinions of the participating TUs for discussion to identify the major issues to be taken forward in the next phase of the project. The draft questionnaire was based on a list of 10 important factors taken from previously published work, which ranged from general considerations, such as a national culture of valuing human wellbeing, to more specific considerations, such as personal protective equipment. A questionnaire survey instrument of 36 questions was derived from these factors. The ITC-ILO administered the survey, including translation into the languages of the respondents. All 12 trades unions attending the Workshop responded and it was pleasing to note that senior people, such as presidents and executive secretaries, completed the questionnaires.

The responses proved to be very diverse but some clear themes emerged: national and government attitudes to Occupational Safety and Health (OSH) were not very positive but definitely improving; clients generally did not view OSH as an issue for them; large employers were committed to good OSH but small and medium sized enterprises were not; the logic of the business case was recognized but so were the difficulties on implementation; some countries treated their older workers very well; women were in a minority but generally not harassed; and modern equipment, tools and construction techniques were generally seen to be beneficial. The final discussion session was very positive: "If we didn't think we could really improve workers' conditions, we wouldn't be here today" concluded one senior trade union official. The results of the survey should provide useful guidance for the remainder of the project.

Keywords: Safety and health, construction, European New Member States, trades unions

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INTRODUCTION

A two-day Workshop for trades union officials on 'Decent Work for the Construction Industry' formed part of a substantial project for the further development of trades unions (TUs) in the New Member States of the European Union, plus Turkey as an aspiring member. The Workshop was an essential element of the project, bringing together participating TUs with the officials who were managing the project, supported by some external specialists, to discuss relevant issues and their possible resolution. In preparation for the Workshop, a questionnaire was formulated to review the current perceptions of the participants about occupational safety and health (OSH) in the construction industries of their countries. The questionnaire was fairly wide-ranging and was based on ten important factors that had been identified through previous work. The responses were summarised and presented at the beginning of the Workshop, so laying a useful foundation for the discussions that followed.

This paper begins with a summary of the project in the context of the EU construction industry. The methodological context of the questionnaire is then summarised, followed by an explanation of the ten important factors. A description of the development of the questionnaire is followed by a summary of the respondents and responses. An analysis of the results and a concluding discussion complete the paper.

THE PROJECT AND THE EU CONSTRUCTION INDUSTRY

The project is entitled 'Decent Work for Workers in Construction Industry'. It is a project of the Programme for Workers' Activities of the International Training Centre (ITC) of the International Labour Office (ILO), in partnership with the European Federation of Building and Wood Workers (EFBWW) and the European Trade Union Confederation (ETUC). It aims to increase the institutional capacity of the EFBWW and the ETUC affiliates from New Member States and Candidate Countries to engage in constructive social dialogue at national and European levels, so as to contribute to the promotion of decent work in construction industry (ILO-ITC 2014).

The project focuses on the construction industry because it is one of the biggest industrial sectors of the EU economy and has an important multiplier effect on other sectors, contributing to more than 10% of EU GDP. It is a labour-intensive sector and the value-added per person employed is significantly lower than in many other industries, mostly due to the limited potential for increased automation and capital intensity of production (ILO-ITC 2014).

The construction sector is the biggest industrial employer in the European Union. The following statistics were compiled for the project (ITC-ILO 2014). With more than 18.5 million employed, and more than 14 million businesses, it represents around 26% of industrial employment in the EU, or 7% of total employment, and more than 20% when taking into account the indirect jobs generated in other sectors of the economy. The majority of employed workers in the construction sector are low and medium skilled, while the share of highly skilled workers of around 10% is well below average. More than 90% of workers in the sector are men. Employment is often temporary, and there is a high prevalence of undeclared work. Construction activity is primarily local, and the sector is characterised by a predominance of small and medium sized enterprises (SMEs), and a very important number of micro enterprises and self-employed people. The sector has around 2.5 million enterprises, 93% of which have less than 10 employees. Only 1% of the EU companies in the construction sector have more than 50 employees, but these companies undertake approximately 40% of the volume of construction work.

The project comprises six training activities: (1) 'kick-off' Workshop, (2) four thematic Workshops (migrant workers, freedom of association and organising workers, 'precarious workers' and OSH) and (3) a final evaluation conference. The OSH Workshop is the subject of this paper.

METHODOLOGICAL CONTEXT OF THE QUESTIONNAIRE

This was a project for TUs involved in the construction industry in the participating countries, which had been through a very structured process of formulation, approval and funding. Since the federations of these trades unions participated in the development of the project, in essence the trades unions **were** the project. The purpose of the Workshop was to discuss the project with its participants to identify important issues to be taken forward – in partnership of course with the other parties to the project. The methodology was to use a pre-Workshop questionnaire to seek the opinion of the TUs, and a summary of the responses would be used to initiate discussion in the first plenary session of the Workshop. So, in terms of research methodology, all those who would attend the workshop would complete the questionnaire, so the whole 'population' was involved rather than a sample of it.

The questionnaire was based on ten important factors that are described in the next section. The first author of this paper drafted a questionnaire for discussion with the project officials, which was refined through discussion to include some issues specific to this project. The ITC-ILO administered the survey, including translation into the languages of the respondents. All 12 trades unions attending the Workshop responded and it was pleasing to note that senior people, such as presidents and executive secretaries, completed the questionnaires. 'Teams' from the 12 TUs were represented at the Workshop by a total of 29 delegates.

Since the TUs were committed to the project and the respondents to the questionnaire knew that their responses would be presented in full, in their presence, for discussion in the plenary session, the authors of this paper are confident that the respondents completed the questionnaire thoughtfully and in discussion with the members of their teams who would accompany them to the Workshop.

TEN IMPORTANT FACTORS INFLUENCING OSH IN THE CONSTRUCTION INDUSTRY

OSH in the construction industry is a very wide-ranging topic, so if improvement is to be achieved an assessment has to be made of the most influential factors. An initial assessment was made as part of the design of a training package for the ILO (ILO 2011), in which 15 Themes were derived from a study of the literature and the authors' own expertise.

The derivation of the important factors continued for a chapter in a book on the construction industry in developing countries (Neale and Waters 2012). This was based on a wide-ranging literature review and a set of ten important issues was formulated. There are 76 references in the chapter so there is insufficient space in this paper to reference them, but this is a CIB book which should confirm that the research was comprehensive and rigorous, and of course the book, and so the references, are readily available. These factors were presented in a keynote address to an international workshop sponsored by the British Council (Neale 2013a) and refined through discussion. Delegates came from 21 countries. A variation of this address was given subsequently to a group of senior construction staff from the construction industry of Sudan and further useful discussion followed. The ten factors were published in an invited paper (Neale 2013b). Since these factors had been developed in a very broad context of developing countries, a revised version was formulated to suit the countries of this project and these became the basis for the questionnaire. These revised factors are described briefly below.

1 A national culture of safety and health

International experience has shown that it is very difficult for employers to implement effective OSH procedures and practices unless there is an overall, national culture that values human wellbeing. This may be the most crucial issue of all.

2 A national regulatory framework

Governments must devise, implement and supervise the appropriate statutory instruments, regulations and supervisory organizations. These need to be effective in their design and must be enforced comprehensively, but in many countries such provisions are poorly constructed, overly bureaucratic and laxly implemented.

3 Clients of the construction industry must take an active role

Historically, in many countries, clients of the construction industry have only taken an interest in safety and health in regard to the completed works, and have delegated OSH of the construction activities wholly to the construction company. There is, therefore, an issue about client involvement in encouraging decent working practices throughout the project.

4 A business case for OSH

Construction is generally a very competitive and commercial business, with a complex responsibility structure through layers of subcontracting. OSH is usually seen as a cost to be minimised, yet the costs of incidents may well justify a business case approach.

5 Method statements and risk assessment

In many countries, the accepted procedure for all but the most simple construction tasks is as follows: Assess the task, thoroughly and comprehensively, and devise a method statement for its execution; assess the hazards and risks involved in the method statement; if required, revise the method statement to eliminate or minimize the hazards and risks. It was of interest to ask how prevalent this procedure is in the respondents' experience.

6 Worker participation

In many countries, formal worker participation is commonplace, usually through TUs and site safety committees. A possibility is to extend worker participation into the process of devising method statements and the assessment of hazards and risks, on the grounds that the workforce has useful first hand knowledge.

7 Older construction workers

It is generally recognized that construction work is physically demanding, so there will come a time when workers become too old to be productive. What happens to them?

8 Social and physical welfare of women

In some countries, very few women work in the industry. In others, women comprise a substantial part of the labour force, and in some countries women are quite commonly found in managerial and technical roles.

9 Training

Training of all those involved is obviously crucial yet it is often neglected.

10 Applications of modern technologies

Technologies now available, and currently being developed, have the potential to make a significant contribution to improving OSH. Conversely, modern technology and materials can be lethal in inexperienced hands.

DEVELOPMENT OF THE QUESTIONNAIRE

Through dialogue with the project officials, a total of 36 questions was derived from these factors. These questions were translated into the languages of the Workshop participants and administered through SurveyMonkey.

Obviously there were some specific questions about each TU the start the questionnaire, and some specific questions were added as follows:

- Safety Coordinators were seen to play an important role, so questions were asked about their appointment at national and company level.
- Factor 3 was extended to distinguish between public and private clients.
- Factor 4 was extended to ask about the commitment of large and SME employers.
- The value of the support available from international agencies was queried.
- Explanations were sought of ways in which each TU promoted good OSH.
- A general question about the likely development of OSH in their industries was added.

Taking out some specific questions about the TUs themselves left a total of 29 questions. These are listed, in necessarily terse form, in Table 3.

RESPONDENTS

The respondents to the questionnaire and their countries are shown in Table 1, which shows a good mix of responsibilities, many of them senior. Sadly, they were all men.

Table 1: Respondents to the questionnaire

Country		Position
1	Bulgaria	Executive Secretary
2	Croatia	President
3	Czech Republic	President
4	Hungary	National Office Union Officer
5	Latvia	Coordinator of Health & Safety
6	Malta	Union Safety at Work Inspector
7	Poland	President
8	Serbia	Regional representative
9	Serbia	Executive Secretary
10	Serbia	OSH Coordinator
11	Slovenia	Project Coordinator
12	Turkey	President

SUMMARY OF RESPONSES

The responses are as wide-ranging and diverse as the questions and countries of the respondents. Many of the questions were in the form shown in Table 2 so it was quite straightforward to classify the responses as positive, negative or neutral (or no response) so a simple analysis can be made, as shown in Table 3.

Table 2: Example question

PUBLIC CLIENTS of construction projects consider OSH during the construction process to be:	
Answer Options	**Response class**
Entirely the concern of the construction company (contractor) and nothing to do with them	Negative
Of some concern to themselves but in a very general and limited way	Neutral
An important part of the client's role in the project	Positive

Table 3: Analysis of positive, negative or neutral responses to the questionnaire

FACTORS & QUESTION TOPICS		**RESPONSES**												**Overall Topics**
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	
	Safety coordinators?	+	-	+	-	+	+	+	+	+	+	+	-	**6+**
1	National perceptions						+				-			**0**
1	Changes in national perceptions		+	+	+	+	+	+	+	+	-	+	+	**9+**
1	Importance to government			+		+	+	+	+		-			**4+**
1	Explanations of above		-	+	-		+		+	+	-	+	+	**3+**
2	Implement EU Directive	+		+	+		+	+		+	-		+	**6+**
2	Explanation of above		-	+	-		+	-		+	-	+	-	**1-**
3	Public clients' commitment	-	-		-	-	-	-	-	-	-	-	-	**11-**
3	Private clients' commitment	-	-		-	-	-	-	-	-	-	-	-	**11-**
4	Large employers' commitment	+		+	+		+	+	+	+	-	+		**7+**
4	SME employers' commitment		-		-					-	-		-	**5-**
4	Business case	+	+	+	+	+	+	+	+	+	+	+	+	**12+**
4	Would most companies agree?	+	+	-	+	+	+	+		+	-	-	-	**3+**
5	Use of method and risk analysis		+	+			+	+			-			**3+**
5	Is above realistic?										-			**1-**
5	Provision of PPE	+	+				+	+			-		+	**4+**
6	Worker participation		-				+	+			-			**0**
6	Value of worker participation	+		+	+		+	+		+	+	+	+	**9+**
7	Older workers		-	+	+		+		-	-	-	+	+	**1+**
8	Professional women			+	+		+			-	-	-	+	**1+**
8	Women in manual trades			-				+		-	-			**2-**
9	Training for workers		-	-			+	+			-			**1-**
	Help of international agencies			+	+		+	+		+	+	+		**7+**
10	Construction machinery	+	+	+	+	+	+	+	+	+		+	+	**11+**
10	Hand held power tools		-	+	+	+	+	+		-			-	**2+**
10	Techniques & materials			+	+	+	+	+		+	+	+	+	**9+**
	How does your TU help?	+		+	+		+	+		+	+	+		**8+**
	How can the industry develop?			-	+		-			-	-	+		**2-**
	Other suggestions, comments			+	+		-				-			**0**
	Overall Responses	**7** +	**4** -	**14+**	**9** +	**6** +	**18+**	**15+**	**4** +	**5** +	**15** -	**9** +	**3** +	**71** +

The table sums the positives and negatives, which is probably just acceptable within the qualitative research methodology used for this survey. (Note that the sequence of responses A-L is different from that given 1-12 in Table 1 so the TUs cannot be identified.)

Discussion on the summary of responses

The ‘Overall Responses’ row of the table demonstrates the diversity that would be expected of states involved, especially since they are relatively new to the EU or have not yet joined. Serbia’s three TUs were within a range of 5, indicating a good degree of consistency. The maximum possible ‘score’ is 29+, so 18+ and 15+ are indicative of a country that takes OSH seriously, whereas 15- is indicative of a country in which it is neglected. Descriptive responses from these countries support this analysis. We have tried to correlate the totals with such possible determinants as those with joint borders but there was no discernable pattern.

The ‘Overall Topics’ column also shows this diversity but some clear conclusions can be drawn. Nine of the responding TUs have appointed safety coordinators at national and/or company level, which is a very positive. Although OSH was not seen as important nationally, this is improving in all countries except two, which is encouraging bearing in mind that legislation is difficult to implement in the current state of development of some countries. Clients do not see OSH as their problem, but large employers do take it seriously. There is strong support for a business case for improving OSH, whereas risk analysis approach and provision of PPE have yet to become commonplace. Factors 6-9 relate to the workforce and opinions are very mixed, except that (perhaps predictably) there was good support form the TUs for worker participation. TUs do value the support that they get from international agencies but seek more funding because they are quite active in trying to improve OSH in countries where this is difficult. Modern construction machinery, tools and techniques are seen to be a positive influence, although some responses noted the dangers when used without proper training.

The overall rating of 71 is positive and taken with very positive responses to some of the questions, is encouraging.

NARRATIVE RESPONSES TO THE QUESTIONNAIRE

Some of the questions sought narrative responses. A selection of these responses is given below, under headings of the ten principal factors to which narrative responses were requested. The selection was made on the basis of the topics which aroused most discussion at the Workshop after the summary of responses had been presented. These responses amplify the discussion on Table 3 given above.

1. A national culture of safety and health

“With its proactive role, in the past 10 years, our trade union provoked a change in the attitude of the competent state authorities and institutions towards OSH. Although we are not completely satisfied with the achievements, the fact remains that the processes of harmonization of the national legislation with the EU … are in progress.”

“Our government thinks that this is not the right time to place a high emphasis on OSH due to bigger crisis-related problems. However, if we take into account the statistical data that shows a very high percentage of accidents at work and lethal accidents, we think that there shouldn't be anything more important than this.”

2. A national regulatory framework

“In recent years significant efforts have been done in terms of upgrading the legislation. The implementation in practice is usually delayed and not completely efficient. As far as OSH is concerned, a large number of employers in construction industry are just satisfying minimum formal requirements.”

“In the construction sector in recent years there has been a significant improvement in statistics related to the accident rate. We associate it closely with the impact of the implementation of EU law, as well as increase awareness of employees.”

“Due to the need to keep any job, workers often accept to work under no matter which conditions. Employers don't pay sufficient attention to OSH, convinced that this is the responsibility of the agencies that they hired. The government's perception is that there is an adequate legal framework and instructions on OSH standards, but the core of the problem is the implementation of the law. Statistics confirm that national regulations do not achieve desired impact.”

4. A business case for OSH

“More investment into improving working conditions would result in fewer accidents at work, improved labour efficiency and, consequently, increased revenues for the construction company. Fewer accidents, fewer injuries, greater productivity, more profit.”

“It has been proved that money invested in OSH returns in triple value.”

“I think, the logic is obvious, but from implementing this in real life, employers is stop because of financial capacity and that's directly linked to lowest price rule we have in public procurements.”

5. Worker participation

“The contribution of workers themselves towards advancing the OSH measures is essential. The important role of the workers is due to the fact that workers are directly concerned with OSH measures, and are directly exposed to and threatened by the risks at work. In (our country) there are several foreign companies that are giving rewards to the workers who propose improvements of the OSH measures at the workplace and they actually adopt worker’s proposals.”

“Worker participation is definitely improving safety at the workplace.”

6. Older construction workers

“Labour Code or Collective Agreement does not offer any special protection to senior workers, unless the issue is raised by medical doctors in charge of establishing workers' ability to work. Workers older than 55 years of age are protected by the law from dismissals, overtime etc.”

“Most of the workers in the construction industry work in the private sector under vulnerable conditions as precarious workers. Thus, especially after the age 50, they are being fired and have no right to be retired and get retirement wage. For public construction workers, they have the right to choose to be retired after the age 65 and they are being paid.”

"Most of these workers are not unionized. So they have to cope with their job, some employers are lenient with their good workers but others try to get rid of them."

"At present there is no comprehensive solution; however, some projects and proposals for the government have already been prepared. This situation occurs approximately when they are 50 to 55 years old."

"Workers older than 50 are often transferred to less demanding working positions, so that their experience can be well used."

"Usually around 45-50 employers do not continue the employment relationship with the employee."

7. Social and physical welfare of women

"We are not familiar with cases of harassment of women in male dominated work environment in construction. No cases have been reported so far."

"There are cases of gender discrimination especially in male-dominated environments. Approximately 10% of women are occupying professional and managerial grades in construction industry in (our country)."

"In (our country), women are rarely employed in professional and managerial grades in construction industry. For those who are employed, their specific and separate welfare needs are ignored and subjected to harassment."

"Few women work in these environments but nowadays these are increasing, especially when these are family members of the contractor. There is an increase also in female architects and engineers. I honestly don't know how these are treated."

"A few of the construction companies have women employed in high managerial grades. To my knowledge, they have not been the target of any kind of abuse or harassment by their male colleagues."

"In our experience, we have noticed many women employed in professional and managerial grades. It is true that they can be subject to harassment at work in a male-dominated environment, but the number of such cases that we are aware of is rather small."

"Generally, women in construction sector work in administrative and managerial positions, and there is no particular discrimination or harassment."

"Meeting a woman on construction site, doing practical work, is great rarity."

Questions on what is likely in the future

"Modernization of technology and introduction of new materials will change the attitudes towards the OSH."

"The policies implemented by our government are all in favour of the employers, thus, the OSH, wage and all other standards and rights are under the danger of being unprotected by the laws. Therefore, it is for sure that the number of deadly accidents and precarious working conditions will increase."

"One of the major problems in the construction industry is the large share of construction companies (mostly small and micro ones) operating in the shadow sector of the economy. These are the ones responsible for most of the violations of the health and safety requirements. They fail to provide the required personal protective equipment and do not invest enough in new technology and machines."

"We are expecting the continuation of big infrastructure projects in (our country), implemented by foreign companies from all over the world. According to our experience, foreign companies usually introduce well-established OSH standards. A separate problem is linked to construction workers in informal economy where OSH standards are usually lower."

CONCLUDING COMMENTS

This paper describes the major issues facing 12 TUs working to improve OSH in the construction industries in nine New Member States and one aspiring member. The responses proved to be very diverse, with some countries and employers taking occupational safety and health seriously and applying good practices and procedures, while the standard in others was very low.

A general discussion concluded the Workshop, in which the participants were generally very positive and confident that progress can be made, provided that the TUs continue to put pressure on governments and employers and to organize campaigns, conferences, promotional materials, training, and legislative initiatives.

The whole Workshop was characterised by a sense of humanity and determination, typified by this quotation: "If we didn't think we could really improve workers' conditions, we wouldn't be here today"

REFERENCES

Council of The European Communities (1989) "Council Directive on the Introduction of Measures to Encourage Improvements in the Safety and Health of Workers at Work" (89/391/EEC).

ILO-ITC (2014) "Decent work for workers in construction industry." A project of the International Training Centre of the International Labour Organisation and the European Union, Project VS/2013/0262. Available from: http://actrav-courses.itcilo.org/en/a4-57298/copy2_of_a4-57298-presentations/flyer

ILO (2011) "Construction OSH", a web-based training package available at: http://www.ilo.org/sector/Resources/training-materials/WCMS_161706/lang--en/index.htm

Neale, R H and Waters, J (2012) Safety and health in construction in developing countries: The humanitarian paradox. In George Ofori (Ed.) "Contemporary issues in construction in developing countries". Abingdon, UK, Spon Press.

Neale, R H (2013a) Safety and health in construction in developing countries: The humanitarian paradox. Unpublished keynote address to an International Research Workshop “The Role of Construction in Development and Economic Growth: Challenges and Opportunities for Developing and Emerging Economies” Reading, 5-6th September.

Neale, R H (2013b) Ten factors to improve occupational safety and health in construction projects. “African Newsletter on Occupational Health and Safety”, Vol 23, No 3, Helsinki, Finland. (This is not a refereed journal but it is a joint publication of the World Health Organisation and the International Labour Office so it must have some standing. It is free to download.)

IMPACT OF SUPERVISOR'S SAFETY LEADERSHIP ON WORKERS' SAFETY CONSCIOUSNESS ON CONSTRUCTION SITE

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Safety is a key area that construction industry leaders need to focus on. Past research has identified that safety leadership is critical to prevent injuries and fatalities. However, it appears that no research has been conducted to investigate the impact of frontline supervisors' transformational leadership and passive leadership on their workers' safety performance in construction environment. This study aims to investigate the impact of supervisory transformational leadership and passive leadership on safety performance of construction workers. A quantitative research method was used to achieve the research aim. Data were collected using questionnaire survey with workers from a Sydney Construction Company conducted over multiple sites under construction. The results show that (1) safety- specific passive leadership has a negative effect on safety climate and workers' psychological capital and safety consciousness; and (2) safety specific transformational leadership has a positive effect safety climate and workers' psychological capital and safety consciousness. The results also show that the relationship between supervisory transformational leadership and employee safety consciousness was mediated by workers' psychological capital. The findings of this study may explain how supervisor's leadership skills influence their workers' safety performance on construction sites, and thus may inform the training and development of leadership skills for front-line supervisors on construction sites.

Keywords: Construction, Leadership, Supervisor, Safety, Safety consciousness.

INTRODUCTION

The organizational structure of construction industry makes the management of occupational health and safety even more challenging than many other industries (Ringen et al. 1995). The construction industry, when compared to other industries, such as manufacturing, is often classified as high-risk due to it being plagued in the past with a higher and unacceptable injury rate (Rowlinson, 2000). Safety is a key area that construction industry leaders need to focus on. Leadership is one of the most important aspects of management (Weihrich et al, 2008) due to it being a factor which contributes immensely to the general wellbeing of any organisation. Previous studies have identified that safety leadership is critical to promote safety culture and prevent injuries and fatalities. Hofmann and Morgeson (1999) found that high-quality leaders contributed to improved safety communication and safety, which also contributed to reduce the incidence of accidents. Similarly, Kelloway et al (2006), found that perceptions of supervisor's safety-specific transformational leadership were also related to individual safety consciousness and perceptions of safety climate. Although past research has identified that safety leadership is critical to prevent injuries and fatalities, it appears that no research has been conducted to investigate the impact of frontline supervisors' transformational leadership and passive leadership on their workers' safety performance in construction environment. This study aims to examine the impact of supervisory safety-specific leadership on workers' safety consciousness in the construction environment.

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LITERATURE REVIEW

Transformational leadership and passive leadership

Warrilow (2012) described transformational leadership as a theory in which leadership creates positive change in followers whereby they take care of each other's interests and act in the interest of the group as a whole. Transformational leadership behaviour is a means by which managers can become positive role models for their employees in regards to safety-specific activities (Barling et al, 2002). Transformational leaders challenge employees by communicating high expectations and focusing employee efforts (Bass, 1998). Barling et al (2002) found that safety-specific transformational leadership predicted safety climate and safety consciousness. Zohar (2000) found that transformational leadership was also associated with improved safety climate and reduced incidence of injury.

Passive leadership can be defined as comprising of elements from both the laissez-faire and management-by-exception styles (Bass and Avolio, 1990). In management-by-exception, leaders fail to intervene until problems are either brought to their attention or become serious enough to require their attention (Bass and Avolio, 1990). Bass and Avolio (1990) also stated Laissez-faire leaders avoid both making decisions and the responsibilities of leadership. Both of these forms of passive leadership are considered ineffective approaches. It is noted however; far fewer studies have been conducted on the impact of passive or inefficient leadership on work place safety. This is also of major importance as some leaders may not be actively involved in promoting safety (Kelloway et al, 2006). Reasons to this could include the unlikeliest of leaders to admit to not enforcing safety, or disregarding safety protocols, it may be possible in some cases leaders simply ignore safety concerns (Kelloway, et al, 2006). Zohar (2002) found passive leadership negatively impacted safety climate and therefore contributed to increased injury rate.

Psychological Capital

The term psychological capital can be defined as an individual's positive psychological state of development (Luthans et al, 2007). Psychological capital is relevant to employees in high risk activities as it may facilitate safety focused behaviour (Eid et al, 2012), and through four characteristics of psychological capital, greater safety awareness and safety behaviour can be promoted. First, the concept of self-efficacy implies that the employee has confidence to take on and out in the required effort to succeed when faced with a challenging task. Workers in high risk industries such as construction must feel confident they have skills and technical knowledge to understand risks and dangers in work operations and ability to report potential hazards, and becomes a fundamental to safety focused behaviour. Self-efficacy can be regarded as a fundamental to safety focused behaviour (Eid et al, 2012). Secondly, optimism refers to the workers preferences and tendencies to make positive and realistic attributions about success now and in the future. This allows for the possibility to change the situation and is important in acting in accordance with safety rules and regulations, taking action avoiding work related issues that may have safety implications, be they technical or human. Thirdly, hope denotes an individual's preference to preserve towards goals, and when needed, redirect paths in order to achieve gaols and succeed. This tendency seeks out new opportunities, implements new equipment, procedures or knowledge to stay focused on safety focused behaviour and loss prevention and is important in avoiding relaxed attitude to safety issues. Finally, resilience refers to the individual's tendency to sustain and bounce back from problems and adversity. The individual seeks to overcome problems and obstacles.

Hypotheses

Based on the above review of literature, the following hypotheses are set out:

H1: Safety-specific transformational leadership (TRALEA) has a positive effect on psychological capital (PSYCAP).

H2: Perceived safety climate (SAFCLI) will be positively impacted by safety specific transformational leadership (TRALEA).

H3: Safety-specific passive leadership (PASLEA) is negatively associated with psychological capital (PSYCAP).

H4: Safety specific passive leadership (PASLEA) has a negative impact on safety climate (SAFCLI).

H5: Psychological capital (PSYCAP) has a positive impact on safety climate (SAFCLI).

H6: Safety climate (SAFCLI) has a direct and positive impact on safety consciousness (SAFCON).

H7: Safety specific passive leadership (PASLEA) negatively impacts safety consciousness (SAFCON).

H8: Safety specific transformational leadership (TRALEA) positively impacts safety consciousness (SAFCON).

H9: Psychological capital (PSYCAP) positively impacts safety consciousness (SAFCON).

METHODOLOGY

Development of the Data Collection Instrument

This is a correlation research study that seeks to explore the impact of safety leadership on construction safety performance. The development of the data collection instrument is based on previously developed questionnaires as identified in the literature review. Safety specific passive leadership was measured by a scale developed by Kelloway et al (2006). Example scales include "My direct supervisor waits for things to go wrong before taking action" and "My direct supervisor avoids making decision that affect safety on the job". Safety specific transformational leadership was assessed with 10 items also from Kelloway et al's (2006) scale. This scale was originally adapted from the MLQ-5 (Bass & Avoli, 1990). Examples of these questions include "My direct supervisor expresses satisfaction when I perform my job safely" and "My direct supervisor spends time showing me the safest way to do things at work". Psychological capital was measured following Luthans et al's (2007) 12 Item PsyCap Questionnaire (PCQ). With such questions as "Right now I see myself as being pretty successful at work" and "I can think of many ways to reach my current work goals". Each of the four components in psychological capital was tested. This study measured safety climate using subscales from Johnson's (2007) measure; Safety climate Survey. This measure was based on the 16 item ZSCQ of Zohar & Lurina (2005). Safety consciousness was measured by using Barling et al's (2002) 7 items. Examples of questions include "I would know what to do if an emergency occurred" and "I do not use equipment that I feel is unsafe". The respondents were requested to indicate to what extent they agree or disagree with the scale items on a 5-point Likert scale. To derive the overall score for each variable, the weights of all factors and their measurement items need to be determined. It appears that no research has been done to examine the weights or relative importance of each construct. In this situation, the equal weights method (Dawes and Corrigan, 1974) was applied to compute the overall scores of the constructs As the weights of the variables was unknown, each question had 5 potential answers and by using the equal weights method, a dimensionless quantity, this research used the average score of the questions to measure each construct, equal weight was presumed. A pilot study was conducted with 6 construction professionals using the initially designed data collection instrument. This then led to some adjustments to the initially designed data collection instrument.

Participants

The questionnaire survey was administered to the construction workers employed by a typical mid tier building contractor (Company A) operated in New South Wales Australia. Company A has an annual turnover of around 150 Million and around 250 full-time staff. It offers a complete construction service for a wide range of project types, including commercial and residential projects, industrial facilities, aged care, education and religious projects. Questionnaires were distributed to 300 workers on 4 sites under construction. Workers were asked during lunch break to complete questionaries. A covering letter was attached to the questionnaire emphasized both the confidentiality of the response and the voluntary nature of participation, in addition to instructions on how to complete the questionnaire. Once completed, questionnaires were collected from respondents. Some respondents preferred to home to complete and return them the following day. These were then collected by the site manager. Out of the 300 workers over 4 sites, 97 workers agreed to participate in this study representing a response rate of 32%.

RESULTS AND DISCUSSION

The data was analysed using the Statistical Package for Social Science (SPSS). Bivariate correlation analysis was conducted to examine the correlation between variables; the result is presented in table 1.

Safety-specific transformational leadership and psychological capital (H1)

Transformational leadership was found to be positively and significantly correlated the 4 constructs of psychological capital, being efficacy ($r = 0\ .802$, $p <0.05$), hope ($r = 0.722$, $p <0.05$), resilience ($r = 0.580$, $p<0.05$), optimism ($r = 0.580$, $p < 0.05$). The result indicates that transformational leadership behaviour contributes to this positive mind set in followers, influencing their decision-making and ultimately safety behaviour. Luthans et al (2006) found that psychological capital is open to development and subject to change following brief structured interventions. The psychological capital factors of hope, optimism, resilience and efficacy therefore represent potential pathways of leaders influence on follower's safety behaviour. Eid et al (2012) found that psychological capital mediates leadership behaviour in terms of raising workers motivation and mobilizing effort to maintain focus on safety issues, assess critical hazards and to be proactive in order to avoid adverse safety outcomes. The transformational leadership and psychological capital therefore combine to increase followers motivation to engage in safety focused behaviours and actions.

Table 1: Results of Correlation Analysis

	TRALEA	PASLEA	SAFCLI	EFF	HOP	RES	OPT	SAFCON
TRALEA	1							
PASLEA	-0.67*	1						
SAFCLI	0.85*	-0.63*	1					
EFF	0.80*	-0.71*	0.79*	1				
HOP	0.72*	-0.52*	0.73*	0.82*	1			
RES	0.58*	-0.42*	0.41*	0.67*	0.69*	1		
OPT	0.64*	-0.55*	0.59*	0.62*	0.70*	0.41*	1	
SAFCON	0.77**	-0.60*	0.77*	0.76*	0.74*	0.50*	0.68*	1

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

Perceived safety climate and safety specific transformational leadership (H2)

The result shows that transformational leadership was positively and significantly correlated with safety climate ($r = 0.847$, $p <0.05$). It implies that when leaders actively promote safety, it results in positive impact on safety climate. Transformational leaders take an active approach to safety issues and encourage other in the workplace to also work in a safe manner. When supervisors promote positive safety climate, this allows and encourages workers to become actively involved in and take ownership and responsibility for safety. Weick et al (1999) also found that the role of the site manager has been acknowledged as a major impact on the safety climate that exists at the workplace. This study supports and agrees with this finding. When supervisors call attention to the importance of safety, thereby displaying idealized influence, employees' perception of safety climate is enhanced.

Safety-specific passive leadership and psychological capital (H3)

Results of bivariate correlation analysis show that passive leadership is negatively and significantly ($p < 0.05$) correlated with the four constructs of psychological capital, being efficacy ($r = -0.712$), hope ($r = -0.515$), resilience ($r = -0.418$), optimism ($r = -0.555$). The results provide strong support for the mediation model linking safety specific passive leadership and psychological capital. The results further support Kelloway et al's (2006) findings that passive leadership behaviour can have a damaging effect on employee's psychological capital. If as supervisor avoids to identify and clarify potential problem areas, they avoid getting involved, avoid setting standards and to monitor for results (Bass et al, 2003), then as these results have shown, passive leadership therefore results in a negative association with psychological capital. Therefore, this hypothesis is supported.

Safety specific passive leadership and safety climate (H4)

The results show passive leadership is negatively and significantly ($p < 0.05$) correlated with safety climate ($r = -.634$). A passive leader is not concerned about either the emotional or the physical well-being of employees. Passive leadership fails to intervene until the problems are brought to their attention or become serious enough to require attention. The lack of concern for safety therefore directly impacts the safety climate within the workplace. When direct supervisors fail to promote positive safety activities, the perception of safety of the employees is affected. If this perception captures poor leadership due to leaders ignoring safety concerns, then this in turn will influence the safety climate of employees.

Psychological capital and safety climate (H5)

The four constructs of psychological capital, efficacy, hope, resilience and optimism were found to be significantly and positively correlated to safety climate, with efficacy ($r = 0.761$, $p < 0.05$), hope ($r = 0.742$, $p < 0.05$), resilience ($r = 05.00$, $p < 0.05$) and optimism ($r = 0.68$, $p < 0.05$), implying that psychological capital has a positive impact on safety climate. This supports the results of Avey et al (2010), who stated that psychological capital has emerged as a strong predictor of work attitudes and behaviour. Psychological capital concepts of efficacy, hope, resilience and optimism mediate leadership behaviour and safety climate in terms of raising workers motivation and mobilizing effort to maintain a vigilant focus on safety issues, assess critical hazards and to become proactive in order to avoid adverse safety outcomes.

Safety climate and safety consciousness (H6)

Safety climate was found to be positively correlated ($r = 0.766$, $p < 0.05$) with safety consciousness. A good safety climate has an active influence on workers safety consciousness. This result supports Zohar (2000), who indicated that since organizational level climate perceptions relate to instituted procedures, it follows that these perceptions inform employees of desired role behaviours. Increased focus on creating a safety climate of caring, compliance and coach will define procedural patterns and suggest a high priority in employees for safety, which then in turn will increase the likelihood of safe work behaviour.

Safety specific passive leadership and safety consciousness (H7)

The results show passive leadership is negatively and significantly ($p < 0.05$) correlated with safety consciousness ($r = -0.604$). Safety consciousness is defined as the values, attitudes and beliefs that under lies the awareness of safety hazards. It is the individual's awareness of safety hazards they face and this is impacted directly by supervisor's leadership style. When the direct supervisor's place no emphasis on encouraging employees to think about safety, the employee's attitudes and beliefs about safety decrease. Without positive reinforcement from supervisor, safety conscious employees lose a positive attitude and awareness of safety, and may take on the non-concerned approach portrayed by passive leaders. This is turn could see employees displaying lack of concern in regards to discussion making, and eventually lead to an increase in injury rates.

Safety specific transformational leadership and safety consciousness (H8)

Transformational leadership was found to be positively and significantly correlated with safety consciousness ($r = 0.772$, $p < 0.05$). Transformational leaders place a large emphasis upon leader influence and its effect on employee's attitudes and behaviours. Through the use of the four characteristics of transformational leadership, idealized influence, inspirational motivation, intellectual stimulation and individualized consideration, transformational leaders encourage employee's values, attitudes and beliefs to become positive and exhibit an awareness of safety. Employees are encouraged to think about safety and potential hazards that may arise.

Psychological capital and safety consciousness (H9)

The four concepts of psychological capital, efficacy, hope, resilience and optimism were positively correlated to safety consciousness. Firstly, efficacy implies the employee has confidence to take on challenging tasks. Secondly, the concept of optimism refers to employee's preferences and tendencies to make positive and realistic attributions about success now and in the future. This effects how employees act in accordance with safety rules and regulations, and decision made relating to safety issues. Thirdly, the concept of hope refers to an individual's preference to preserve towards a goal, seek out new opportunities, procedures or knowledge in order to stay focused on safety behaviour. Hope positively impacts safety consciousness by encouraging a positive attitude of the employee towards safety and increasing their awareness of potential safety hazards. Finally, the concept of resilience refers to the individual's tendency to bounce back from problems and adversity; they seek to overcome problems and obstacles. Resilience positively impacts safety consciousness through a general awareness of safety issues as well as a more specific knowledge of the behaviours required to ensure safety of employees.

CONCLUSIONS

This study examined the impact of supervisory safety-specific leadership on workers' safety consciousness in the construction environment. From the statistical results of this research, it can be seen that safety-specific passive leadership has a negative effect on safety climate, psychological capital and safety consciousness; whilst, safety specific transformational leadership has a positive effect on safety climate, psychological capital and safety consciousness. Supervisors' safety-specific transformational leadership and passive leadership impact on workers' safety consciousness through changes of workers' psychological capital and the group's safety climate. The findings of this study may contribute to the theory explaining how supervisors' safety leadership influence their workers' safety consciousness in construction environment. The limitations of this research need to be highlighted. The first limitation lies in the generalizability of the findings. The findings of this research were derived based on the data collected from multiple constructions sites of only one construction company in Sydney. The findings may be difficult to be generalized to other population. Although this research surveyed only one company, the methodology of this research may be useful for a similar survey conducted with several different construction firms. In the future, research may be conducted to collect data from multiple companies to further test the relationships between the variables. The second limitation is that only quantitative data were collected in this research. It is acknowledged that quantitative data are not effective to explain the causal relationships between variables. Future research may be conducted to collect qualitative data via in-depth interviews or case studies to verify and explain the causal relationships. Moreover, more advanced statistical techniques (e.g., mediation regression and structural equation modelling techniques) may be used in future study to confirm the mediated effects.

REFERENCES

Avey, J.B, Wernsing,T.S &Luthans, F, 2010, 'The additive value of positive psychological capital in predicting work attitudes and behaviours', *Journal of Applied Management*, vol 36, pp. 430-452.

Barling, J, Kelloway, E & Loughlin, C, 2002, 'Development and Test of a Model Linking Safety-Specific Transformational Leadership and Occupational Safety', *Journal of Applied Psychology*, vol.87, no.3, pp.488-496.

Bass, B. M., & Avolio, B. J 1990, 'Transformational leadership development', *Manual for the Multifactor Leadership Questionnaire,* PaloAlto, CA: Consulting Psychologists Press.

Bass, B.M, Avolio, B.J, Jung, D.I, & Berson, Y, 2003, 'Predicting unit performance by assessing transformational and transactional leadership', *Journal of Applied Psychology*, vol. 88, no. 2, pp. 207-218.

Dawes, R.M., Corrigan, B., 1974,' Linear models in decision making', Psychol. Bull. 81, pp95-106.

Eid, J, Mearns, K, Larsson, G, Laberg, J, Johnsen, B, 2012, 'Leadership, psychological capital and safety research: Conceptual issues and future research questions', *Safety Science*, vol.50, pp55-61.

Hofmann, D. A, & Morgeson, F. P, 1999, 'Safety-related behaviour as a social exchange: The role of perceived organizational support and leader-member exchange', *Journal of Applied Psychology*, vol. 84, pp. 286–296.

Johnson, S, 2007, 'The Predictive Validity of Safety Climate', *Journal of Safety Research*, vol. 38, pp. 511-521.

Kelloway, K, Mullen, J, Francis, L, 2006,' Divergent Effects of Transformational and Passive Leadership on Employee Safety', *Journal of Occupational Health Psychology*, vol.11, no.1, pp.76-86.

Luthans, F, Avolio, B, Avey, J.b & Norman, S.M, 2007, 'Psychological capital: Measurement and relationship with performance and job satisfaction', *Personnel Psychology*, vol.60, pp. 541-572.

Ringen, K, Seegal, J & England, A, 1995, Annual Review of Public Health, Vol.161, pp.165-188.

Rowlinson, S, 2000, 'Human Factors in Construction Safety - Management Issues In Management', New Jersey, Prentice-Hall, pp. 59-86.

Warrilow. S, 2012, 'Transformational Leadership Theory- The 4 Key Components in Leading Change & Managing Change'. *International Review of Management and Business Research*, vol. 2 Issue.2, pp.355- 361.

Weick, K, Sutcliffe, K & Obsfeld, D., 1999, 'Organizing for high reliability: process of collective mindfulness', vol 12, 1998 (special issue)

Weihrich, H, Cannice, M.V & Koontz, H., 2008, *'Management'*, 12th edn, New Delhi: McGraw Hill.

Zohar, D, 2000, 'A group-level model of safety climate, Testing the effect of group climate on micro accidents in manufacturing jobs', *Journal of Applied Psychology*, vol. 85, pp. 587–596.

Zohar, D, 2002, 'The effects of leadership dimensions, safety climate, and assigned work priorities on minor injuries in work group', *Journal of Organizational Behaviours*, vol 23, pp.75-92.

PERCEPTIONS OF WORK-RELATED STRESS LEVEL INDICATORS, AND THE RELATIVE IMPORTANCE OF CONTRIBUTORY STRESSORS, AMONG SOUTH AFRICAN CONSTRUCTION PROFESSIONALS

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Levels of work-related stress are known to correlate to the stressors imposed by the demands of the work environment. Field administered interview surveys explore these factors at greater depth among professionals working in the construction industry in South Africa. The response data from 36 interviewees are analysed. For physical indicators of stress levels, the mean transition points (where positive stress is perceived to change to negative stress) between positive (contributing to job outcomes) and negative (not contributing to job outcomes) stress were lower than those for other types of stress, for all professional groups. The mean transition points for emotional indicators of stress were higher than those for either physical or mental indicators; but for this indicator female respondents recorded a significantly lower transition point value than male construction professionals. Critical project time constraints; level of co-operation from other project stakeholders; having to work long hours; critical project cost constraints; and having to skew the work/family life balance were found to be the top five project-related job demand factors in terms of perceived importance in contributing to stress, with no significant differences emerging between professional groups or between genders. However, female respondents recorded significantly higher mean values than males for three lower-ranked factors: disruption of meals patterns; disruption of leisure activities and disruption of exercise or sports activities. The findings suggest that stress management (mitigation) strategies by organisations could more carefully target the type of stress encountered. Strategies should also carefully monitor employee working hours, and recognise the particular needs of female construction professionals. Continuing administration of the survey is planned to improve validation of the results.

Keywords: occupational stress; construction professionals; South Africa

INTRODUCTION

Work-related (occupational) stress is "*the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker*" (NIOSH, 1999). To that definition might be added the sub-optimal situations where a worker's mental capacity is overwhelmed by demands of problem solving and/or decision-making. Occupational stress thus has physical, mental and emotional dimensions.

This paper reports on the preliminary findings of research that, *inter alia*, explores levels of stress and job demands through the perceptions of professionals working in the South African construction industry. Following a brief contextual background, the research design, survey administration and data analysis are described. The results are presented and discussed; and conclusions drawn.

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WORK-RELATED STRESS

In terms of the NIOSH (1999) definition of occupational stress, the physical *strain effects* of human stress are associated with cardiovascular diseases (Kivimäki *et al*., 2002), musculoskeletal disorders (Hoogendoorn *et al*., 2000), and repetitive strain injuries (Ariëns *et al*., 2001). Mental strain effects may be responses such as difficulty in concentration, the intensity of intellectual effort required; the need to optimise decision-making; and the need for multi-tasking. Emotional strain responses include frustration; anger; and feelings of helplessness, fear and panic.

Physical, mental or emotional health impairment arising from stress may lead to longer periods of work absence and higher direct costs per health claim than other injury/illness categories. Treatment may take longer, and eventual recovery to complete well-being may be less certain.

The association between stress and the demands of work is well known. The Job Demand-Control (JDC) model of occupational stress (Karasek, 1979) proposes that work that is simultaneously high in demands and low in control produces the most stressful responses and is most damaging to health (Belkic *et al*., 2004; De Lange *et al*., 2004).

While the general connotation of stress is almost wholly negative (i.e., harmful to personal well-being), a view is held that, up to a point, some intermittent work-related stress may be beneficial (Dienstbier *et al.,* 1989; Park and Fenster, 2004). It puts workers “on the edge”, spurring extra effort and creativity. The problems with this view are that we do not know where the transition points occur between ‘good’ and ‘bad’ stress; nor if the transition points are different for different types of stress; or if workers in different occupations experience different transition points. Gender differences might also arise. While the Dienstbier study measured the physiological presence of substances such as adrenaline and noradrenaline under different stress situations; the Park study was conducted longitudinally with repeated administration of a set of self-assessment measures. Neither study attempted to yield a transition point.

Similar questions arise with respect to the job demand factors that can influence stress. Do people employed in different occupations have similar perceptions of the importance of various factors that impose demands on their working lives?

These questions spearhead the current research into work-related stress for people engaged in professional occupations in the construction industry.

RESEARCH DESIGN, ADMINISTRATION AND DATA ANALYSIS

Field-administered survey questionnaires are used for primary data collection. The complete instrument design is multi-sectional, incorporating a one-week work log/diary (provided in two format options); an eight-interval catalogue of descriptors for physical, intellectual and emotional stress state indicators (see Table 1); three catalogues for: job demand factors (25 items: see Table 4), job control factors (19 items) and job support factors (17 items). Further sections comprise: three catalogues for physical (15 items), psychological/emotional (18 items) and sociological (6 items) strain effects; and three catalogues for physical (17 items), mental (25 items) and other (negative, 10 items) stress countermeasures. Respondents are offered 5-point Likert scale options to indicate perceived levels of importance, intensity or degree of contribution, and are also asked to rank the top five items in each catalogue in terms of their own work experience. Finally, participants are asked to describe a recent work-related stress experience in greater detail.

Given the complexity of the instrument, field interviews with participants are necessary to explain the research and the requirements more fully. Interviewees may record their responses immediately if they have sufficient time available. Alternatively, after the explanatory process is completed, respondents can treat the instrument as a ‘take-away kit’ to complete in their own time. Thus, while data collection largely relies on a survey questionnaire approach, the explanatory interviews often yield useful qualitative information.

Only the survey instrument sections dealing with *stress level indicators* and *job demand* factors are dealt with in this report. The job control and support issues associated with this research are reported elsewhere (Bowen *et al.*, 2015). Analysis of response data for the remaining questionnaire inventory (e.g., work diary, strain effects, stress counter-measures and personal stress experiences) is currently underway.

Table 1 shows the indicators for work-related professional stress, separately aligned as physical, mental and emotional states. The intervals define a range of *self-perceived* states progressing from complete absence of stress to almost total distress and personal incapacitation.

The stress state descriptors were designed by the researchers, with assistance from an industrial psychologist. Participants are asked to draw a line across the table at the point (in each column) where they think a transition *should* occur between “positive” stress (contributes to work outcomes) and “negative” stress (hinders or detracts from work outcomes). They are advised that the line can be stepped. The *a priori* research expectation, based upon the state descriptors, is that the line will most frequently be placed between intervals 2 and 3 for physical and mental stress (i.e., before physical distress or mental difficulty start to occur); and between 3 and 4 for emotional stress (i.e., before the onset of fear).

The 25-item catalogue for perceptions of job demands is shown in data analysis Table 4. Survey participants can nominate up to two additional factors. They are asked to rate the importance of each factor, on a scale of 1–5 (1=negligible contributor to workplace stress; 5=major contributor; without other interval definitions). They are also asked to rank, from their own work experiences, the top five factors in terms of *frequency* encountered. The latter rankings are reverse coded in the data analysis so that: 5=most frequently encountered. This is to allow more complex analysis. It is envisaged that the five *frequency* rankings would not necessarily match the five highest-rated factors for *contribution to stress* since, while respondents might regard a particular factor as capable of making a major contribution to stress, they might seldom or never have experienced it in their own work experience. The rationale for this approach in the instrument is that, although a job demand factor might be quite onerous in terms of its effect upon stress, a less demanding factor might lead to a similar stress result if experienced more frequently.

While not exhaustive, the Table 4 catalogue attempts to embrace, through the literature and the collective personal experiences of the researchers, typical job demand situations encountered by professionals working on projects in the construction industry. In fact, *no additional* factors have been offered by survey respondents to date. To some extent, the catalogue also attempts to reflect factors that may be more relevant to partners or sole principals in professional consultancies than to employees. The *a priori* assumption is that the ‘iron triangle’ of project ‘time/cost/quality’ will dominate the job demand responses (with the “Level of professional skills required” factor serving as the experiential surrogate for quality).

Table 1. Descriptors for occupational stress level indicators

Scale Interval	Physical Indicator	Mental Indicator	Emotional Indicator
0	Completely comfortable and untroubled physically.	Routine work requiring minimal concentration	Relaxed, at peace. Satisfied with work performance.
1	Relaxed, comfortable. Good energy level sustained	A few things have to be thought through but no great intellectual demand	Feeling calm, pleased with work performance.
2	Not tense or uncomfortable Adequate energy level.	Aware of need to concentrate. Significant creative / analytical thinking required.	Excited by process and achievements.
3	Occasional tenseness felt. Some tiredness. Rest and/or recreation break desirable.	Much greater concentration needed. Multi-tasking may be required.	High personal satisfaction with process and progress.
4	More frequent or longer tension periods. Some skeleto-muscular aching. Fatigue more evident. Occasional breaks needed.	Close focus and substantial problem-solving skills required. Shorter attention span experienced.	Relief when some issues resolved. Residual concern over outstanding issues.
5	Persistent tension felt. Occasional headaches, shoulder or neck pain. Frequent breaks needed.	Difficult to concentrate effectively. Easily distracted. Any interruptions affect ability to focus.	Frustrated with progress. Annoyed by small disappointments.
6	Constant tension. More frequent aches and pains. Constantly fatigued.	Cannot think clearly about work issues. Even minor or trivial matters seem difficult. Attention span seriously diminished.	More frequent feelings of anger. Blaming self (depression) and others (rows and conflict). Frequent “fight or flight” feelings.
7	Lethargic inertia. Intense headaches, aching or per-sistent distress.	Overwhelmed by situation. Cannot focus or think properly upon anything about or beyond work situation.	Feeling helpless, isolated, desperate. Close to panic.

Purposive convenience sampling is used to develop the response sample for the survey. Purposive sampling seeks to achieve adequate representation of professional disciplines and gender differences. Convenience sampling in this instance is victim to the financial and logistical feasibility constraints imposed on the research. These have so far restricted the target frame to professionals working in the construction industry in the Western Cape province of South Africa, and largely to the metropolitan boundaries of Cape Town. Convenience was also exploited for the initial response by re-approaching professionals who had participated in an earlier value-management research project.

The survey commenced in February 2012 and continues incrementally to date. Initial field interviews were conducted by the researchers, and the first ten treated as a pilot test for the instrument. Comments about the length of the questionnaire were made by interviewees, but no changes were suggested. Ongoing fieldwork is now carried out by Honours students as a research training activity. The response sample to date totals 36 interviews with construction professionals, each conducted in respondents’ own offices. The respondent profile is shown in Table 2. While the sample is small, it has an adequate gender and professional discipline spread. Nevertheless, the findings should be regarded as preliminary.

For the stress level indicator data, modal values represent discrete transition points. The mean score values are used to explore gender and between-groups differences. Range values are also calculated. The Cronbach’s alpha for the job demand data is 0.89, indicating excellent internal consistency. No missing or anomalous cases have been detected.

Table 2. Profile of survey respondents

Profession	Male	Female	Total
Architects	7	4	11
Project & Construction Managers	7	1	8
Engineers	4	1	5
Quantity Surveyors	7	5	12
Totals:	**25**	**11**	**36**

The response data for job demand factors are subjected to more extensive analysis, commencing with the Kolmogorov-Smirnov test for normality. For all factors, values of the statistic are all below 0.05 indicating a violation of the assumption of normality. Non-parametric techniques are therefore used to examine differences between groups in terms of gender and profession. The Mann-Whitney U Test is used to test for differences in the job demand factor scores on the basis of gender, and the Kruskal-Wallis H Test for differences between professional groups. Median factor values are used to explore factor clusters.

RESULTS

For a transition point from positive to negative stress, a modal value of '3' occurs for *physical stress* for both male and female survey respondents and across all professional groups. Modal values of '4' occur for *mental stress* and for *emotional stress*, again with no differentiation between genders, nor between professional disciplines. These results suggest that the *a priori* assumptions for these transitions are mistaken – by one indicator level in each case. The mean transition score values (Table 3) support this finding, although for *emotional stress* the female mean score value is significantly less (3.55: $p<0.05$) than the male mean score value (4.16). While differences in mean values occur between the professional groups, none of these are significant. For perceptions of physical stress indicator levels and a transition point between positive and negative stress, architects record a higher mean transition point value than other construction professionals; while project and construction managers record the lowest mean point value.

Table 3. Mean values of perceived stress level indicator transition points

Stress Indicator Type	All (n=36)	Male (n=25)	Female (n=11)	Between gender p-value
Physical indicator	3.22 (+/-0.012)	3.32 (+/-0.150)	3.00 (+/-0.191)	0.253
Mental indicator.	3.67 (+/-0.126)	3.84 (+/-0.111)	3.27 (+/-0.304)	0.094
Emotional indicator	3.97 (+/-0.135)	4.16 (+/-0.149)	3.55 (+/-0.247)	***0.046****

Notes: Mann-Whitney Test used for gender; Kruskal-Wallis Test used for differences between professional groups; * $p<0.05$.

The range values for the stress level transition point indicators reveal that no zero values are reported. For the physical and emotional stress indicators, the reported values range from level 2 – 5; while for mental stress indicators the reported values range from 1 – 5.

Only the importance ratings for the job demand variables are dealt with in this paper. As Table 4 shows, the top five job demand factors, in terms of their perceived importance as contributors to stress, are: critical project time constraints; co-operation from other project stakeholders; long working hours required; critical project cost constraints; and the consequential skewing of desirable work/family life balance.

The *a priori* assumptions regarding job demands are supported to some extent, although quality (through the surrogate ‘Level of professional skills required’ factor) is perceived as not important in contributing to occupational stress; and the ‘project cost constraints’ factor is somewhat decisively beaten into fourth place by ‘Co-operation from other project stakeholders’ and by ‘Working long hours’.

Although not ranked in the top five job demand factors, significant differences between male and female construction professionals’ perceptions are found for: ‘Disruption to meals patterns’ (n=22; p=0.014); ‘Disruption to leisure activities’ (n=10; p=0.017); and ‘Disruption to exercise/sports activities’ (n=11; p=0.017). Females report these three factors as more important in contributing to work-related stress than do males. None of the job demand factor results show any significant differences in terms of professional discipline. Median factor importance values are analysed to investigate if any factor clusters occur. It was thought that these might be identifiable as distinct categories. The results are inconclusive and no clear categories emerge from the data in terms of importance as contributors to occupational stress.

Table 4. Mean perceived importance values for job demand factors (n=36)

Job Demand Factor	**Mean importance value (+/- standard error)**	**Rank**
Critical time constraints.	4.06 (+/-0.178)	**1**
Critical cost constraints.	3.42 (+/-0.180)	**4**
High level reporting demands.	2.58 (+/-0.223)	15
Frequency of reporting demands.	2.47 (+/-0.197)	18
Complexity of project problems.	2.94 (+/-0.207)	8
Adequacy of technical resources (ICT, etc.).	2.62 (+/-0.223)	13
Task frustrations (interruptions).	2.92 (+/-0.193)	9
Co-operation from other project stakeholders.	3.69 (+/-0.168)	**2**
Level of professional skills required.	2.44 (+/-0.197)	21
Amount of professional experience required.	2.50 (+/-0.185)	17
High level meetings required.	2.47 (+/-0.185)	19
Number of meetings required.	3.03 (+/-0.209)	7
Leadership skills needed.	2.44 (+/-0.212)	22
Number of other staff involved.	2.47 (+/-0.180)	20
Information processing level required.	2.64 (+/-0.196)	12
Long working hours required.	3.50 (+/-0.205)	**3**
Interpersonal skills required.	2.60 (+/-0.184)	14
Red tape levels encountered.	3.11 (+/-0.261)	6
ICT competence level required.	2.09 (+/-0.236)	23
Need to ‘prove’ oneself.	2.57 (+/-0.210)	16
Skewing of work/ family life balance.	3.40 (+/-0.236)	**5**
Job travel demands.	2.03 (+/-0.161)	24
Disruption to meals patterns.	2.23 (+/-0.205)	22
Disruption to leisure activities.	2.89 (+/-0.235)	10
Disruption to sport/ exercise activities	2.86 (+/-0.240)	11

Notes: Mann-Whitney Test used for gender; Kruskal-Wallis Test used for differences between professional groups.

However, *personal competencies and skills* rate quite low (median value 2) in importance in contributing to stress. Demand factors relating to *work processes* such as reporting levels, reporting frequency, number of meetings required, and amount of information processing required, all have median values of 3 (i.e., fairly important contributory factors). Demand factors with median value 4 importance ratings comprise those constituting the top five-rated factors indicated above. Two of these can be categorised as *project characteristics* (time constraints, cost constraints); one is *inter-personal* (co-operation from other project stakeholders); one is related to *project processes* (having to work long hours); and one is *personal* (skewing of work/family life balance).

DISCUSSION

The preliminary findings give rise to the proposition that construction professionals may be prepared, at least for a time, to regard some negative physical stress arising from their work on projects as beneficial to job outcomes, even if the work itself is mentally challenging and there is lingering emotional concern over un-resolved issues. Given that the response data range values represent the compass of respondents' different perceptions of transition points between positive and negative stress, those results are surprising. More narrowly-grouped ranges were anticipated, and the results suggest that some survey participants may have been 'conditioned' to regard persistent tension, occasional headaches, shoulder or neck pain, difficulty in concentration, frustrations and annoyances, as either simply incidental to getting the job done or as a spur to greater effort. More alarming is that views of positive stress are predicated on *intermittent* experiences. In the Table 1 descriptors, the labels for physical stress indicators in Levels 5 – 7 were deliberately couched in terms such as 'persistent' and 'constant'. If the Level 3 indicator for physical stress is accepted as a genuine transition point, then any strain effect beyond that, even if intermittently experienced, must be seen not only as potentially counter-productive (despite any perception of a positive contribution to job outcomes) but also as constituting a serious danger to the health and well-being of a person.

The top five ranked job demand factors (Table 4) do not quite match the *a priori* 'iron triangle' expectations. Project time (i.e., the time required to deliver a project to the client) emerges as the factor with the highest importance in terms of contributing to occupational stress for the construction professionals involved in the procurement process. If time constraints are seen as unreasonable, this is likely to lead to a more rapid onset and higher levels of stress.

Achieving the co-operation of other project stakeholders (an objective made more difficult by the fragmented nature of the construction industry) may require high-level interpersonal relationship skills than can be demanding mentally, emotionally and physically.

If project time constraints are critical, then long working hours (a typical feature of the construction industry) are probably inevitable. Project cost constraints (meeting pre-determined budget or performance targets) limit the solution space available to construction professionals. The mental and emotional demands this imposes may be stressful.

The first four demand factors, as well as others relating to professional processes involved in delivering construction projects, can lead to the creation of another demand factor whereby lifestyles outside the work environment have to be adapted to meet the requirements of work. While this adjustment may be reluctantly tolerated in the short term, it may eventually become intolerable in all three stress dimensions: emotionally, mentally and physically; and burn-out or breakdown occurs.

For the three factors where female professionals' importance ratings are significantly higher than those of male respondents, a possible explanation is that the demands of work may entail forced changes to preferred or planned lifestyles, and females find this consequence more stressful than males (Lingard and Francis, 2004). Whether the changes are personal, or have to be made on behalf of other family members is not ascertainable from the data, but women professionals with family responsibilities may already be making compromises with domestic arrangements that are then further skewed through the demands of work on particular projects. Support for this explanation is found in the higher (although not significantly different) mean rating values among female respondents for the demand factor 'Skewing of work/ family life balance' (Overall ranking 5; males: 3.21; females: 3.82).

The cluster analysis suggests that construction professionals do not tend to experience stress in relation to their professional capability – they are confident in their ability to do the job, whatever the level of expertise required. Project processes that are more administrative (e.g., reporting and meeting frequencies and levels) appear to be important in their capacity to generate stress. They take up time that professionals may think could be better spent on other features of projects. The typical constraining characteristics of individual projects (time and cost) conspire to create high potential for stress, but a key factor in the top-ranked group is No.2 (co-operation from other project stakeholders). Essentially this involves interpersonal relationship management, reinforcing the view that construction is a social, as much as a technical, process.

Published work dealing with similar occupational stress issues in cognate industries and professions is scarce. However, other studies provide continuing general support for the JDC stress model, for example, Angelo and Chambel (2013) in their research among fire-fighters; von Humboldt *et al*. (2013) for management consultants; and González-Muñoz and Gutiérrez-Martinez (2007) for electrical workers.

CONCLUSIONS

Analysis of response data gathered from a sample of 36 construction professionals in South Africa has yielded interesting preliminary findings. Many respondents perceive a transition point between positive and negative stress occurring at a level that, for physical stress, is clearly dangerous to health and well-being. Professionals, and employer organisations, must be far more careful in monitoring work environments to detect if such levels are occurring more than just intermittently. The mental and emotional stress levels of professionals in the workplace should also be monitored carefully.

Good interpersonal relationship skills are vital for all construction professionals. So too are the development and implementation of appropriate personal and organisational stress management strategies. Individually, construction professionals must learn to recognise their own stress limits and how to deal with stress arising in the workplace. Helpful stress management guidance is found in Munz *et al*. (2001) who suggest that organisational stress reduction processes should identify work stressors and their relative impact; undertake root cause analysis; plan and implement causal minimisation/removal strategies; and evaluate success. Self-management strategies for individuals might include *situational* skills to minimise initial stress reactions (cognitive re-programming; movement exercises; breathing/self-centering techniques). *Renewal* skills would aid recovery from physical, mental and emotional strain effects (power naps; relaxation techniques); while *preventative* approaches would strengthen adaptive capability and reduce susceptibility (movement meditation; mental re-imaging; inner silence focusing). Above all, however, mutual *awareness* of work-related stress, its causes and effects, is vitally important among construction professionals and their employing organisations.

ACKNOWLEDGEMENTS

The authors acknowledge the contribution to this research by the following Honours students in the Department of Construction Economics and Management at the University of Cape Town: Yamiko Chanje; Chido Chikumbu; and Unangoni Munamati. Grateful thanks are extended to the interviewees for their willing and often enthusiastic participation.

This work is based on the research supported in part by the National Research Foundation of South Africa (Grant specific unique reference number (UID) 85376). The Grantholder acknowledges that opinions, findings and conclusions or recommendations expressed in any publication generated by the NRF supported research are those of the author(s), and that the NRF accepts no liability whatsoever in this regard.

REFERENCES

Angelo, R.P. and Chambel, M.J. (2013) The reciprocal relationship between work characteristics and employee burnout and engagement: a longitudinal study of firefighters. Stress & Health. Vol. 31, No. 2, pp. 106-114.

Ariëns, G.A.M., Bongers, P.M., Hoogendoorn, W.E., Houtman, I.L.D., van der Wal, G. and van Mechelen, W. (2001) High quantitative job demands and low co-worker support are risk factors for neck pain: results of a prospective cohort study. Spine, Vol. 26, No. 17, pp. 1896-1901.

Belkic, K.L., Landsbergis, P.A., Schnall, P.I. and Baker, D. (2004) Is job strain a major source of cardiovascular disease risk? A critical review of the empirical evidence, with a clinical perspective. Scandinavian Journal of Work, Environment & Health, Vol. 30, No. 2, pp. 85-128.

Bowen, P.A, Edwards, P.J. and Cattell, K.S. (2015) Perceptions of the relative importance of job control and support factors, as moderators of workplace stress, among construction professionals in South Africa. Proceedings: ARCOM (Association of Researchers in Construction Management) 31st Annual Conference. University of Lincoln, UK. 11-12 September, 2015 (in publication).

De Lange, A.H., Taris, T.W., Kompier, A.J., Houtmans, I.L.D. and Bongers, P.A. (2004) The relationship between work characteristics and mental health: Examining normal, reversed and reciprocal relationships in a 4-wave study. Work and Stress, Vol. 18, No. 2, pp. 149-166.

Dienstbier, R.A. (1989) Arousal and physiological toughness: implications for mental and physical health. Psychological Review, Vol. 96, No. 1, pp. 84-100.

González-Muñoz, E.L. and Gutiérrez-Martinez, R.E. (2007) Contribution of mental workload to job stress in industrial workers. Work, Vol. 28, No. 4 pp. 355-361.

Hoogendoorn, W.E., van Poppel, M.N.M., Koes, B.W. and Bouter, L.M. (2000) Systematic review of psychosocial factors at work and private life as risk factors for back pain. Spine, Vol. 25, No. 16, pp. 2114-2125.

Johnson, J.V., Hall, E.M. and Theorell, T. (1989) Combined effects of job strain and social isolation on cardiovascular disease morbidity and mortality in a random sample of the Swedish male working population. Scandinavian Journal of Work, Environment and Health, Vol. 15, No. 4, pp. 271-279.

Karasek, R.A. Jr. (1979) Job demands, decision latitude and mental strain: implications for job design. Administrative Science Quarterly, Vol. 24, No. 2, pp. 285-308.

Kivimäki, M., Leino-Arjas, P., Luukkonen, R., Riihimäki, H., Vahtera, J. and Kirjonen, J. (2002) Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. British Medical Journal, Vol. 325, No. 7369, pp. 857-863.

Lingard, H. and Francis, V. (2004) The work-life experiences of office and site-based employees in the Australian construction industry. Construction Management and Economics, Vol. 22, No. 9, pp. 991-1002.

Munz, D.C., Kohler, J.M. and Greenberg, C.I. (2001) Effectiveness of a comprehensive work site stress management program: combining organisational and individual interventions. International Journal of Stress Management, Vol. 8, No. 1, pp. 49-62.

NIOSH (1999) Stress…At Work. Publication No. 99-101. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health: Cincinnati, OH.

Park, C.L. and Fenster, J.R. (2004) Stress-related growth: predictors of occurrence and correlates with psychological adjustment. Journal of Social and Clinical Psychology, Vol. 23, No. 2, pp. 195-215.

von Humboldt, S., Leal, I., Laneiro, T. and Tavares, P. (2013) Examining occupational stress, sources of stress and stress management strategies through the eyes of management consultants: a multiple correspondence analysis for latent constructs. Stress & Health, Vol. 29, No. 5, pp. 410-420.

THE OCCUPATIONAL STRESSORS, BURNOUT, AND NEAR MISS EVENTS AMONG CONSTRUCTION WORKERS

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[The role of construction workers (CWs) is often associated with diverse sources of stress, while stress can cause both the physical health problems and emotional exhaustion to CWs. Moreover, suffering from stress increases CWs exposure to dangerous situations. This study therefore aims to promote the prevention of near misses for CWs by exploring ways in which they can manage occupational stressors and release burnout. Based on the extensive literature, a questionnaire survey was adopted to collect data from CWs in Hong Kong. A total of 209 responses were received. In order to investigate the relationships among stressors (i.e., unsafe climate, poor supervisor support, poor coworker support, job certainty and job control), burnout, and near misses, various statistical techniques including reliability analysis, correlation and multiple regression analysis were applied. The results of both the correlation and regression analysis show that: (1) poor supervisor support is predicted by unsafe climate, job certainty and poor coworker support, and unsafe climate is predicted by job control and poor coworker support; (2) burnout of CWs is directly exacerbated by poor coworker support; and (3) poor supervisor support and burnout can lead to near miss events among CWs. Based on the results, a number of practical suggestions, including appropriate work assignment, establishing hometown associations, promoting the value of peer support, and organizing Mindfulness-based Stress Reduction program are proposed for the stress management of CWs in the industry. Little work has so far been done in the study of the complicated relationships between occupational stressors, burnout, and near misses in the construction industry, though stress management plays an essential role in the industry. This study fills the research gap by investigating the interaction between stress management and accident prevention for CWs.]

Keywords: Burnout; Construction workers; Near miss; Occupational stressors.

INTRODUCTION

Construction workers (CWs) are responsible for construction activities, and their performance is essential for the success of construction projects. Hence, they are often forced to focus on productivity even at the expense of their own safety, which results in a high accident and fatality rate (Mitropoulos and Memarian 2012). However, in addition to the reported accidents, there are even more near miss events. In fact, the ratio of near miss events to major injury accidents (e.g. fatalities) may be as high as 600:1 (Bird 1974).

The occurrence of near misses has been attributed to factors such as crowded working environment, unsafe conditions, and poor safety awareness (Choudhry and Fang 2008). In addition to the inherently dangerous nature of the work involved, the construction industry is also a stressful industry in which the majority of construction personnel have been found suffering from stress (CIOB 2006). In fact, CWs have double suicide rate of general population, which reflects their high stress level to some extent (Jacobsen et al. 2013).

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Several studies have been carried out to investigate the relationship between accidents and stress (e.g., Goldenhar et al. 2003). However, there is still a lack of comprehensive study on the relationship between burnout and near misses. Hence, the current study sets out to investigate the complicated relationship between occupational stressors, burnout, and near misses using a scientific methodology.

Near Miss

Near miss events is the term used to describe dangerous events that result in no injury to the personnel involved (Bird 1974). They are more frequent than accidents, but the majority of near misses are not reported and recorded. Loss of control over near miss events will not only cause significant negative consequences to individuals but also to the organization and the community. Near misses can also be caused by occupational stressors such as unsafe climate, low job control, lack of support from supervisor or coworkers, job uncertainty, and so on (Abbe et al. 2011). It has also been found that burnout can lead to near misses in other professions (Li et al. 2013).

Occupational Stressors

Occupational stressors are the stimulus in working environment that result in CWs' emotional and/or physiological responses (Lazarus and Folkman 1984). Facing stressor can induce stress to CWs (e.g., Leung et al. 2014), and even, directly lead to poor safety performance at work (Goldenhar et al. 2003). It is true that CWs' unsafe work practices often expose themselves to increased risk of accident, such as being struck by materials, being caught between machinery, and so on (Choudhry and Fang 2008). The safety climate, in terms of employees' perceptions of the value of safety, can greatly affect the incidence of unsafe practices. Safety climate relates to whether CWs work safely, whether their safety is valued within the organization, and whether safety is emphasized by CWs' supervisors (Christian et al. 2009). It has been found that a safe climate not only leads to the reduction of near miss events, but can also affect the psychological stress of CWs (Goldenhar et al. 2003).

Supervisor support is necessary for CWs to efficiently and effectively complete their work and address problems. Lack of or poor supervisor support results in high stress levels among CWs, and increases their exposure to near miss events and accidents (Iverson and Erwin 1997). Complicated construction tasks make it necessary for CWs to work as a team in which they cooperate and help with each other (Mitropoulos and Memarian 2012). Hence, coworker support, which refers to work-related assistance given by coworkers to help them carry out their own tasks, is important and necessary (Susskind et al. 2000). Receiving poor coworker support can induce burnout among CWs, and result in near misses or accidents (Sherry 1991).

Job control is defined as the perceived ability of employees to exert influence over their job in the workplace. It concerns the individual's degree of autonomy and participation in decision-making processes affecting their work. It has been confirmed that a lack of job control may cause stress, and even lead to injury or near misses (Bowen et al. 2013). In the construction industry, job certainty has long been regarded as one of the occupational stressors given that CWs are often employed project by project and have very little job certainty. Lack of job certainty can result in burnout, as well as accidents (Abbe et al. 2011).

Burnout

Burnout is a syndrome of physical and emotional exhaustion that results from chronic exposure to sources of occupational stressors (Yip and Rowlinson 2009). Within the working environment, there are many occupational stressors that can induce burnout, including a lack of job control, a low level of job certainty, and poor job support (i.e. supervisor and coworker support) (Sand and Miyazaki 2000). People suffering from burnout feel a lack of energy, exhausted emotional resources, and so on, which results in lower performance levels as well as near miss events (Leung et al. 2008).

CONCEPTUAL MODEL

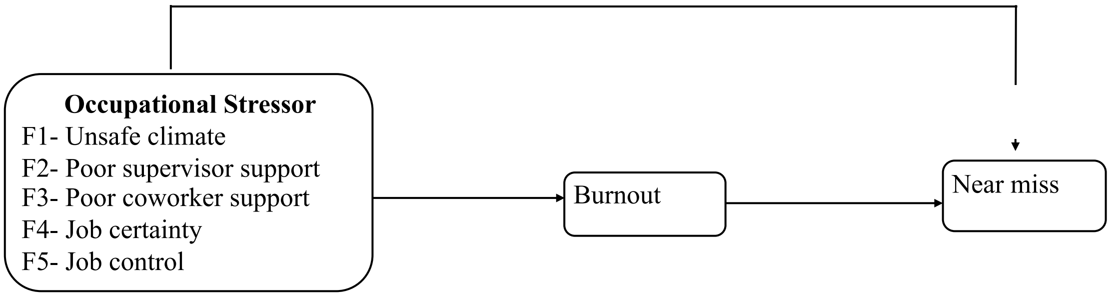


Figure 1 Conceptual Model of Stressors–Burnout–Near Miss Events for CWs

Based on the literature, we hypothesize that occupational stressors can directly result in near miss and/ or indirectly lead to near misses among CWs through burnout. The conceptual model consists of five occupational stressors (unsafe climate, poor supervisor support, poor coworker support, job certainty, and job control) that contribute to burnout and near miss (see Figure 1).

RESEARCH METHOD

In order to collect data for investigating the complicated relationships between occupational stressors, burnout, and near misses among CWs, a questionnaire was designed and disseminated among CWs in Hong Kong via fax, e-mail, or personal contact. In addition to personal information, the questionnaire includes a five-stressors scale (Goldenhar et al. 2003) and a burnout scale (Maslach et al. 1996). Using a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), participants rated their levels of agreement with each statement. They were also asked to report the total number of near misses that they had experienced at work during the past year. Statistical analyses, including reliability analysis, Pearson correlation and multiple regression, were then used to analyze the data.

In order to control the quality of data, purposive sampling was adopted. A total of 500 surveys were distributed to CWs who: 1) were skilled workers; 2) were qualified in a specific work trade (e.g. carpenter, bricklayer, pile operative); and 3) were currently working either for a main contractor or subcontractor. Of 500 distributed questionnaires, 209 were returned, representing a response rate of 41.8%. Eleven per cent of respondents were aged 21-30, 19% were aged 31-40, 42% were aged 40-49, and 28% were aged over 50. Almost half of them (48.3%) had amassed over 20 years of work experience in this industry.

Statistical Results

Reliability analysis was used to test the internal consistency of scales, and Cronbach's alpha was used to indicate the degree of reliability (Pallant 2011). The alpha value ranged from 0.550 to 0.931, representing an acceptable reliability (Hair et al. 1998). Pearson's correlation analysis, which is used to identify the strength and direction of a relationship between two variables, was used to investigate the relationships between occupational stressors, burnout, and near miss events in this study (see Table 1).

Poor supervisor support is significantly related to all the other stressors (i.e., unsafe climate (F1: 0.207; $p<0.01$), poor coworker support (F3: -0.164; $p<0.05$), job certainty (F4: 0.231; $p<0.01$), and job control (F5: 0.149; $p<0.05$). Poor coworker support is negatively related to unsafe climate (F1:

-0.330; $p<0.01$) and job control (F5: -0.231; $p<0.01$). Job control is also related to unsafe climate (F1: 0.425; $p<0.01$). Only poor coworker support is related to burnout (BO: 0.164; $p<0.05$), and only poor supervisor support significantly correlates with near miss (NM: 0.162; $p<0.05$). CWs' burnout is correlated with near miss (NM: 0.154; $p<0.05$).

Table 1 Correlation Coefficients between Stressors, Burnout and Near Miss

Factors	F1	F2	F3	F4	F5	BO	NM
F1 Unsafe climate	1.000**						
F2 Poor supervisor support	.207**	1.000**					
F3 Poor coworker support	-.330**	-.164*	1.000**				
F4 Job certainty	-.084	.231**	.131	1.000**			
F5 Job control	.425**	.149*	-.231**	-.081	1.000**		
BO Burnout	.079	-.059	.164*	-.112	-.004	1.000**	
NM Near miss	.024	.162*	-.020	.046	-.007	.154	1.000

Note: **Correlation is significant at the 0.01 level (2-tailed);

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

Regression analysis is one of sophisticated analysis technique allowing for the prediction of dependent variable from a group of independent variables (Hair et al. 2010). It has been applied to investigate the interrelationships between five stressors, burnout and near miss. Various assumptions for multiple regression analysis have been checked, such as normality by inspecting normal probability plot of the regression standardized residual and multicollinearity by checking the value of Variance Inflation Factors (VIF). No violation to these assumptions has been found (i.e., the normal P-P plot of regression standardized residual display as a reasonable straight diagonal line from bottom left to top right, and all VIF value are within 10) (Pallant 2011). As time was not considered in current study, it is not necessary to consider autocorrelation (Johnson et al. 2007).

The Model 1 shows that burnout is positively predicted by poor coworker support and unsafe climate. In Model 2, Near miss is exacerbated by poor supervisor support and burnout. According to the results of both correlation and regression analyses, it is reasonable to infer that burnout mediates the relationship between poor supervisor support and near miss (Baron and Kenney 1986). Hence, multiple regression analyses have been conducted to test the possible mediating effect. However, the burnout did not regress on poor supervisor support in first model and the near miss regressed on both burnout and poor supervisor support in the last model. This confirmed that there is no mediating effect of burnout on the relationship between stressors and near miss. In order to investigate the interrelationships between five stressors,

Table 2 Regression Model for Stressors, Burnout and Near Miss

Dependent Variables	Variables	Beta	Sig.	VIF	R square	ΔR square	F(A)	Sig.
1a Burnout	Constant		.000		.027	.027	5.690	.018
	PCS	.164	.018	1.000				
1b Burnout	Constant		.000		.047	.020	5.039	.007
	PCS	.213	.004	1.122				
	Unsafe climate	.149	.039	1.122				
2a Near miss	Constant		.196		.026	.026	5.571	.019
	PSS	.162	.019	1.000				
2b Near miss	Constant		.181		.053	.027	5.775	.004
	PSS	.172	.012	1.004				

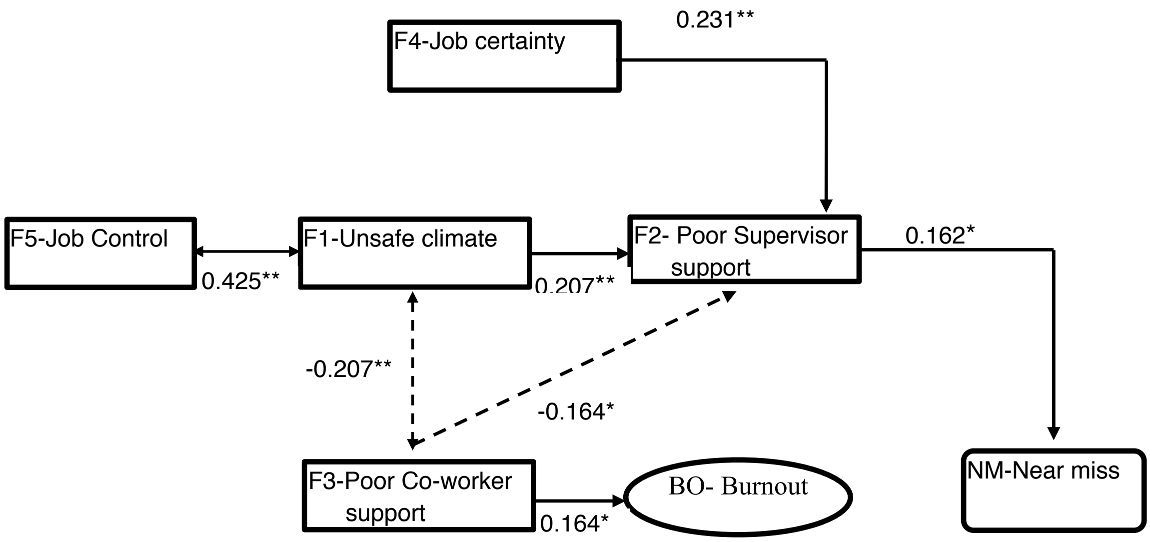
	Burnout	.165	.019	1.004				
3a Unsafe climate	Constant		.000		.181	.181	45.728	.000
	Job control	.425	.000	1.000				
3b Unsafe climate	Constant		.000		.238	.057	32.091	.000
	Job control	.369	.000	1.056				
	PCS	-.245	.000	1.056				
4a PSS	Constant		.000		.053	.053	11.684	.001
	Job certainty	.231	.001	1.000				
4b PSS	Constant		.000		.105	.052	12.099	.000
	Job certainty	.250	.000	1.007				
	Unsafe climate	.228	.001	1.007				
4c PSS	Constant		.000		.122	.017	9.483	.000
	Job certainty	.265	.000	1.019				
	Unsafe climate	.184	.009	1.124				
	PCS	-.138	.049	1.136				
5 PCS	Constant		.000		.109	.109	25.251	.000
	Unsafe climate	-.330	.000	1.000				
6 Job certainty	Constant		.000		.053	.053	11.684	.001
	PSS	.231	.001	1.000				
6 Job certainty	Constant		.000		.083	.030	9.272	.000
	PSS	.260	.000	1.028				
	PCS	.173	.011	1.028				
7 Job control	Constant		.000		.181	.181	45.728	.000
	Unsafe climate	.425	.000	1.000				

Note: PCS=Poor coworker support; PSS=Poor supervisor support;

Models 3-7 are also developed. The Model 4 shows that poor supervisor support is increased by job certainty and unsafety climate, but reduced by poor coworker support. The Models 3, 5 and 7 show that job control and poor coworker support can predict and be predicted by unsafe climate, respectively.

DISCUSSION

To ensure the reliability and validity of the research results, only the relationships that are confirmed by both correlation and regression analysis will be taken into account (see Figure 1). Poor supervisor support is predicted by unsafe climate, poor coworker support and job certainty. Unsafe climate is increased by job control, but reduced by poor coworker support. Burnout is found to be induced by poor coworker support only. Poor supervisor support and burnout will increase the rate of near miss.



Note: significant negative relationship confirmed by regression analysis;
significant positive relationship confirmed by regression analysis.

Relationship between Occupational Stressors

Poor supervisor support is positively predicted by unsafe climate and job certainty, but negatively predicted by poor coworker support. According to the social exchange theory, good supervisor support is the signal of supervisors' concern about the welfare of CWs. It can generate an implicit obligation for CWs to reciprocate by avoiding taking shortcuts, following safety regulations, and so on (Christian et al. 2009). Support from the supervisor may result in employee envy among CWs. A higher level of this envy ultimately decreases CWs' voluntary helping behaviour toward coworkers (Kim et al. 2010). CWs with higher level of job certain know how to support themselves if they lost their current job (Mak and Muller 2000). Hence, they may be lack of motivation for keeping good relationship with their supervisor, and thus, getting less support from their supervisor.

Unsafe climate is found to be exacerbated by job control, but released by poor coworker support. Perhaps, CWs need to spend some of their time helping other CWs, which will subsequently delay their own work and affect their safety outcomes (i.e. increase the likelihood of near misses). CWs who have job control over their job may perceive that their job is totally under their control, and thus underestimate the risk around them, which will increase the rate of near miss (Goldenhar et al. 2003).

Poor Coworker Support and Burnout

Among the five occupational stressors, only poor coworker support is positively related to burnout. Since construction tasks are often huge in size and complicated, CWs have to rely on each other at work so that they can successfully finish their job. Coworker support is therefore an important resource for maintaining mental and physical health (Lazarus and Flokman 1984), and serves as a predictor of burnout (Sand and Miyazaki 2000). This may be attributed to CWs lacking resources from their peers to resolve problems, discharge negative emotions, and so on, if their coworkers do not support each other in the workplace.

Poor Supervisor Support, Burnout, and Near Miss

The results also show that poor supervisor support and burnout are positively related to near miss events. Supervisor support, in terms of providing information, resources, and guidance, would make it more efficient and safe for CWs to work on construction sites. This will decrease the probability of near miss events for CWs. In addition, support from supervisors could reflect care and concern for the wellbeing of CWs. A clearly communicated and proactive approach to workplace safety by supervisors can lead to reciprocal behavior by CWs, in line with the idea of safety citizenship behavior (Mearns and Reader 2008). As a result, near misses will be reduced or even prevented. CWs who suffer from burnout can also cause near miss events. Burnout makes CWs feel fatigued, used up, and emotionally drained at work, which distracts their attention from their tasks and as a result places them at risk of dangerous events.

RECOMMENDATIONS

Lack of supervisor support can directly lead to near misses among CWs, while poor coworker support indirectly triggers near miss events through CWs burnout. Hence, it is necessary to pay more attention to the provision of adequate and appropriate support at work. As supervisor support is necessary for CWs to work efficiently and safely, supervisors have to offer all necessary information, resources, and guidance to CWs. In addition, the assignment of work to CWs should take into account their actual ability, so that, with the correct resources and information, CWs are able to finish their job as well as take care of their own safety at the same time.

Good relationships and support from coworkers are necessary for CWs to prevent burnout and resulting near misses. It is recommended, therefore, that construction companies facilitate the establishment of hometown associations among CWs, so that CWs can develop relationships with their colleagues and establish a friendly and supportive environment at work. In addition, it is also recommended that construction companies emphasize the importance of coworker support by advertising the benefits of coworker support, rewarding CWs who help their colleagues, and so on.

Construction organizations are also recommended to take direct action to release CWs' burnout, such as provision of psychological counselling, therapy, and so on. For instance, the construction companies can organize Mindfulness-based Stress Reduction (MBSR) training program for CWs which was introduced to enhance the well-being and release burnout through cultivation of mindfulness (Kabat-Zinn 2001).

CONCLUSIONS

CWs often face difficulties and dangers on the construction site. Their work environment not only exposes them to various high-risk events, but also induces burnout. In view of this, the present study set out to investigate the complicated relationships between occupational stressors, burnout, and near miss among CWs.

Five occupational stressors (unsafe climate, poor supervisor support, poor coworker support, job certainty, and job control) and their influence on burnout and near miss were identified in this study. The results showed that: (1) there are interrelationships between five stressors; (2) poor coworker support results in CWs' burnout, and burnout increase their near miss events; and (3) among five stressors, poor supervisor support can directly lead to near miss events among CWs.

Based on the research results, a number of practical suggestions, such as appropriate work assignment to CWs, establishing hometown associations, and promoting the importance of a supportive work environment, are proposed to prevent burnout and reduce the incidence of near miss events in construction industry.

ACKNOWLEDGEMENT

The work described in this paper was fully supported by the Strategy Research Grant project [Project No. CityU 7004273].

REFERENCES

Abbe, O.O., Harvey, C.M., Ikuma, L.H., Aghazadeh, F. (2011) Modelling the relationship between occupational stressors, psychological/physical symptoms and injuries in the construction industry. International Journal of Industrial Ergonomics, 41(2), 106-117.

Baron, R.M., Kenny, D.A. (1986) The moderator-mediator variable distinction in social psychological research: conceptual, strategic and statistical considerations. Journal of Personality and Social Psychology, 51(6), 1173–82.

Bird, F. (1974) Management Guide to Loss Control. Houston: International Safety Academy.

Bowen, P., Edwards, P., Lingard, H. (2013) Workplace stress experienced by construction professionals in South Africa. Journal of Construction Engineering and Management, 139 (4), 393-403.

Chartered Institute of Building (CIOB) (2006) Occupational Stress in the Construction Industry. Berkshire: CIOB.

Christian, M.S., Bradley, J.C., Wallace, J.C., Burke, M.J. (2009) Workplace safety: a meta-analysis of the roles of person and situation factors. Journal of Applied Psychology, 94, 1103–1127.

Choudhry, R.M., Fang, D. (2008) Why operatives engage in unsafe work behavior: Investigating factors on construction sites. Safety Science, 46(4), 566-584.

Goldenhar L.M., Williams L.J., Swanson N.G. (2003) Modelling relationships between job stressors and injury and near-miss outcomes for construction labourers. Work and Stress, 17(3), 218-240.

Hair, J.F.J., Anderson, R.E., Tatham, R.L., Black, W.C. (1998) Multivariate Data Analysis (5th ed.). New Jersey: Prentice Hall.

Jacobsen, H.B., Caban-Martinez, A., Onyebeke, L.C., Sorensen, G., Dennerien, J.T., Reme, S.E. (2013) Construction workers struggle with a high prevalence of mental distress, and this is associated with their pain and injuries. Journal of Occupational and Environment Medicine, 55(10), 1197-1204.

Johnson, R.A., Wichern, D.W. (2007) Applied Multivariate Statistical Analysis (6th eds.). New Jersey: Pearson Education Hall.

Iverson, R.D., Erwin, P.J. (1997) Predicting occupational injury: The role of affectivity. Journal of Occupational and Organizational Psychology, 70 (2), 113-128.

Kabat-Zinn, J. (2001) Mindfulness Meditation for Everyday Life. London: Piatkus.

Kim, S., O'Neill, J.W., Cho, H.M. (2010) When does an employee not help coworkers? The effect of leader-member exchange on employee envy and organizational citizenship behaviours. International Journal of Hospitality Management, 29(3), 530-537.

Lazarus, R.S., Folkman, S. (1984) Stress, Appraisal, and Coping. Springer Publishing Company.

Leung, M.Y., Chan, Y.S., Olomolaiye, P. (2008) Impact of stress on the performance of construction project managers. Journal of Construction Engineering and Management, 134(8), 644-665.

Leung, M.Y., Bowen, P., Liang, Q., Famakin, I. (2014) Development of a job-stress model for construction professionals in South Africa and Hong Kong. Journal of Construction Engineering and Management, 04014077.

Li, F., Jiang, L., Yao, X., Li, Y.J. (2013) Job demands, job resources and safety outcomes: The roles of emotional exhaustion and safety compliance. Accident Analysis and Prevention, 51, 243-251.

Mak, A., Mueller, J. (2000) Job insecurity, coping resources and personality dispositions in occupational strain. Work and Stress, 14 (4), 312-328.

Maslach, C., Jackson, S.E., Leiter, M.P. (1996) Maslach Burnout Inventory Manual (3rd eds.). Palo Alto, CA: Consulting Psychologists Press.

Mearns, K.J., Reader, T. (2008) Organizational support and safety outcomes: An un-investigated relationship? Safety Science, 46 (3), 388-397.

Mitropoulos, P., Memarian, B. (2012) Team processes and safety workers: Cognitive, affective, and behavioural processes of construction crews. Journal of Construction Engineering and Management, 138(10), 1181-1191.

Pallant, J. (2011) SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS (4th ed.). NSW: Allen and Unwin.

Petersen, J.S., Zwerling, C. (1998) Comparison of health outcomes among older construction and blue-collar employees in the United States. American Journal of Industrial Medicine, 34 (3), 280–287.

Powell, R., Copping, A. (2010) Sleep deprivation and its consequences in construction workers. Journal of Construction Engineering and Management, 136 (10), 1086-1092.

Sand, G., Miyazaki, A. (2000) The impact of social support on salesperson burnout and burnout components. Psychology and Marketing, 17(1), 13–26.

Sherry, P. (1991) Person-environment fit and accident prediction. Journal of Business and Psychology, 5 (3), 411-416.

Susskind A. M., Borchgrevink C. P., Michele Kacmar, K., Brymer R. A. (2000) Customer service employees' behavioral intentions and attitudes: an examination of construct validity and a path model. International Journal of Hospitality Management, 19(1), 53-77.

Yip, B., Rowlinson, S. (2009) Job redesign as an intervention strategy of burnout: Organizational perspective. Journal of Construction Engineering and Management, 135 (8), 737-745.

SCAFFOLDING COMPANY INITIATIVE TO IMPROVE PSYCHOSOCIAL WORK ENVIRONMENT OF WORKERS

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Work is a mechanism that enables people to develop and express their identities. Building the identity through work gives a necessary context for a meaningful life. Work pace control, autonomy, learning new skills, or participation in company decision making are specific psychological factors included in the job control dimension. On the other hand, high absenteeism and poor health are symptoms used to associate with poor psychosocial working environment. This industry paper presents the effort of a scaffolding company to improve the psychosocial work environment in their organisation. Due to several long sick leaves among its personnel the management contacted a health and safety consultant to help perform an assessment of their current conditions. Previously, the company measured the employees psychosocial work environment using various approaches in-house. Together with the consultant, a questionnaire that targeted specific psychological aspects that was deemed important was formulated to investigate the employees' psychosocial environment. A total of 148 questionnaires were sent out. A response rate of 38% was achieved. The result shows that overall the workers are satisfied with their psychosocial work environment. However, there were a few factors that merited the attention from the management: lack of communication and structure in the company, no feedback when an incident was reported; and lack of performance appraisal from management. Even though the response rate was modest, the management used the results to improve the situation.

Keywords: psychosocial, work environment, scaffolding workers, health and safety

INTRODUCTION

For the past 60 years, many research attempts have been undertaken to gain a better understanding of the relationship between work-related psychosocial risks and employees' health by means of theoretical models. Back in 1997, Jonge and Kompier had already highlighted the changing nature of work itself and its increased psychosocial workload. Psychosocial work environment means an individual's mental health and development that are affected by the conditions prevailing in the environment and the interaction with other people (Lennéer and Thylefors 2005). More specifically, the term may include job satisfaction, good physical condition, opportunity to grow, satisfactory wages, committed management, clear organisation, high job control and respect and empathy (Benavides et al 2002; Salem et al. 2008).

Psychosocial factors include exposures that effect the well-being and health of workers (e.g. temporal aspects of employment and the work itself, wages, work content, co-workers; supervision, organisational conditions) (Sobeih et al 2009; Tabenelli et al 2008. Zika-Viktorsson 2003). Additional, Kasl (1987) and Kristensen (1995) claimed that strain (i.e. workers' psychological and physiological reactions to stressors in terms of anxiety, depression, high blood pressure, heavy smoking, alcohol consumption, etc.) and coping strategies.

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Today much work poses mental and emotional demands, apart from the physical demands. Work is a mechanism that enables individuals to develop and express their identities (Christiansen 1999) where individual will, habits and experiences are integrated in their occupational identity (Kielhofner 2002). Building the identity through work gives the necessary context for a meaningful life, which facilitates the feeling of well-being (Arwedson et al 2007). People are healthy when they feel well and they function well in a social context. The essential health requisites are at a psychological and social level. Efforts have been made to gain more wisdom into the relationship between work-related psychosocial risks and health by means of theoretical models.

AIM OF THE STUDY

This study aims to present the initiative taken by a scaffolding company to measure the current psychosocial factors experienced by its employees. The management of the company is keen to continuously work hard to improve physical safety and well-being of its employees. Over the years the progress and success enjoyed by the company have had an impact on the psychosocial health of the employees. Therefore, the management deems it necessary to carry out regular assessments of the psychosocial environment throughout the organisation. This study presents the results of the latest assessment performed in 2014.

COMPANY PROFILE

The company in this study was founded in 1986 and started as a small family run scaffolding company. It has grown to include five regions and a number of subsidiaries. The regions are Gistad (region 1), Skåne (region 2), Stockholm (region 3), Östergötland (region 4) and Borås (region 5). Each region consists of its own management and project leaders, administrators and scaffold workers.

The company strive to provide safe scaffolding for every type of building projects. The personnel vary between 140 and 200 employees. During 2013, 96 accidents or near-misses were reported in all five regions. Of the reported accidents, most were falls to a lower level, tripping or struck by materials. Ten percent of these led to sick leave and close to ten percent required first aid. Fifty percent were considered to be due to unsafe behaviour.

The company allocate a lot of resources and effort to meet the requirements of several ISO-standards, e.g. ISO 9001 in Quality Management and the Swedish SIS-OHSAS 1001:2007 for work environment.

SCAFFOLDING WORK

Scaffold workers or scaffolders, are often exposed to physical and psychosocial stress. In 2013 there were as many as 204 reported accidents with absence of work (Samuelsson 2014). The biggest cause is fall followed by body movement with and without physical stress. Their work includes erecting and dismantling of scaffolds. Workers must have adequate training to identify the specific risks involved to perform the work safely.

To work with the assembling and dismantling of scaffolds requires an extensive amount of training and work experience. First, the scaffolder needs to work as a trainee for 4200 hours under supervision. During this time he or she will also receive education in the theoretical knowledge of scaffolding, mathematics, construction, weather impact as well as health and safety, including ergonomics. Upon completion of the trainee program, the worker is accepted as a certified scaffolder. This means he or she can build scaffolds independently. All training must meet the Swedish requirement. It is always the employer that is responsible for ensuring that the workers have the training required. A written plan must be provided before the work of assembling, using, making significant changes to, or dismantling a scaffold can begin.

In scaffolding work, tasks are often carried out in unfavourable postures with highly repetitive movements, and thus generating a load believed to increase the risk of injury. Siebert et al (2001) stressed that despite innovation in the working condition in the construction industry, adverse effects resulting from heavy lifting and carrying, static work, climate factors, noise, dust and stress still impose heavy burden that force workers into early retirement. Zika-Viktorsson et al (2003) noted that workers must be able to make quick adjustments and decisions regarding situations that may arise. They need a certain degree of autonomy in planning their work to meet deadlines. Additionally, rigid frames in term of time and resources, and the pressure to coordinate work with others at all times, can generate a heavy workload. Extended exposure to heavy workload, alongside ambiguous project roles and continuous changes in plan, may result in psychosocial stress reactions. In 2013, 56% ill-health problems among construction workers constitute of work load issues (Samuelsson 2014). The same report shows that 3 cases per 1000 workers are reported to be on sick absence for more than 14 days. Further efforts must still be made to reduce or eliminate occupational ill-health. Reduction in sick leave can be views as a commercial bonus.

CONSEQUENCE OF AN UNHEALTHY PSYCHOSOCIAL WORK ENVIRONMENT

It is the employer's responsibility to ensure that illness and accidents at work are prevented and that a satisfactory work environment is acquired.

According to Labriola et al (2006) there is a positive correlation between a good work environment and low rates of absenteeism. A sign of an unhealthy psychosocial work environment is where the individual is experiencing ill-health which leads to increased sickness absence. Benavides et al (2002) found that sickness absence is related to high work demand and low work control. Long sick absences will affect the company negatively by first losing skills that can be difficult to replace. Secondly, this will affect the company's economy in terms of providing a medical and rehabilitation program and replacement of the lost skill. In Sweden, the employer will be responsible to pay the sick leave for days 2-14 day (the first day is a waiting day, where the employer does not need to pay anything). Table 1 provides an example of an employer earning 300 000kr/year with job benefits such as 31.4% employers fees + 12 % holiday semester + 20% overhead.

As of the 15th day, the responsibility is transferred to the Swedish Social Insurance Agency since the sickness is classified as long-term sickness, although the company continues to pay employment taxes. For the example above, the sick benefit borne by the Swedish Social Insurance Agency is 4 466kr a week and can lead up to 232 870kr in a year for a prolonged absence. This system means that all absenteeism from work that is more than 15 days will eventually burden the society where taxpayers end-up paying for the leave. According to a study performed by Jonge and Kompier (1997), 35% of the disables employees claimed that they will still be working if preventive measures were taken at the early stage.

Table 1 - Salary earned when working (A) and salary earned when absent from work (B) in kr/hr.

A - Salary earned when working (kr/hr)	
Reimbursement rate 100%	
Salary	160
Employees fees	19
Holiday salary	56
Total	235
Overhead	32
Total salary paid by employer	267

B - Salary earned when absent from work (kr/hr)		
Reimbursement rate	Day 1	Day 2-14
	0 %	80 %
Salary	0	128
Employees fees	19	19
Holiday salary	6	46
Total	25	193
Overhead	32	32
Total salary paid by employer	57	225

* Day 15–180 can vary depending on the employment contract.

Examples of a satisfactory work environment are everything from influence, freedom of action and development, work variation, collaboration and social contacts. Therefore, all employers must systematically plan for the daily operations including physical, psychological and social factors as stipulated in the provisions Systematic work environment, AFS 2001:1. The provision stipulates that employers take care of work environment by examining, implementing and monitoring activities in the organisation. There shall be a company work environment policy that explains how a satisfactory work environment is to be achieved within the organisation. For an organisation of ten workers or more, a work environment policy and procedures must be documented.

QUESTIONNAIRE SURVEY

A quantitative study was used in the survey. The result from a quantitative study can be measured and valued numerically. A previous assessment of psychosocial health in the case organisation studied was made in 2011. The response rate of this survey was the lowest ever, only 34%. The results showed that the employees didn't feel involved or welcome to participate in the development of the company. The survey indicated that due to this, the employees felt less loyal and responsible towards the company.

No initiative for another assessment was taken between 2011 and 2014 mainly due to loss of key personnel. In 2014 the company initiated a new attempt with the help of a health and safety consultant company. The questionnaire of 2011 was used as a basis for the development of an improved questionnaire for 2014. Many questions were re-written or re-formed to capture better psychosocial aspects. Among the changes made were removing irrelevant questions that did not involve any psychosocial aspects, for e.g. questions about material-supply, material storage, clothes and the company magazine. Unlike the survey of 2011, where the questions were mixed without any special order or theme, the re-writing of questions resulted in the formulation of five themes to ease the understanding of the questions asked. The themes are: appreciation and participation; job satisfaction; perception of safety; near-miss and accident reports and structure and routines.

Appreciation and participation contains questions about the workers influence of the company development, how involved they feel within the region, if they feel responsible for the regions result and development, if they experience an occupational development and if they have enough knowledge and information for their tasks.

Job satisfaction include questions about the feeling of their work, incentives for tasks undertaken, if they have enough time to finish their tasks, if there is somebody to consult when in doubt, how the communication works with the manager and if the support from the manager is enough.

Perception of safety deals with questions about conflicts, if the management is engaged in solving conflicts, if the workers are worried about their safety or physical/psychical health at work and if they are able to report safety flaws.

Near-miss and accident reports have questions about knowing how to report near-miss and accidents, if they know who their safety- representative is, if they get feedback from reporting, and if they sometimes avoid reporting when they know they should and if the reports lead to any visible improvements.

Structure and routines finds out if the structure and routines are good, if regular meetings with manager and colleagues is necessary and if regular meetings and performance appraisals were held in 2013.

The questionnaire is based on a scale with six different alternatives, ranging from 1- strongly disagree to 6 - strongly agree. There is also an option for responding "do not know". Additionally, three questions have been added to give the respondents a chance to express their thoughts and opinions in free writing.

RESULTS AND DISCUSSION

A total of 148 surveys were sent out to employees in the company. The response rate was only 38% despite several reminders and extended deadline. It is a small difference from 2011 and below the expectations of the company. The company recommendable the low response rate and examine the reasons for it before making the next assessment. The suggestions from the consultants are that management must improve feed-back and communication within the organisation.

Despite the low response rate, the results reflect the present reality. Table 1 presents the mean value for each theme for all five regions combined. The result indicates that the company has satisfied employees that perceive their work to be safe enough. They do however; need to work on the routines for near-miss and accident reporting.

Table 1: Theme results from all five regions

Themes	Mean value
1. Appreciation, participation	3,8
2. Job satisfaction	4,1
3. Perception of safety	4,0
4. Near-miss and accident reports	3,5
5. Structure and routines	3,9

To demonstrate the result how the regions fare separately, see figure 1 below. The best result is that from Region 5 while Region 1 and 3 have the lowest score in total. Further discussion of the results of each theme is presented below.

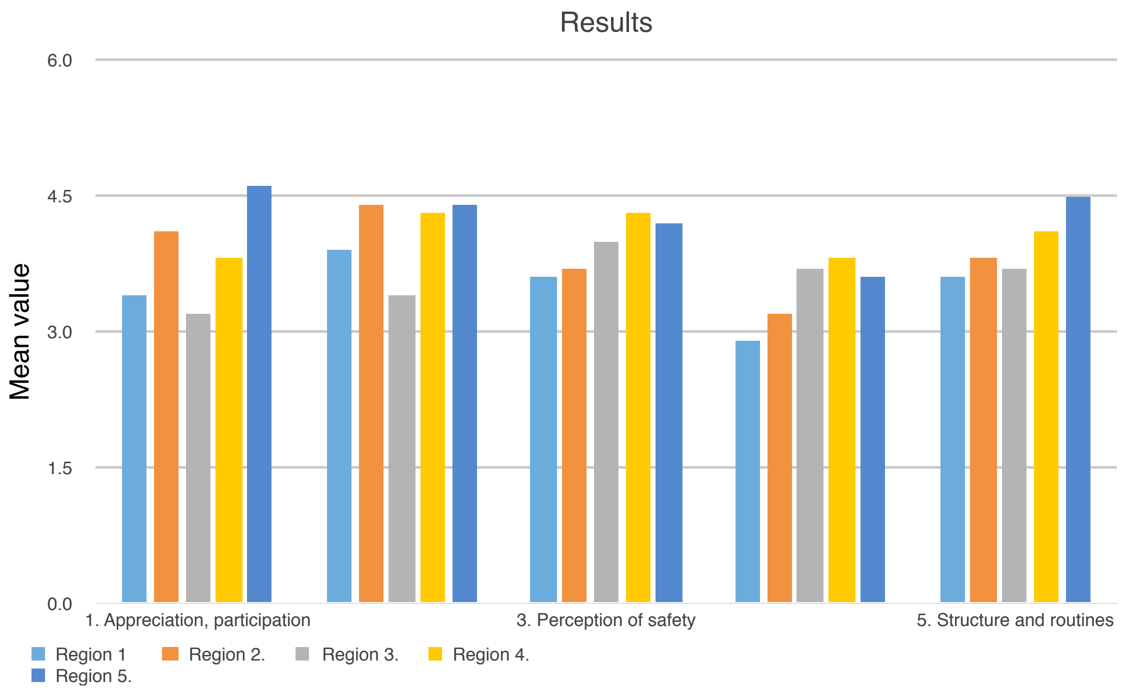

Figure 1 - Theme performance between regions

It is evident that Region 5 is experiencing a better psychosocial work environment followed by Region 4. Overall, it can be observed that Region 1 is not experiencing a healthy working climate as the other regions. Further explanation of the performance of each district for each theme is discussed below.

Theme 1: Appreciation, participation

This theme comprises of appreciation by management and the employees influence on their own future and company development. The result varies greatly between the five regions. Comments from Region 1 (mean 3.4) and 3 (mean 3.2) indicate that the management is not approachable or less concerned about their employees. The employees in these regions do not feel appreciated by their management and feel they do not have the right conditions to perform a good job, due to insufficient communication. On the other hand, Region 2 (mean 4.1) and 5 (mean 4.6) achieved very high results, so further investigation into what separates these regions could give hints on how to improve the situation.

Theme 2: Job satisfaction

This theme contains questions on whether or not the employees are satisfied with their job, if they feel positive when going to work and if the job demand is high or low. Over all, the answers about job satisfaction are on the positive side. The employees like their job and feel committed and involved. The most positive comments from the last three questions in the survey concern team spirit and colleagues. Most of the respondents feel that they have enough time to finish their daily tasks and that their supervisors are good at communicating and encouraging. Region 3 (mean 3.4), stands out compared to the rest when it comes to questions about job satisfaction. They feel neither regional management nor supervisors have the time or ability to give support and encouragement. This is in line with the results for "appreciation and participation" above.

Theme 3: Perception of safety

This theme comprises of questions regarding general well-being, physical health and conflicts at the work place. There are positive comments in the survey about the company's active work to improve safety. The employees feel that the management actively work to improve and prevent physical risks.

When it comes to worrying about safety, physical or psychosocial, Region 4 (mean 4.3) does not seem to be worried at all, while Region 1 (mean 3.6) and 2 (mean 3.7) feels more insecure. This seems to be correlated to the perceived amount of conflicts in the regions. Region 3 (mean 4.0) seems to experience a higher amount of conflicts at work than the rest. This might be related to the fact that they also perceive their management as less involved and hard to reach, a part of the solution could be to improve routines and communication.

Theme 4: Near miss and accident reports

This theme is about knowledge of the company's safety organisation, if the employees report near-misses and accidents and if they get feed-back when reporting. Region 4 (mean 3.8) seems to have the best knowledge of the company's safety organization and their reports more often seem to lead to a visible improvement. However, there are a low number of accidents or near-misses reported in this region. This seems to be because they feel uncomfortable to convey safety flaws due to expected response from management.

Many respondents in Region 1 (mean 2.9) and 2 (mean 3.2), say that they rarely report near-misses even if they should. These low results might be caused by a lack of results and feed-back on reported incidents.

Theme 5: Structure and routines

This theme contains questions about the level of structure and routines in the region and meetings with management and between colleagues. There seems to be a general lack of scheduled meetings throughout the organisation. According to the results, the employee's wish for more regular meetings and improved communication.

Region 5 (mean 4.5) has very interesting results regarding structure and routines when comparing the surveys of 2014 and 2011. The results shown great improvement during recent years, the clear structure and good routines can be traced to a change of management in 2012. This region now stands out compared to the rest of the company. Negative results and comments for structure and routines in the other regions mainly concern information, communication and efficiency. This is directly linked to "structures and routines" since poor communication leads to a lack of information which affects efficiency. The overall conclusion is that the employees have a feeling of more talk than action from the management.

CONCLUSIONS AND RECOMMENDATIONS

In general the company's attitude to improve the psychosocial work environment is encouraging. This is evident through the company´s regular assessments of the psychosocial work environment and their will to improve the instruments used.

Overall, the physical work environment is satisfactory, and the employees acknowledge and appreciate the effort made by management regarding this. When it comes to psychosocial work environment there are certain areas that can be improved, for example communication and information. To deal with this problem, most of the employees agree on the need of having regular meetings with the management and colleagues. These meetings should be scheduled on a regular basis on both a regional and local scale to further communication. Since a relatively large amount of employees did not have a meeting with their direct manager in 2013 it is an issue that needs to be addressed. Since the survey was conducted in 2014, the company has created a human resource department to improve routines on information and communication in the organisation.

"Structure and routines" can be clarified with an improvement regarding communication and information. Since the number of reports on near-misses and accidents are very low, the management needs to improve on their feedback from reported incidents. Currently, the employees do not know if their reports lead to any improvements since they have not received any feedback.

Overall, the employees seem to enjoy their work and have a great sense of responsibility of what they do. The respondents agree that they have good colleagues and working community. The company as a working place has in general improved compared to earlier surveys. There seems to be a will and loyalty among the employees to help form and expand the company. They want to be a part of the company's result and future development, which indicates a positive trend. It is strongly suggested that the company make the management more visible to all employees, and that they make an effort to improve communication among the different levels in the hierarchy.

REFELECTIONS ON METHOD ADOPTED

Some improvements are recommended to be applied in the next survey to make the most out of the results presented here. The questionnaire should be divided in two cohorts, on-site (scaffolders, supervisors) and off-site (project managers, administrators). This may give a more accurate view on the actual situation for both cohorts since their problems are rather different. To improve the response rate, management should make an effort to give more feedback and involve the employees in making necessary improvements. Also, to further increase the response rate, information needs to be given on the fact that the results will be totally anonymous and collected by an external source. This may reveal greater variation in results and provide a more detailed picture of where improvements can be made, whilst also potentially increasing respondent rate.

REFERENCES

Arwedson IL, Roos S and Björklund A (2007) Constituents of healthy workplaces. "Work" 28, 3-11

Benavides F G, Benach J and Muntaner C (2002) Psuchosocial rism factors at tye workplace: Is there enough evidence to establish reference values? "Journal of Epidemiol Community Health". 56, 244-245.

Christiansen C (1999) Defining Lives: Occupation as identity: An essay on competence, coherence and creation of meaning. "The American Journal of Occupational Therapy". 53, 547-558.

Jonge1 J de and Kompier M A J (1997) Critical Examination of the Demand-Control-Support Model from a Work Psychological Perspective. "International Journal of Stress Management". 4(4), 1997.

Kasl SV (1987) Methodologies in stress and health: past difficulties, present dilemma, future directions. “Stress and health: issues in research methodology”. Kasl SV, Cooper CL (eds) Wiley, New York, 307–318

Kielhofner G (2002) "A Model of Human Occupation: Theory and Applications" (3rd ed). Baltimore: Williams & Wikings.

Kristensen TS (1995) The demand-control-support model: methodological challenges for future research. “Stress Med”.11, 17–26

Labriola M, Lund T and Burr H (2006) Prospective study of physical and psychosocial risk factors for sickness absence. "Occupational Medicine". 56, 469-474.

Lennéer, A. B., & Thylefors, I. (2005). "Arbetsgruppens psykologi". Stockholm: Natur & Kultur.

Salem O, Sobeih T M, Genaidy A, Shell R, Battacharya A and Succop P (2008) Work compatibility and musculoskeletal disorders in the construction industry. "Human Factor and Economic in Manufacturing", 18(2), 230-252.

Samuelsson, B (2014) "Arbetsskador inom byggindustrin". Byggindustrin Centrala rbetsmiljöråd,

Siebert U, Rothenbacher D, Daniel U and Brenner H (2001). Demonstration of the ehalthy worker survivor effect in a coghort of workers in the construction industry. "Occupational and Environmental Medicine". 58, 774-779.

Sobeih T, Salem, Genaidy A, Abdelhamid T and Shell R (2009) Psychosocial factors and musculosketel disorders in the construction industry. "Journal of Construction Engineering and Management. 135 (4), 267-277

Tabanelli M C, Depolo M, Cooke R M T, Sarchielli G, BonWglioli R, Mattioli S and Violante F S (2008) Available instruments for measurement of psychosocial factors in the work environment. “Int Arch Occup Environ Health”. 82, 1–12

Zika-Viktorsson A, Hovmark S and Nordqvist S (2003). Psychosocial aspects of project work: a comparison between product development and construction projects. "International Journal of Project Management". 21, 563-569.

MIGRANT WORKERS AND HEALTH AND SAFETY MANAGEMENT IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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The strong growth of the Malaysian construction industry since 2010 has been partly stimulated by the government's Economic Transformation Programme (ETP) and the active implementation of projects under the Tenth Malaysia Plan (10MP). The sector is still, however, heavily dependent on cheap, low-skilled migrant labour. The CIDB (2014) reports that, of the 800,000 registered workers in construction, 69% are foreign workers and this figure excludes the high number of illegal workers. This paper builds out of rich ethnographic fieldnotes, which reflect on OHS practice of migrant workers in the Malaysian construction industry. The research is based on eight weeks of ethnographic fieldwork on a construction project in Penang. It draws on work shadowing the junior project manager and monitoring site activities, and participant observation with a number of trade groups onsite, including the plasterers, bricklayers, carpenters and tilers. During the ethnographic research, a combination of heavy manual construction work in a hot climate, interplaying with factors such as fasting and the wearing of PPE, were seen as posing routine problems for the safety and health of workers onsite. In addition to these factors, a major safety risk to the operations onsite was seen to stem from encroachment of the government strategy, the Comprehensive Settlement Program on Illegal Immigrants (6P Program), on everyday decision-making onsite. For a large section of the migrant construction workforce, the physical demands of manual labour in this equatorial climate are accompanied by the threat of detainment. In this context, our paper argues for the necessity of a consideration of labour rights and the continuities between the offsite and onsite worlds of the workers in any credible attempts to implement effective OHS management in Malaysia.

Keywords: Ethnography; Illegal Workers; Malaysia; Migrant Workers.

INTRODUCTION

The Malaysian construction sector has experienced consistently strong growth since 2010, partly stimulated by the government's Economic Transformation Programme (ETP) and the active implementation of projects under the Tenth Malaysia Plan (10MP). 2015 is the final year of the 10MP strategy, which was designed to enable Malaysia to become a high-income and developed nation by 2020. In addition to driving its global performance and competitiveness as part of the Construction Industry Master Plan 2006-2015, the Construction Industry Development Board (CIDB) has recently amended the Act 520 to broaden its mandate to include the setting of standards with regards to "registration of construction personnel; training; accreditation and certification; company quality assessment; and health, safety and environment" (CIDB Malaysia, 2014).

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The sector is, however, highly dependent on migrant labour. The CIDB reports that, of the 800,000 registered workers in construction, 69% are foreign workers. However, this figure excludes illegal workers, and the immigration authorities estimate that there may be as many as an additional 2.2 million undocumented workers in Malaysia (Amnesty International, 2010). In detailing the significant contributions made by migrant workers in the economic development of Malaysia, Pappusamy (2014) points to how the term 'migrant worker' can be used interchangeably with 'foreign worker' to refer to a person who works in a country other than the one of which he or she is a citizen. He notes how the term 'migrant worker' is generally confined to lower-wage fields and low wage earnings. Migrants have become a significant part of the construction workforce and research shows how, once foreign labour becomes a dominant feature of a labour market, it becomes a difficult trend to reverse (Abdul Aziz, 2001). However, rather than entering into economic arguments around the effects of a sustained dependence on cheap, low-skilled foreign labour in the sector, this paper accepts migrant workers as a defining feature of the Malaysian construction labour market and only considers the management of labour policies specifically in the context of the everyday management of OHS on projects.

The Malaysian construction industry has long been characterised as being high risk. The fatality rate rose from 60 to 95 deaths in the period between 1995 and 2003 (an increase of 58.3 %), and Hamid et al's (2008) investigation identified the critical factors leading to accidents to include "unsafe methods, human element, unsafe equipment, job site conditions, management, and the unique nature of the industry "(p. 242).

This paper reports on ethnographic research into the health and safety practices of migrant workers in the construction industry, undertaken during an eight week working internship on a construction project in Penang. In-fitting with the nature of qualitative inquiry, the research focus shifted away from the communication of health and safety information, to the emergent and immediate health and safety concerns being encountered onsite. These included undertaking heavy manual construction work in a hot climate, and the interplay of factors such as fasting and the wearing of PPE. During the research period, the government started the crackdown on illegal migrants within the country under the Operation 6P Integrated Programme, and the fieldwork also charts how the impending threat and eventual execution (through the "Ops 6P Bersepadu" raids) impinged on safe practice onsite.

BACKGROUND

Kamal and Flanagan (2012) describe a shift in the Malaysian construction industry, since independence in 1957, from a labour intensive, craft-based sector to one with the expertise and production techniques to deliver projects such as Petronas Twin Towers. Yet, they note that this capacity is just one feature of the sector. Kamal and Flanagan (2012) also highlight that there are significant differences between large companies, most of which are concentrating in urban areas, and the SMEs which account for 90% of registered construction companies, of which 41% were operating in rural areas. In terms of the labour market, Malaysians' unwillingness to work in this labour-intensive sector is persistent and well documented. Indeed, research by CIDB Malaysia (2014) reports that contractors employ migrant workers due to their "resilience, mobility and willingness to accept lower wages". While contractor's "preference to use conventional methods of construction involving wet trades like bricklaying and plastering is not attractive to the local workforce due to the 3D (Dirty, Difficult, Dangerous) syndrome" (p. 9).

As Kassim (2014) explains, Malaysia is an attractive destination for migrant construction workers because of its "relatively better economic performance, smaller population and fussy workers compared to other countries in ASEAN [Association of Southeast Asian Nations]" (P. 146). The literature points to employers preferring foreign (especially illegal) workers, due to demands of lower wages and a willingness to work longer hours (Abdul-Aziz, 2001), with their employment status hidden through the multiple layers of subcontracting. Kassim (2014: 167) also explains how the mistreatment of directly employed workers, being paid half of what they were promised despite being covered by the Malaysian Labour Law, led to workers running away to work illegal construction.

A new government strategy was effected in 2011, named the Comprehensive Settlement Program on Illegal Immigrants (6P Program), to reduce the number of illegal migrants and to strengthen the management of foreign workers in the country. To become registered as construction personnel, workers are required under the CIDB Green Card Program to undergo a one day course on Safety Induction for Construction Workers (SICW). On completion, that worker is automatically insured against any injury (Abdul-Aziz, 2012: 206). However, compared to registration of foreign construction workers under the Immigration Department of Malaysia (434,300), the number of foreign construction worker registered with the CIDB remains low (78,204) (CIDB Malaysia, 2014).

Rather than illegal entry across borders, it is now a case that some migrants are entering the country lawfully under different visa conditions and are overstaying (Kanapathy, 2008). Our study's portrayal of the common employment of illegal workers among the subcontractors' workforces supports this as being a common practice. The bureaucratic employment procedures, the high cost of renewing a work permit and the system's restrictions to regulate the movement of workers by tying them to a particular employer, sector and location can be seen as pushing workers towards illegal work.

As Kaur (2014) states succinctly, "the State's low-skilled labour policy essentially vacillates between ensuring a continual supply of cheap labour and instigating crackdowns on undocumented migrants" (p. 345). For instance, in December 2014, the Master Builders Association (MBAM) and major contractor groups (PKMM, GBC, PKIM) appealed to the government to extend the temporary work permits of construction workers registered under the 6P programme (Mun, 2014). The status of these migrant construction workers was on the brink of shifting to illegal foreign workers. The government had initially announced that the 500,000 foreign workers had to return to their home countries in January. Without retaining the existing workforce, the companies risked losing the skills held by, and the training invested in, these migrant workers.

METHODS: ETHNOGRAPHIC FIELDWORK

There is a growing awareness and interest within the field of construction management in ethnographic research and the ways that the approach can challenge common perceptions of the industry through an attendant focus on local practice and contexts (Pink et al., 2012). Ethnographic research in construction can take the form of different routes and engagements onsite. The researcher embarked on eight weeks of ethnographic fieldwork into the practice of safety onsite on a construction project in Penang during summer 2013. This was undertaken whilst working as a practical trainee or intern. Whilst carrying out the internship, the researcher worked under the supervision of two company employees; a senior quantity surveyor (also a senior project manager) and a junior project manager, and undertook tasks composed of both site and office works. The work onsite included shadowing the junior project manager, monitoring site activities and jotting down notes to update the company's site diary. In this way, the ethnography involved an increasing amount of time observing a number of trade groups; mainly the plasterers, bricklayers, carpenters and tillers. In the afternoon the researcher worked at the company's main office, focused on cost related works and participant observation of the work and meetings accessed through shadowing the junior project manager. Fieldnotes were written by the researcher to document different events and experiences and to reflect on their feelings about these. Other construction ethnographers have also followed the route of apprenticeship in order to study and participate in the activities and phenomena they seek to understand. For example, see Gherardi and Nicolini (2002), whose ethnographic study of how the practice of safety is learnt by construction site novices, involved undertaking a three month traineeship.

The appropriateness of this methodological approach, for accessing worker perspectives, is acknowledged through the literature. Abdul Rahmen et al (2012) concede that a limitation of their research into the impact of migrant workers on the Malaysian construction sector “is the difficulty in making inferences about illegal workers without talking with them directly”, which leads the researchers to discuss and interpret “the motives of laborers… based on inferences by these industry representatives” (p.442). Indeed they call for qualitative research to access a cross-section of both legal and illegal labourers in the Malaysian construction industry. We would argue that this need must have been abundantly clear when undertaking the research, and that any research purporting to understand the experiences of foreign workers in construction would need to engage at some level with those workers.

The initial research concerns, on commencing the fieldwork, were with the routes for health and safety communication between migrant workers on construction sites. However, contrary to Salleh et al’s (2012) findings, it was quickly apparent that language did not pose any major health and safety communication problems between local and migrants on the project under study, as Indonesians made up the majority of the workforce and could understand each other due to the similarities between Bahasa Malaysia (Malaysian Language) and Bahasa Indonesia (Indonesia Language). Other potential health and safety problems posed by hiring migrant workers are linked in the literature to the low-level of skills and experience, and refusal to use PPE or to adopt health and safety culture. Yet, as Abdul-Aziz (2001) reports in his survey-based research of the Malaysian construction workforce, the willingness of migrants to work in hazardous conditions is also worryingly acknowledged as one of their merits.

The site operations and health and safety and work practices of the migrant construction workers were observed and fieldnotes written up in the researcher’s notebook over the eight weeks spent at a construction site. Ethnography is a methodology that develops in practice and another methodological barrier encountered during fieldwork lay in the unsuitability of interviews as a key method onsite. Managers politely encouraged the researcher not to approach the migrant workers for interviews. The gendered dimension to this advice was unpacked in the fieldnotes:

I often get questions regarding my choice in studying a construction subject. Again and again I was asked to stay in the site office because it was too hot outside and being a female, I should not ‘get dark’. Indeed, females and construction industry were not perceived as a norm in Malaysia, and probably a lot of other places too.

Consequently, the research was not based upon building close relationships with the migrant workers in the ways first anticipated, through seeking opportunities for conversations about attitudes towards, and the practices of, health and safety onsite. Yet there was a building of trust and acceptance, as the ethnography onsite took on the form, described by Angrosino (2007) as, observer-as-participant, in which the researcher’s everyday presence and observations in the role of intern onsite became recognised and the exchanges increased. As the fieldnotes record, "the stares lessened after a while. Perhaps I was getting more familiar to them and I was not regarded as a threat, but just someone on site". That 'someone' identity was also reflexively reworked through the writing of fieldnotes. For, the intern position was felt to bring with it connotations of a management position (by association), which perhaps initially built a distance between the migrant workers and researcher, but was devoid of the power and authority in terms of enacting a management role or questioning safe practice onsite. This issue is taken up in the next section on PPE.

The serendipitous nature of ethnography was evident again during the fieldwork, when the government started the crackdown on illegal workers, under the Operation 6P Integrated Programme. This provided a very different lens through which to view the management of safe practice, and safety risks to the operations onsite, in terms of its impending threat and eventual execution through the “Ops 6P Bersepadu” raids. As the paper illustrates, the change in perspective it provided was profound.

WHEN TO WEAR PPE

The ethnographic fieldnotes initially recorded the continual resistance of migrant workers to the wearing of hardhats onsite. This included ethnographic reflections on the researcher 'building up' the courage to challenge the workers about their disregard for wearing PPE. The fieldnotes also record fluctuations in the senior project manager's monitoring of PPE onsite, and in the severity of his reprimands for the widespread and wilful disregard for the routine wearing of hard hats. The researcher also plots the ingenuity of Bangladeshi plasterers and bricklayers to become 'kitted up' at a moment's notice: "Upon realising the presence of the site supervisors, only then they would get flustered and asked their friends to throw their hard hats up to them, or put their hats in the mortar bucket, using the pulley system to send to them". However, while the researcher confronted the senior manager about health and safety breaches, including roof welders operating without safety goggles or gloves, and workers "hacking concrete walls without ear protectors", other contributory factors defining the practice of health and safety in Malaysian construction came into closer view over the course of the internship, which we will focus on in this paper.

During participant observation inside halfway constructed buildings with the tilers, painters and suspended ceiling installers, the researcher recorded how "working indoors with poor ventilation could get stuffy, the workers would make themselves comfortable by wearing sandals, shorts or even go topless. Some would even go as far as bringing portable fans to improve ventilation. I myself would only wear light colours to avoid suffering from the heat." The embodied experience of working (alongside) migrant workers, and of 'being there', opened the researcher up to a sensory understanding of the how the wilful disregard for the wearing of PPE may not always be based around ignorance or neglect.

As the weeks of work as a trainee onsite continued, the field notes recorded the hard hat "to be a bit of a nuisance mainly due to its weight and for some reason, it would not fit me properly. To a certain extent, I could understand why the workers prefer to work without the hats on. Wearing such a thing on my head under the hot glaring sun made it even worse". Clearly the critical protection a hard hat offers to prevent major injury or fatality heavily outweighs the issues of discomfort or even the contribution to heat exhaustion and heat stroke cited by workers, where heat stress is badly managed. However, through these experiences, the fieldnotes reveal local, informally developed practices developed by workers to bridge this gap: "I too cheated my way and adopted the workers’ tactic by putting on a large ‘farmer’ hat under my hard hat to reduce the glare and to stop myself from squinting my eyes". Beyond changing personal understandings towards (and indeed adaptations to) the wearing of PPE onsite, was the researcher's slowly building awareness of the personal choices and sacrifices that migrant workers made towards achieving the base requirement of achieving safe practice onsite, including the breaking of fast.

BREAKING FAST

Factors affecting the workers' physical condition and the risk of sustaining a heat-related incident manifested themselves in other ways. Reflecting on the challenges of working onsite during the fasting month, the researcher quickly noticed how the majority of the workers were eating and drinking during break times on the second day. This stood in stark contrast to the first day when most of the migrant workers took leave and fasted as a sign of respect for the holy month, with the majority of the Indonesian and Bangladeshi workers being Muslim. Indeed, it was only the local Malays, who worked in management roles, as project managers and site supervisors, or who operated the heavy plant and machinery, that continued to fast. The researcher's understanding of the situation developed through the experience of working through Ramadan, as is reported in the field notes extract below:

I too fasted in Ramadan. It was a difficult experience I had to go through, especially during the first two weeks whilst trying to adapt to fasting while being under the hot sun. Despite not *having to do heavy works, I was physically and mentally affected. The experience made me understand why most workers, except for a handful, chose not to fast. Working in poor physical conditions would definitely reduce their concentration level, which could result in accidents occurring. For the site supervisors and local workers who were fasting, I found their presence in the air conditioned site office to be more frequent than normal non-fasting days… If I were to put myself in the workers' shoes, I would probably not fast too. For those who did, I personally found them to be undeniably strong, physically and mentally.*

The decision not to fast is a personal one, and can be seen as a necessity in terms of self-preservation in difficult working situations documented above, but it also contributed strongly to preservation of safety onsite. The very self-questioning of the researcher's strong belief towards the enforcement of health and safety on site, and of the personal conditions in which one would consider the breaking of fast, are testament to the power of ethnography and sensory knowing, namely the ways of experiencing and knowing that come from trying to occupy the spaces and places of your research participants first-hand (Pink et al., 2012).They also help articulate some of the distinct contextual requirements to be considered in practicing appropriate health and safety management in the Malaysian construction sector.

An engagement with migrant construction workers for an extended period of time - a prerequisite for gaining a level of immersion in the setting - can afford a different lens on health and safety and the factors at play, including the seepage of the offsite world into onsite practice. Indeed, as is abundantly clear from ethnographic research with migrant workers in the Gulf States and other emerging economies, given the working hours and arrangements and the operation of labour camps and onsite accommodation, there can sometimes be no effective distinction made between onsite and offsite in practice (see for example Human Rights Watch (2012) on Qatar; Gardner (2012) on Bahrain; or Buckley (2012) on Dubai). On the Penang project under study, the main contractor provided the onsite accommodation (kongsi) and basic facilities for the migrant workers, which Abdul Aziz (2001) describes as a typical arrangement. Yet, as the next section indicates, with the impending government strikes in Malaysia, migrant workers faced the prospect of being moved out of site accommodation or of detainment.

We will now turn to another distinctive feature of the Malaysian construction sector which this ethnography revealed to be having a large impact on the everyday practice of safety onsite. Namely the shifting application of the 6P program and crackdowns on (illegal) migrant workers.

OPS BERSEPADU RAIDS

During the research period, the government started the crackdown on illegal migrants within the country under the Operation 6P Integrated Programme (Operasi 6P Bersepadu), also known as Ops 6P. It was known that here were a large number of illegal migrants within the sub-contractors' workforce, and the main contractor called a meeting to assess the exact level and address the problem of the impending strikes. The meeting was held a week before the operation started. All sub-contractors, project managers from several sites, and quantity surveyors attended the meeting at the main contractor's office. The senior quantity surveyor led the meeting.

The meeting started off with a simple, "So, who has illegal immigrants in their workforce on site, and who doesn't?" Since nobody replied the quantity surveyors had to ask the sub-contractors one by one. Every one of the sub-contractors was questioned, from one end of the oval table to the other end. Chan, who was responsible for providing formworks, was the fourth to be questioned … He could not give a straight answer and tried recalling the number of people in his workforce again and again, which suggested the large amount of workers *which he employed. Chan was also one of the two sub-contractors who employed female labourers, which led to one of the project managers saying, "Next time, don't bother hiring females. It's difficult because they can't escape quickly if the authorities come" …The plastering sub-contractor, Lim, had a large number of illegal migrants in his workforce. It was perceived that more than half of his workers were illegal workers and a majority of them were Bangladeshis.*

After determining the rough number of illegal migrants in the sub-contractors' workforce, the discussion on how to prepare to face Ops 6P started. It was decided that during the first week of the operation, no illegal migrant workers would be allowed to work or even stay in the site accommodation. Therefore, the sub-contractors had to relocate their illegal workers somewhere else. Chan did not say much and just obeyed the instructions, knowing it was the best option. However, Lim appeared unsatisfied with the decision leading to a heated discussion. Since his workforce comprised of mainly illegal migrant workers, only a few would be left to work on site. With such a small workforce, it was impossible for him to meet the deadline set by the main contractor. He also complained that it was difficult to search for workers with legal work permits. …Upon hearing Lim's complaints, the senior quantity surveyor assured him to just lay low during the first week of the operation and not to mind the work speed. A decision on whether to allow illegal workers to return or not would be made later on.

Long before the strikes reached this project, the threat of the "Ops 6P Bersepadu" raids hung over the site and its daily operations. For example, a fieldnote entry records one such event in which "the workers became extremely agitated and seemed worried when they saw an unfamiliar man, fully clothed in PPE whilst holding a clipboard. At a glance, he really did look like an authority inspecting the site. Then I saw one of the site supervisors went up to greet him. Apparently the man was there to inspect the scaffolding installation". In addition to affecting workers' performance and slowing productivity, this prevalent fear of raids provoked other dangerous behaviour such as workers jumping off scaffolding at height on another occasion when unfamiliar faces were seen onsite.

In countries in the developing world, who are struggling to develop a local and sustainable workforce through the implementation of localization strategies, the unstable and shifting employment environment can transform overnight. For a large section of the migrant construction workforce, the physical demands of manual labour in this equatorial climate are accompanied by the threat of these raids and of detainment. In this context, our paper argues that any credible attempts to improve OHS management in Malaysia requires a consideration of labour rights and the continuities between the offsite and onsite worlds (Tutt et al, 2013) of the workers. While such issues remain peripheral to debates in the construction management research field, any consideration of them would cast serious doubts on the meaningfulness of Abdul Rahmen et al's (2012) proposed strategies for "minimizing negative impacts induced by foreign workers". Their recommendations of "attracting local workers into the construction industry", "eliminating illegal migration", and "improving governance structure", are over simplistic, misunderstanding the structure of the Malaysian construction labour market. As this paper argues, the definition of an 'illegal worker' continually shifts along with government policy, and critically only takes on meaning with its implementation (of the 6P program). Similarly, making the Malaysian construction sector more attractive to local workers is a colossal issue with no short term remedy. Localization strategies and the long-term drive to create local sustainable labour forces are one of the most fundamental issues facing international labour markets today. However, while Malaysia works towards enacting this aspiration, migrants continue to dominate the workforce.

CONCLUSIONS

The vacillating status of migrant workers under the 6P program has provided ample opportunities for construction work in the shifting gaps between labour policy and practice. Indeed, it is the different enactment of policy (through government strikes, or the renewal or termination of permits) that defines who an undocumented or illegal construction worker is. However, in this paper we argue that this instability also creates a climate of fear and paranoia which amplifies the risk of accidents on site and undermines the management of health and safety on global construction projects.

Drawing on fieldnote extracts, the paper has demonstrated how ethnographic methods offer the potential to produce detailed understandings of the realities and lived experiences of those working within the construction industry. Here it has enabled the issue of migrant worker safety practices in Malaysia to be reframed to account for the distinct requirements of heavy manual construction work in a hot climate, and the everyday negotiation of factors posing routine problems for the safety and health of workers, such as fasting, the wearing of PPE and the threat of government raids.

This paper is intended as the start of a discussion, but one which takes account of how the particular characteristics of a construction sector and labour market set distinct requirements for, and require new conceptualisations of, what successful health and safety management onsite entails. The situation in Malaysia might be seen as part of the paradox of development, flagged up by Neale and Waters (2012: 146), in which a consideration for human welfare is too easily dismissed when constructing the infrastructure required to benefit and enhance human welfare. While Malaysia strives to improve the global performance of the construction sector, improve the standards and training regarding health and safety, and reduce the number of illegal migrant workers, it becomes all too easy to heap greater risk, uncertainty and danger at the feet of the dominant construction labour force.

REFERENCES

Abdul-Aziz, A.R. (2001), Foreign workers and labour segmentation in Malaysia's construction industry. Construction Management & Economics. 19 (8): 789- 798.

Abdul-Aziz, A.R and Yahaya, I. (2012), "Sub-contracting and joint venturing in construction in developing countries", in Contemporary Issues in Construction in Developing Countries. Ed by G. Ofori. Abingdon, Oxon: SPON Press. pp. 190-215.

Abdul-Rahman, H., Wang, C., Wood, L.C., Low, S. F. (2012), "Negative impact induced by foreign workers: Evidence in Malaysian Construction Sector", Habitat International 36: 433-443.

Amnesty International (2010) Trapped: The exploitation of migrant workers in Malaysia. London: Amnesty International Publications.

Angrosino, M. (2007), Doing ethnographic and observational research. London: Sage.

Buckley, M. (2012), From Kerala to Dubai and back again: Construction migrants and the global economic crisis, Geoforum 43 (2012): 250–259.

CIDB Malaysia (2014), Meeting Construction Industry Resources Requirements: The Malaysia way, 20th AsiaConstruct Conference Hong Kong 13 & 14 November 2014:

http://www.bre.polyu.edu.hk/20th_asia_construct/Theme%20Papers/Malaysia.pdf

Gardner, A. (2012), "Why Do They Keep Coming? Labor Migrants in the Gulf States", in Migrant Labour in the Persian Gulf, edited by Kamrava, M. and Babar, Z. New York: Columbia University Press, pp. 41–58.

Gherardi, S. and D. Nicolini (2002), 'Learning the trade: a culture of safety in practice', Organization, 9: 191–223.

Human Rights Watch (2012), Building a Better World Cup: Protecting Migrant Workers in Qatar Ahead of FIFA 2022. Available at: http://www.hrw.org/reports/2012/06/12/building-better-world-cup-0

Kamal, E. M. and R. Flanagan (2012). "Understanding Absorptive Capacity in Malaysian Small and Medium Sized (SME) Construction Companies" Journal of Engineering, Design and Technology 10(2): 180-198.

Kassim, Azizah (2014), “Foreign workers in Malaysia in the Post-Independence Era: Race Paradigm in State Policy, Academic Writings and Public Discourse” in Transforming Malaysia: Dominant and Competing Paradigms. Edited by A. Milner, A. Rahman Embong and T. S. Yean. Singapore: ISEAS, pp. 143-178.

Kaur, A. (2014), Managing Labour Migration in Malaysia: Guest Worker Programs and the Regularisation of Irregular Labour Migrants as a Policy Instrument. Asian Studies Review, 38 (3): 345-366

Mun, Song Boon (2014), “Time running out for foreign workers under 6P program”, The Sun Daily, 15th December 2014. URL: http://www.thesundaily.my/news/1267884

Neale, R. and Waters, J. (2012), "Safety and health in construction in developing countries: The humanitarian paradox", in Contemporary Issues in Construction in Developing Countries. Ed by G. Ofori. Abingdon, Oxon: SPON Press. pp.144-189.

Pappusamy, P. Iruthayaraj D (2014), “Migrant Workers Contribution towards the Malaysian Economic Transformation”, Asian Conference on Globalization and Labor Administration: Cross-Border Labor Mobility, Social Security and Regional Integration. November 19-21, 2014, Manila, Philippines: http://islssl.org/wp-content/uploads/2014/12/Pappusamy_2014_Asian_Conf.pdf

Pink, S, Tutt, D., Dainty, A. (2012), “Introducing Ethnographic Research in the Construction Industry”. Edited by S. Pink, D. Tutt, A. Dainty. Ethnographic Research in the Construction Industry. London: Routledge.

Salleh, N.A.B., Nordin, N.M., and Rashid, A.K.A. (2012), The language problem issue among foreign workers in the Malaysian construction industry. International Journal of Business and Social Science. 3 (11): 97-99.

Tutt, D., Pink, S., Dainty, A. and Gibb, A. (2013), Building networks to work: an ethnographic study of informal routes into the UK construction industry and pathways for migrant up-skilling. Construction Management and Economics, 31 (10), 1025-1037.

CONSTRUCTION SAFETY MATURITY MODEL: CORPORATE-LEVEL INDICATORS OF SAFETY PERFORMANCE

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It is no secret that construction safety is an important global issue. This has prompted researchers to conduct a stream of research largely fixated on stock technical practices (*i.e., exposure assessment/hazard analysis and control*) for improving construction safety and health outcomes. However, these research efforts have not been nearly as beneficial as they could be. Although calls have been made to study construction safety from a management strategy perspective empirical research is lacking in the literature. To begin to rectify this deficiency construction safety research needs to analyze prospects for improving worker safety and firm competitiveness using the same strategy frameworks that guide other core construction business functions. In this paper, we place major attention on the construction industries core internal business drivers (i.e., cost, quality, schedule, safety, & sustainability) that form the platform upon which specific safety and health management strategies and tactics can then be formulated. We offer a model for assessing, formulating and linking safety strategy within the larger context of a construction firms overall business strategy that is supported by results from multiple research studies, insights from a variety of theories, and case analyses. The end product of this meta-analysis is a decision-support guidance tool (*i.e., Construction SMM*) that provides a series of prompts, rather than a definitive set of standards for owners and contractors to opt for when considering safety strategy.

Keywords: health and safety

INTRODUCTION

The construction industry has made great improvements in safety performance since the inception of the Occupational Safety and Health Act of 1970. In fact, in the past forty years, the fatality rate in construction has declined by over 400 percent (Bureau of Labor Statistics 2014). Nevertheless, the fatality and injury rate in construction remains five-times higher than the all-industry average. In the last decade the U.S. construction industry accounted for more fatalities than any other industry (Bureau of Labor Statistics 2014). In fact, construction fatality rates are almost three times the all-industry average, behind only agriculture, transportation, and mining. Although construction fatality rates have declined significantly in the last century, the past 20 years have seen a plateau in industry-wide safety improvement (Bureau of Labor Statistics 2014). The fatality rate per 100,000 full-time equivalent workers has seen a slow decline from13.7 in 1992 to 9.3 in 2009 (National Safety Council 2011). Researchers continue to seek new safety knowledge that leads to continued safety improvement.

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To address these safety challenges and enhance competitiveness, construction organizations must form a corporate strategy for institutionalizing and supporting a culture of safety that exceeds government requirements. To support this need, researchers have conducted a stream of nearly 100 qualitative and quantitative studies that associate specific managerial practices with safety performance (Hinze et al. 2014). Most recently, safety practices as actionable predictors of safety performance have been labeled *leading indicators* (Hallowell et al. 2013). The majority of these leading indicators are focused on construction site practices, despite a plethora of literature that describes the importance of corporate-level support and proper organizational structure (Toole 2005). Additionally, there is a dearth of literature that describes how organizational leadership can effectively assign resources, manage, structure, monitor, and continuously improve safety despite calls from the research community (Brown 1996, Kibia 2009). This paper addresses this knowledge gap by summarizing literature and codifying the current body of knowledge into an actionable Construction Safety Maturity Model (CSMM). The expected practical contribution of this model is that it may serve as a tool for practitioners who wish to assess the safety maturity of their organization with which they contract or collaborate; and identify specific areas for improvement.

It is important to note that the focus on corporate-level safety strategies should not be interpreted as a devaluation of stock technical practices, which are critical for achieving the organization's safety mission. For example, efforts taken to comply with OSHA regulations remain an important element of the corporate safety strategy. Our position in this paper is that specific corporate-level behaviors can ensure that all safety efforts, from compliance to new initiatives, are supported and that synergies and efficiencies are explored. Such corporate focus yields enhanced performance when organizations manage a portfolio of projects and risks (Brown 1994; Porter 2006; Das et al. 2008).

LITERATURE REVIEW

Existing literature has focused a great deal on the relationship between stock technical practices and safety performance and has rarely considered the linkage between safety strategy and the construction firms core internal business drivers (Hallowell and Calhoun 2011). Further, the current literature is devoid of a cohesive corporate safety strategy. To establish the current state of knowledge, this paper includes a review of literature related to safety practices with a focus on the methods that organizations can employ to (1) confront and manage safety and health issues; (2) integrate safety within the organization's formal structure; (3) appropriately finance the safety and health plan; (4) identify technical components of a safety system; (5) manage safety knowledge; (6) monitor and respond to performance; (7) research and develop new safety strategies.

The (CSMM) presented later in this paper is a result of a thorough review of existing literature in the areas mentioned above. The literature was codified using a pseudo meta-analysis method that combined commonly-cited practices into a single resource. As will be discussed in detail, the authors reviewed literature and searched for commonality among peer-reviewed articles, empirically-derived relationships among stock safety practices and safety strategies within the larger context of construction industries internal business drivers, and de-emphasized equivocal, unsubstantiated, or rhetorical evidence. Although the model has been derived from over 50 journal articles, the key articles that influenced the structure and content are described in the relevant sections below. To date, there is no SMM that is targeted at corporate-level activities and purview.

Management Practices and Technical Components of a Safety System

Literature describing safety practices that link to better safety performance abounds. In fact, in a recent study Hinze et al. (2013) found over 20 studies that describe a total of 100 practices that have been correlated with favorable injury rates. Among them, upper management support, commitment of resources to new initiatives, positive reinforcement, employee involvement and engagement, effective pre-task planning, orientation and specialized training, drug and alcohol testing, accident analysis, and proper safety staffing were cited as the most impactful practices (Liska et al. 1993; Meridian Research 1994; Jaselskis et al. 1997; Hill 2004; Findley et al. 2004; Hallowell and Gambatese 2009). Hinze et al. (2013) further found, with high statistical significance, that foreman involvement in safety policy creation, medical facilities, worker-to-worker observation programs, perception surveys, and client review of safety plans as differentiators between mediocre and world-class safety performance.

Organizational Structure

To integrate safety as a core organizational function, leadership must integrate rather than insert safety within the organizational structure. It is well documented that a poorly designed safety strategy can cost construction companies dearly (including the individual impacts for workers, families, and communities), but safety is still often perceived to be in conflict with the goal of adding competitive value (Asche and Aven 2004; Kleindorfer et al. 2005; Pagell et al. 2014). To begin to rectify this deficiency, construction safety research needs to analyze prospects for improving worker safety and firm competitiveness using the same strategy frameworks that guide profitability. Many organizations approach safety as an ancillary unit responsible for future losses related to both humans and the environment (Hinze 2006). Further, most small organizations' safety staff is also responsible for other business functions such as procurement, quality, and general site management. Such an approach devalues safety in the organizational structure. Instead, organizations with strong safety records, often have dedicated and well-supported staff for safety that are assigned to projects based upon a minimum worker-to-safety-staff ratio (Hardison et al. 2014; Hinze et al. 2013). This safety staff reports directly to the project management who also share overall safety responsibility. In such a structure, safety becomes integrated and well supported within the organization.

Senior managers must frequently juggle a number of issues without a means for setting priorities or a method for integrating those issues into business decision making. The common rallying cry of many safety specialists is that safety strategy must be integrated into everyday business decisions, yet few specify what that means. It is true that regulations are making it more difficult to integrate safety and health into business strategy. Yet treating this challenge requires a framework for managers to manage changes in the business environment, such as the quickening global economy, a shrinking labor pool, or changing technology.

Financing Safety

Unlike the previous areas, there is a limited amount of literature focused on financing strategies for construction safety. There is a great deal of literature describing the cost of injuries (Everett and Frank 1997), yet few that describe an investment strategy for safety. A notable exception is Veltri and Ramsay's (2009) exploration on economic analysis of environment, safety and health investments. Many argue that organizations face challenges when attempting to confront contingent liabilities. That is, it is difficult for organizations to evaluate the risk of future safety-related costs and properly balance investments in programs that prevent future liabilities. This investment strategy is known as contingent liability planning (Hallowell 2011).

Many companies approach safety funding in a budget format where safety professionals provide a yearly or quarterly justification for a safety budget. In such an arrangement, the safety function justifies the assignment of funds based upon the funds allocated in the previous cycle and additional initiatives planned in the next cycle. Unfortunately, this approach does not involve a clear argument of how safety impacts business performance and how investment in the present helps to reduce the probability of future liabilities. In recent research, Hallowell (2011) quantified the cost-effectiveness of safety program elements in an effort to help organizations to better justify specific investments. Building upon this, Hallowell (2011) built a risk-based framework to support safety finance optimization, balancing resources invested in specific strategies with expected reductions in risk of injuries and their associated costs. This recent research suggests that safety practitioners need to better justify their safety financial needs with empirical risk-based data so that organizations can respond by properly financing core safety strategies.

Safety Knowledge Management

While knowledge management in organizations is a rich research area, relatively few studies have focused on formally capturing and disseminating explicit and tacit safety knowledge (Shiery and

Karwowski 2006). Teo et al. (2005) found that safety knowledge must not only be acquired and stored but also transferred to and retained by the workers. Additionally, gathering safety knowledge from reliable and diverse sources is important for operating and improving training (Hadikusumo and Rowlinson 2004). Shiery and Bartlett (2006) argued that companies must establish a formal process to capture and disseminate safety knowledge gained from workers in order to develop a safety culture. Finally, Hallowell (2012) found that organizations with a robust knowledge management program that handles both explicit and tacit knowledge had vastly reduced experience modification rates (EMR) when compared with their counterparts that did not have a formal program.

Safety Monitoring and Control

Very recently, there has been a shift in focus from measuring and monitoring lagging indicators of safety performance to leading indicators. Lagging indicators include injury rates (e.g., OSHA Recordable Injury Rates), experience modification ratios, and first-aid cases. Alternatively, some organizations have begun measuring and monitoring events, behaviors, and practices that predict future performance such as near misses, safety audit scores, housekeeping, and the quality of safety meetings. Such a shift from lagging to leading indicators involves changing mindsets from past events to observations and actions that can be taken to systematically identify deficiencies and take actions in a preventative manner (Hinze et al. 2012; Hallowell et al. 2012).

SMM Development and Structure

In this paper we offer a model for assessing, formulating and linking safety strategy within the larger context of a construction firms overall business strategy that is supported by results from multiple research studies, insights from a variety of theories, and case analyses. This (CSMM) was created using guidance primarily from literature, which was supplemented by case data from a complementary effort (Maxwell and Veltri 2013; Veltri, 2008). This collective knowledge was used to formalize content for various levels of maturity. It should be noted that the literature described in a high-level summary earlier in this paper were the foundation for the model with specific statements for each level of maturity populated using case data. The end product of this *pseudo* meta-analysis is a decision-support guidance tool (*i.e., construction SMM*) that provides a series of prompts, rather than a definitive set of standards for owners and contractors.

The model structure includes six categories and four levels per category as described below. The seven categories are congruent with the literature review in this paper and the prevailing research that has linked effective practice to safety improvement. The four levels of maturity define an organization on the spectrum from reactive to dynamic for each category. The maturity model itself includes specific statements for each category and each level, totaling 28 total statements. Below are definitions for each category and each level.

Elements of a Construction Firm's Occupational Safety & Health Strategy **:**
Management Strategy: The manner in which the firm intends on confronting and managing occupational safety and health issues.
Organization Structure: The manner in which the firm intends on arranging occupational safety & health strategy within the overall organization structure/chart of the firm.
Financing Strategy: The manner in which the firm intends on funding occupational safety & health strategy.
Technical Practices: The manner in which the firm intends on making sure that the occupational safety & health strategy can be realized through technology practices and investment.
Knowledge Management: The manner in which the firm intends on making available information about occupational safety & health performance to internal and external stakeholders.
Monitoring and Control: The manner in which the firm intends on continuing improving occupational safety & health performance.

Developmental Levels of Occupational Safety and Health Strategy within a Construction Firm **:**

Level 1 Reactive: Minimal and reluctant effort is extended with a tendency to respond to occupational safety and health issues only after the fact.
Level 2 Static: Limited technical effort is extended with a tendency to be focused predominately on the process of complying with the prevailing construction safety and health regulations.
Level 3 Active: Broad strategic & technical management effort is extended with a tendency toward accepting and internalizing construction safety and health issues.
Level 4 Dynamic: Extensive and forward looking strategic, technical & financial effort is extended with a tendency to be focused on reducing worker risk and adding competitive value from safety and health practices.

Construction Safety Maturity Model Content

The content of the (CSMM) is shown in Table 1 through 3. The (CSMM) has been broken into three tables for clarity and so that every level can be shown for each category. Scores in the model can range from a low of 6 (a score of 1 in each category) to a high score of 24 (a score of 4 in all 6 categories. It is expected that only elite companies would score a 24 and only companies with very poor safety practices would score 6. Most companies will fall firmly in the middle of the continuum and can use the model to identify specific methods for improvement.

Implications for Practice & Conclusions

Construction safety & health issues are forcing many owners and contractors to rethink how they formulate, structure and finance their safety strategy. Our model offers a series of prompts, rather than a definitive set of standards for owners and contractors to opt for when considering safety strategy. By characterizing safety strategy in terms of these prompts, a construction firm can adjust to changing business and regulatory conditions, benchmark leading indicators of performance, assess the maturity of subcontractors or other organizations with which a construction company may joint venture and to identify specific areas for improvement. The model provides actionable recommendations to the user when candid self-assessments are completed. Besides filling a gap in the literature, our model represents an important step towards understanding what it will take to build organizational capabilities to confront and manage construction safety and health issues. This model offers six main elements of safety strategy proposed to simultaneously protect workers and serve as a platform for contributing to firm competitiveness: management strategy, organization structure, financing strategy, technical strategy, knowledge management, and monitoring and control. We have also developed 4 levels of development which each level can be rated. We visualize several paths for furthering this research. Future research might follow the development of safety strategy in construction firms over time to better understand the relationship between the elements and levels. It also could explore key performance questions concerning worker safety impacts and firm competitiveness as well as performing a study to validate the efficacy of the tool. Since all types of industries, not just construction can be characterized by the safety strategy model we are optimistic that many insights from this research could be generalized beyond construction. Finally, whenever a construction firm wants to manage its capability more strategically, it should consider addressing the elements offered by this research.

Table 1 – SMM Statements for Strategy Formation and Organizational Structure

		Strategy Formulation	Organizational Structure
Level 1 – Reactive	**1**	Characterized as somewhat indiscreet and scanty with response to S&H issues occurring after a harmful incident happens or the organization is mandated to do so. Organizational stakeholders tend to be unaware of the extent and magnitude of S&H issues and unconcerned about formulating any strategy to confront and manage S&H issues. There are more pressing demands on the business agenda of the construction firm than to recognize the S&H challenge facing the business. The firm excuses itself from taking any prudent action because of financial, technological, and human capital deficiencies.	Characterized as an unspecified arrangement that tends to be shaped only when the organization is confronted with orders by government agencies and/or insurance carriers to arrange conditions within the organization to control existing S&H hazards. Responsibility for structuring activities tends to be assigned to a S&H coordinator/collateral duty specialist with limited authority usually employing a command and control structure. Efforts are focused on controlling exposures to hazardous that exist and reporting back to stakeholders what practices were employed to control hazards.
Level 2 – Static	**2**	Characterized as mostly dependent and driven by S&H regulations imposed by agencies of government, insurance carriers, and nongovernment interest groups, usually without regard to how these responses strategically fit and contribute to core internal business drivers of the firm. Organizational stakeholders' awareness of the extent and magnitude of S&H issues is somewhat limited and they tend to be passive and detached from formulating any strategy to confront and manage S&H issues. The organization sees its strategy formulation process strictly from a compliance perspective. The strategic plan is comprised of a small portfolio of short-term technical initiatives.	Characterized as a functional-staff arrangement that tends to be shaped by regulatory compliance priorities. When facing existing and new regulatory and/or enforcement activities, construction companies at this level react by letting only their S&H staff handle. Efforts are focused on providing technical advice on regulatory compliance matters and controlling exposures to hazards affecting the construction project. The organizational positioning arrangement is undistinguished and the S&H function is buried within the organizational chart of the firm. The function tends to report to a mid-level project/ operational manager.
Level 3 – Active	**3**	Characterized as pushing for the detection and correction of current and anticipated S&H issues, usually with attention to how these issues impact the competitive and regulatory performance standards of the firm. S&H strategy is generally permanent and ongoing, but not always fully integrated into the business aspects of the firm. Organizational stakeholders are aware of the extent and magnitude of S&H issues and they understand how a well-constructed, financed, and integrated S&H strategy can help in improving core internal business drivers. The mission statement includes preventing the causes of loss producing incidents and minimizing their effects. The strategic plan is comprised of a well-balanced blend of short- and long-term objectives that tend to meet the needs and expectations of key internal stakeholders.	Characterized as a line-staff arrangement that tends to be shaped by existing exposures to hazards, long-term contingent liabilities, and new regulatory priorities expected to affect the organization. When confronting these issues, construction companies at this level bring S&H, legal, and project management staffs together to find effective and efficient solutions. This type of structure is organizationally connected to the core internal business drivers within the organization. The organizational positioning arrangement is somewhat distinguished and arranged on the same level as other major producing and servicing business units within the organizational chart of the firm.
Level 4 – Dynamic	**4**	S&H issues are considered at the earliest possible stage in the life cycle design of construction projects, usually with attention to how they strategically strengthen the construction firm's core internal business drivers (e.g., cost, quality, schedule safety, sustainability). The mission statement is focused on preparing, protecting and preserving the construction firm's resources and spotting opportunities for reducing costs. Strategic plans tend to have a clear fit with the firm's business objectives, focused on a set of high-leverage developmental and reform initiatives and reforms that are characterized substantively while delivering a unique mix of economic value.	Characterized as a hybrid solutions-based business arrangement that tends to be shaped by the competitive performance plans of the organization. Companies determine the cost of controls under different scenarios and conduct risk and economic analysis to find the best solutions. This type of structure is organizationally connected to the firm's products, technologies, processes and services contributing to S&H risk and cost burdens. Responsibility for structuring safety strategy is assigned to a superimposed multi-level and interdisciplinary team of internal and external S&H specialists having dual allegiance to a particular construction project. The organizational positioning arrangement is well organized and internally and externally structured into the business strategy process of the organization, and reports to a senior-level executive.

Table 2 – SMM Statements for Financing and Technical Strategies

		Financing	Technical Practices
Level 1 – Reactive	**1**	Characterized as a reactive and resistive arrangement. Access to financial resources is based solely on correcting violations cited by government regulatory agencies and mandates from insurance carriers. Additional financial resources needed for providing technical day to day S&H services are provided when it financially suits the company. Tools for performing economic analysis of S&H issues do not exist, because the firm does not want to, does not think it needs to, or is not aware of the potential cost impact of failing to counteract these issues.	Characterized as resistive and driven only when required to provide personnel protection equipment to employees. Access to technical resources is based solely on correcting violations cited by government regulatory agencies and mandates from insurance carriers. Concern for providing day to day S&H technical services are provided when it financially suits the company. Technical tools for confronting and managing S&H issues are lacking within the firm's products, technologies, processes and services.
Level 2 - Static	**2**	Characterized as an informal arrangement. A mentality of funding only as much as others in their industry sector are funding. Investments, undertaken for preventing occupational injuries, illnesses, and environmental incidents and compliance with regulations, generally do not compete for access to financial resources. S&H cost accounting practices focus on aggregating cost data causing costs to be hidden in general overhead accounts and to be not included throughout the life cycle of the product, service, technology or process responsible for their generation.	Characterized as driven by technology changes to meet regulatory compliance problems. Only safety and health technical tools that fulfill regulatory reporting requirements by state and federal administrations are used by the firm. Technical tool use tends to be periodic and intermittent, with emphasis on general recognition, evaluation and control of safety and health exposures to hazards affecting the construction firm. Limited and basic technical training sessions are focused on meeting regulations and ensuring current and future compliance.
Level 3 - Active	**3**	Characterized as an applied arrangement. Access to financial resources tends to be allocated when investment requests are intended to reduce risk to products, technologies, processes and services, enhance compliance with regulatory standards, reduce contingent liability caused by past operations, and minimize outlays associated with accidents, environmental incidents, lawsuits and boycotts. The funding level tends to be above others in their industry sector and included into the overall budget of the core business units obtaining the services. Profiling the cost and profitability of S&H issues affecting the organizations products, technologies, processes and services and integrating cost information into decision-making does not occur. This condition results in senior-level executives looking at S&H issues as non-business issues.	Characterized as promoting technological change for production purposes (i.e. main business innovation). Tool attention is focused on current and future detection, interpretation, and modification of safety and health impacts linked to operations. The safety function pursues technical development in elected regulatory-driven projects and aimed at improving safety and health and business performance. The firm has built a technical understanding and capacity for linking safety and health innovation with improved organizational competitiveness. Technically competent employees are expected to better position the company to deal with the regulatory framework and develop cost effective solutions when available.
Level 4 - Dynamic	**4**	Characterized as being self-sustaining and a down-to-business arrangement. A strategically opportunistic funding position is taken, this means having sufficient funding for the long-term, while having the financial wherewithal to remain flexible enough to solve new issues and support research and development and other opportunities for innovation that, over time, will lead to significant S&H performance gains while advancing measurable business goals. Tools for performing economic analysis of S&H investments provide reliable and timely information on the full cost burdens associated with the firm's products, technologies, processes and services over their productive and economic life cycle. Major thinking is performed on how to enhance the efficiency and effectiveness of S&H spending.	Characterized as routinely allocating resources to maintaining a technical knowledge foundation and developing core technologies and new tools for improving technical productivity. The firm has invested in an extensive compilation of ongoing safety and health and economic tools. Tool attention focuses on the comprehensive identification and modeling of: the risk, loss, dangers that resources are subjected to, quality and financial effects from safety and health issues, future liabilities, and organizational sustainability. Trained employees are accountable for viewing and considering safety and health matters equally with other construction project concerns when performing all job tasks.

Table 3 – SMM Statements for Knowledge Management and Monitoring

		Knowledge Management	**Monitoring and Control**
Level 1 - Reactive	**1**	Characterized as a highly incomplete and partial compilation of information pertaining to S&H issues within the firm. Previous insufficient data generation and recording activities are lacking which leads to a piecemeal collection of information. There is a lack of focus on organizing existing information into a coherent and continuous outline. Organizational access of S&H information internally is confined to the point of origin of the data. Information available is not present beyond the actual process, department, or area in which it was generated.	Performance evaluation at this level can be characterized as a nonexistent process. The firm strongly believes that expenditures on S&H improvement represent costs that offer no corresponding benefits in terms of productivity, efficiency, liability, public perception, and competitiveness. There is an inability to define relevant activities, an inability to quantify efforts and funds spent on S&H actions, and an undefined relationship between these activities and their operational impacts.
Level 2 - Static	**2**	Characterized as a fragmented approach that centers on targeted areas within the firm. This focus concentrates on those processes and activities that dictate the regulatory and legal standing of the firm. Organizational access of S&H information is internally available as a limited number of hard-copy graphs, spreadsheets, figures, and tables. These documents are accessible within the department where it was generated and within the S&H function. The extent of the information covers only a limited number of regulated processes over specified time periods.	Characterized as a process to identify and monitor only those processes that affect the regulatory compliance stance of the firm. There is a lack of belief in empirical evidence or analysis that organizational S&H activities impact the business success of the firm outside of the legal perspective. The driving force influencing the firm's evaluation methods are the increasingly stringent regulations regarding S&H impacts of the procedures, products, and production processes. Self-audits from these divisions are regularly carried out and are basically reports stating 'yes' or 'no' we are not in compliance.
Level 3 - Active	**3**	Characterized as an integrated approach that concentrates upon information from functions within the firm experiencing risk, danger, and loss. The firm believes that information from these areas has the same worth as operational information from different department and can equally affect the competitiveness and profitability of the firm. Information management efforts (collection, processing) are concentrated towards these areas that are deemed to hold the majority of the firm's S&H burden. Increasingly upper-level management are involved in the meetings and communication pathways, but this is not permanent.	Characterized as a process to anticipate, identify, and monitor all activities and processes within the firm that affect organizational resources. The foremost driving force influencing the firm's evaluation techniques is a commitment to S&H stewardship to manage risks to resources, minimize accidents/incidents, and improve overall performance. Audits are based on risk-based factors including the complexity of the facility/ operation, intricacy of the regulatory environment, past compliance performance elapsed time since last audit, and influences on the firm's financial standing.
Level 4 - Dynamic	**4**	Characterized as a holistic approach that balances and incorporates all relevant human, operational, organizational and technological components of the firm. Since S&H information, issues, concerns, and innovation are deeply rooted in the employees and framework of the organization, efforts must concurrently address all components of the firm as a single system, not as separate elements. To maintain a favorable reputation and enhance the attractiveness of the firm, public dissemination of S&H strategy, control, and progress is provided. This is accomplished through publishing specific S&H targets, identification of the lines of responsibility for S&H issues, program successes and limitations, and quantitative performance data.	Characterized as an all-inclusive process to assess S&H implementation and outcome measures in organizational procedures, activities, and all resource utilizations to ensure maximum efficiency. The firm views S&H performance as a definitive area of competitive advantage and a gauge of the sustainability of the firm. Metrics are recorded qualitatively, quantitatively, absolutely, aggregated, and index/ weighted for increased accountability, standardization, and comparability over time to produce trends, which can be benchmarked against other companies or industries. Internal audits ensure compliance with company objectives, industry initiatives, and governmental regulations.

REFERENCES

Arditi, D, Kale, S and Tangkar, M (1997) Innovation in construction equipment and its flow into the construction industry. "Journal of Construction Engineering Management", 123(4), 371-78.

Asche, F and Terje A (2004) On the economic value of safety. "Risk, Decision and Policy", 9(3), 253-67.

Black, D D, Hull, M E C and Jackson, K (2011) Systems engineering and safety-a framework. "software", 5(1), 43-53.

BLS (2014) Census of fatal occupational injuries summary, 2010. “Economic News Release”, available at http://www.bls.gov/news.release/cfoi.nr0.htm (accessed 26 March 2015).

Brown, K A (1996) Workplace safety: a call for research. “Journal of Operations Management”, 14(2), 157-71.

Damanpour, F and Wischnevsky, J D (2006) Research on innovation in organizations: distinguishing innovation-generating from innovation-adopting organizations. “Journal of Engineering and Technology Management”, 23(4), 269-91.

Das, A, Pagell, M, Veltri, A and Behm, M (2008) Toward a theory of the linkages between safety and quality, “Journal of Operations Management”, 26(4), 521-35.

Esmaeili, B and Hallowell, M R (2012) Diffusion of safety innovations in the construction industry. “Journal of Construction Engineering and Management”, 133(8), 955-63.

Everett, J and Frank, P (1996) Costs of accidents and injuries due to the construction industry. “Journal of Construction Engineering and Management”, 122(2), 158-64.

Findley, M, Smith, S, Kress, T, Petty, G and Enoch, K (2004) Safety program elements in construction. “Professional Safety”, 49(2), 14-21.

Fiol, C (1996) Squeezing harder doesn’t always work: continuing the search for consistency in innovation research. “Academy of Management Review”, 21, 1012-21.

Gambatese, J A and Hallowell, M R (2011) Factors that influence the development and diffusion of technical innovations in the construction industry. “Construction Management and Economics”, 29(5), 507-17.

Gatignon, H, Tushman, M, Smith, W, and Anderson, P (2002) A structural approach to assessing innovation: construct development of innovation locus, type, and characteristics. “Management Science”, 48(9), 1103-22.

Hadikusumo, B H W, Rowlinson, S (2004) Capturing safety knowledge using Design-for-Safety-Process tool. “Journal of Construction Engineering and Management”, 130(2), 281-89.

Hallowell, M R, Hinze, J, Baud, K, Wehle, A (2013) Proactive construction safety control: measuring, monitoring, and responding to safety leading indicators. “Journal of Construction Engineering and Management”, 139(10), 04013010-1-04013010-8.

Hallowell, M R (2012) Safety knowledge management in American construction organizations. “Journal of Management in Engineering”, 28(2), 203-11.

Hallowell, M R and Calhoun, M E (2011) Interrelationships among highly effective construction injury prevention strategies. “Journal of Construction Engineering and Management”, 137(11), 985-93.

Hallowell, M R (2011) Risk-based economic model for safety investment in construction. “Journal of Construction Engineering and Management”, 592-99.

Hallowell, M R (2010) Cost-effectiveness of construction safety programme elements. “Construction Management and Economics”, 28(1), 25-34.

Hallowell, M R and Gambatese, J A (2009) Construction safety risk mitigation. “Journal of Hill, D C (2004) Time to transform assessing the future of the SH&E profession. “Professional Safety”, 47(11), 18-26.

Hinze, J, Hallowell, M R and Baud, K (2013) Construction safety best practices and relationships to safety performance. “Journal of Construction Engineering and Management”, 139(10), 04013006-1-04013006-8

Hinze, J (2006) “Construction Safety”. 2ed. New York: Pearson Education.

Jaselskis, E, Anderson, S A and Russell, J (1996) Strategies for achieving excellence in construction safety performance. “Journal of Construction Engineering and Management”, 122(1), 61-70.

Kleindorfer, P R and Germaine H S (2005) Managing disruption risks in supply chains. “Production and Operations Management”, 14(1), 53-68.

Liska, R W, Goodloe, D W and Sen, R (1993) “Zero accident techniques”. Austin, TX: Construction Industry Institute, The University of Texas at Austin, 86.

Maxwell, E and Veltri, A (2013) Refining a more complete theory of environment, safety, and health management strategy using case studies. “Journal of Safety, Health and Environmental Research”, 6(1), 48.

Meridian Research (1994) “Worker Protection Programs in Construction: Final Report”. Silver Spring, MD: Meridian Research.

National Safety Council (NSC) (2011) “Injury Facts”. 2011 Edition. Itasca, IL: National Safety Council.

Pagell, M, Dibrell, C, Veltri, A, and Maxwell, E (2014) Is an efficacious operation a safe operation: the role of operational practices in worker safety outcomes. “IEEE Transactions on Engineering Management”, 61(3), 511-21.

Porter, M E, and Mark R K (2006) The link between competitive advantage and corporate social responsibility. “Harvard business review”, 84(12), 78-92.

Sherehiy, B and Waldemar K (2006) Knowledge management for occupational safety, health, and ergonomics. “Human Factors and Ergonomics in Manufacturing & Service Industries”, 16(3), 309-19.

Teo, E A L, Ling F Y Y and Chong A F W (2005) Framework for project managers to manage construction safety. “International Journal of Project Management”, 23, 329-41.

Toole, T M (2005) Increasing engineers’ role in construction safety: opportunities and barriers. “Journal of Professional Issues in Engineering and Education Practice”, 131(3), 199-207.

Veltri, A and Ramsay, J (2009) Economic analysis of environment, safety and health investments. “Professional Safety”, 48(7), 30-6.

Veltri, A and Maxwell, E (2008) Safety, health and environmental strategies available to firms and being used by firms: a conceptual framework for formulating strategy. “Journal of Safety, Health and Environmental Research”, 5 (3), Featured Article #1

PERCEPTIONS OF FAÇADE RISKS: A PRELIMINARY ANALYSIS TOWARDS PRESENTATION OF KNOWLEDGE GRAPHICALLY

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[Prevention through Design (PtD) in construction has been identified as an important factor to improve Workplace Health and Safety (WHS). However, challenges exist implementing PtD in practice due to technical, social and regulatory complexity. Moreover, WHS is poorly embedded in curricula of design professionals who generally have limited experience of construction methodologies. Attempts to assist designers with the relevant knowledge in the past have been limited to generic risk assessment guides, sample databases, or static knowledge-based systems.

We propose that a graphical knowledge based information visualisation device, an infographic, can cue designers to consider relevant knowledge. Façade design is selected as the case study of the project, which involves the development of an infographic and experimental evaluation to determine its impact. The first phase of the project covered the development of the infographic, however this paper reports the findings related to the second phase of this ongoing project; the experimental evaluation of the infographic. A Q-methodology was selected and administered to a group to determine the subjectivity inherent in façade design risk perceptions prior to the introduction of the infographic to the same group in a workshop environment.

27 participants including designers/architects, engineers, contractors and safety professionals were recruited for the project. Each participant was asked to sort photographs of 16 different façade systems into five categories ranging from safest to least safe. The participants were asked to consider the construction risks associated with the façade design presented in each photo and to provide reasons for their sort selection.

Preliminary data analysis of the whole population of data is presented in this paper and a rationale for the common agreements among the whole group is investigated. Further analysis including group-level and detailed quantitative analysis are ongoing.]

Keywords: Q-Sort methodology, design for safety, occupational health and safety, construction, infographic.

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INTRODUCTION

The design choices made by construction designers on methods of construction and the use of materials can have a considerable impact on the Workplace Health and Safety (WHS) of stakeholders who build, occupy, maintain, clean, renovate, refurbish or eventually demolish a building/structure (Hinze and Gambatese 1994, European Construction Institute 1996, Gambatese, Behm et al. 2008). Szymberski (1997) theorised the relationship of the ability to influence safety throughout the whole of life construction project stages and his time-safety influence curve suggests that construction safety is a prime consideration in the conceptual and preliminary design phases of projects.

Prevention through Design (PtD) in construction has been identified as an important factor in improving WHS. The American National Standard for Prevention through Design (PtD) states that occupational hazards and risks can be incorporated into the process of design and redesign of work premises, tools, equipment, machinery, substances, and work processes including their construction, manufacture, use, maintenance, and ultimate disposal or reuse (ASSE 2011, p. 1). This standard provides guidelines for addressing occupational hazards and risks in design and redesign processes in general.

Construction specific PtD initiatives have also been adopted in the 2012 annual meeting of the American Society of Civil Engineers (ASCE) session entitled “Prevention through Design: Construction Safety” and the NIOSH “Prevention through Design Symposium” in 2011. In the Australian context, the construction industry has been identified as a priority industry in the Australian Work Health and Safety Strategy 2012-2022 due to its poor WHS performance and as such, "Healthy and Safe by Design" is one of the seven national action areas in the strategy.

However, the manner by which PtD can be implemented in practice is not well understood. This is further complicated by confusion over the particular aspect of design that is being addressed, that is, whether it is product design or process design. Preventing harm through process design (i.e. construction safety) is particularly challenging and WHS is poorly embedded in curricula of design professionals (CCWHSR, 2013) who generally have limited experience of construction processes and site dynamics. In addition, legislation in many jurisdictions (e.g. The Model Work Health and Safety Act which forms the basis of the Australian nationally harmonised workplace health and safety legislation) unrealistically assumes that designers possess the required WHS knowledge.

We propose utilising an innovative graphical knowledge modelling method as an approach to assist designers addressing PtD. Due to the overly complex nature of the building design; we focussed on “safe façade design” as a case for this project. The aim of this research study is to provide construction design professionals with access to expert WHS knowledge through the graphical knowledge model and to evaluate its effectiveness. This paper reports the findings related to the evaluation of the graphical knowledge model.

BACKGROUND

Knowledge-Based Systems (KBS) have been successfully applied to provide various forms of decision support within the construction design process. For example, HWYCON (Kaetzel, 1993) supports decisions related to selection of materials as well as repair and rehabilitation activities for concrete structures. The Tool for Safety and Health in Design (ToolSHeD) is a web-based knowledge tool that enables construction designers to integrate WHS risk management into their design decision-making by stepping them through a risk assessment (Cooke et al, 2008). At the core of this system is a model that represents a hierarchy of factors called an argument tree. Design for Construction Safety Toolbox (Gambatese et al., 2008) helps address specific construction project hazards and provides design suggestions to minimize and eliminate the hazards through a computer software program. The Safety in Design Risk Evaluator (SliDeRulE) is an online tool (http://www.constructionsliderule.org) that enables designers to assess the construction safety risk associated with their designs. The tool allows the user to input product related parameters (in quantifiable measures such as length and volume) which then estimates the design risk for a number of building elements, such as the foundation, structural frame, exterior enclosure, interiors, roof, fire suppression to name a few. Another approach that supports designers is the Construction Hazard Assessment Implication Review (CHAIR). CHAIR is a safety in design tool, which facilitates a structured review of health and safety implications at different points in the design process. It aims to identify and reduce design related safety risks that potentially exist at construction, maintenance, repair, and demolition stages, to improve constructability, and to reduce project lifecycle costs (WorkCover NSW, 2001).

Codes of Practice and Guidance notes are practical guides that assist parties to comply with the relevant WHS acts and regulations. Codes of Practices and Guidance notes developed to date relate to façade retention include the European Guidance Note GS 5, CIRIA Best Practice Site Handbook -2003 and the NSW's Code of Practice for Façade Retention -1992. Other façade related Codes of Practices and Guidance notes include Best Practice Guidelines for Double Skin Façade (Lund University's Best Practice Guidelines - 2007), the Code of Practice for Demolition (Safe Design of Structures - Safe Work Australia), and WorkSafe Victoria's Guidance Notes.

These above mentioned traditional attempts to assist designers in the past are limited to generic risk assessment guides, examples databases, or static knowledge-based systems. These solutions, as such, do not consider the wickedness associated with design for safety problems which draw from three complex domains of safety, design and construction. Moreover, the authors suggest that none of these solutions have evaluated their own effectiveness.

RESEARCH METHODOLOGY

This project involves the development of an innovative graphical knowledge based system, often called an infographic, to alert designers to the various risks associated with façade construction. The Infographic is subsequently evaluated to determine its impact when used in a social decision-making process.

The development of the infographic was the first phase of the project. The model of the infographic was initially developed as a hierarchy of concepts that culminated in an assessment of "how safe is my façade design". The branches of the tree related several areas including the site layout, building and panel/connection features. Over 95 factors were identified and placed in a hierarchy where child nodes were used to infer parent nodes. The nodes were refined and restructured and the infographic was modified based on various sources such as literature, Codes of Practice, Guidance notes, and data collected from interviews with stakeholders. The nodes were simplified and aggregated into three infographics covering the site layout, building features and façade panel features. Suitable graphics were incorporated into the infographic. The second phase of the project included the experimental evaluation of the infographic. A Q-methodology was used to determine the risk perceptions of individual designers who performed a Q-sort before their use of the infographic. 27 participants were invited to a two-hour workshop where the infographic was introduced. The effectiveness of the infographic was through a risk assessment during the workshop.

The participants included architects and non-architects (WHS professionals, engineers and project managers). The variety of participants in the workshop was chosen to get a range of stakeholder inputs and to capture their social decision making process. The participants overall professional experience as well as their experience working with façades was also recorded. This paper reports the design of Q-Methodology and the results of the Q-sort the participants individually performed.

Q-Methodology

Q-methodology provides a foundation for the systematic study of subjectivity, a person’s viewpoint, opinion, beliefs, and attitudes, and the like (Brown 1993). Typically, Q-methodology involved a Q-sort followed by an interview. Q-sort requires sorting a set of items (called Q-set) into a predefined number of piles according to a forced (predefined distribution) or a forced-free manner. The Q-set include photos, statements or any article. Q-sorting allows participants to give subjective meaning to the individual item, and by doing so, revealing their subjective viewpoint (Smith 2001) or personal profile (Brouwer 1999). The interviews are conducted to capture the subjective meaning. Large numbers of participants are not required for a Q-methodology as it aims to reveal some of the main viewpoints that are favoured by a group of participants (Watts and Stenner, 2005, p. 79).

Q-sorting has been effectively used in understanding perceptions in psychology (Block, 1961; Shields and Cicchetti, 1997), landscaping studies (Green 2005), work-life fit of construction workers (Turner and Lingard, 2011) and more recently in understanding WHS risks of construction stakeholders (Zhang et al. 2014).

Q-Methodology Experimental Design

According to Watts and Stenner (2005), the Q-methodology steps include: generation of Q-Set or item sampling; designing ranking procedure or Q-sorting; piloting to refine Q-set and Q-sorting; and conducting the Q-sort with participants.

Generation of Q-set

Photographs of various façade systems were used as the stimuli for the Q-Sort in this study. Hence, the Q-set includes a set of photographs depicting different façade systems, to capture participants perceived level of risk associated with constructing that system.

Photographs of the façade systems were sourced in a number of ways, including drawing from publicly available photographs and from the collections of researchers and colleagues. The researchers reviewed the initially generated photographs to arrive at the final 19 photographs to be included in the Q-set. This selection process assured that the photographs provided sufficient details for participants to make a reasonable judgement on WHS risks associated with each design. It also ensured photographs did not include objects or items that might otherwise cause ambiguity for the participants to make a reasonable judgement. For example, a photograph depicting an untidy workplace could potentially deviate the focus of the participant to poor work habits rather than the safety associated with the design. In addition, the photographs were selected to represent best possible range of façade systems. A brief description about the façade system was included in each photograph. The description did not contain any reference to WHS risk. The photographs were given a unique identification code (F01 - F19) and were individually printed. Three photographs were reserved to use during the workshop (F09, F10 and F13). Sixteen photographs were used in the Q-set. The codes and descriptions of photographs used in the Q-set are provided in Table 1.

Q-sorting

The participants were given the 16 photographs of façade systems. The researcher explained the sorting instructions to the participants prior to the Q-Sort. The instruction sheet was also given to the participants to read and to clarify any questions they may have had. The participants were asked to consider the health and safety of workers during the course of the construction process as it related to the features of the specific façade system depicted in each photo. They were then asked to sort each photo into a grid, according the participant's evaluation of WHS risks. The grid consists of five columns ranging from ‘least safe’ to ‘safest’ (least safe, less safe, moderate, safer and safest). A rating scale used in the study for 'safety associated in each design' was -2 to +2. The sorting was forced-free, where the participants could place any number of photos in each of five categories based on their judgement.

Table 1: Façade system photograph code and the description

Photograph code	Description
F01	Glazed panel façade
F02	Concrete façade system
F03	Mixed metal/glazed panel façade
F04	Mixed panel façade system
F05	Cast glass panel façade system
F06	Mixed metal/glazed panel façade system
F07	Mixed concrete/glazed panel façade system
F08	Metal panel façade system
F11	Precast concrete panel system for a car park
F12	Full storey panelised façade system
F14	Mixed concrete and metal panel façade system
F15	Glazed panel façade system
F16	Concrete block wall façade system
F17	Concrete and glass panel façade system
F18	Precast concrete wall facade system
F19	Mixed concrete and glass panel facade system

After the sorting exercise, the participants were asked to explain the reasoning for their sort selection where the researcher could prompt with some follow-up questions. The explanation of the participant's decision rationale was audio recorded and transcribed (where consented) and the researcher also took notes. The sorting outcome (the ranking in the grid) was also photographed.

Pilot studies

Watts and Stenner (2005) suggest using piloting for refining Q-set. They also argue that the pilot study provides understandings, which inform the participants' engagement with the Q set. To ensure the effectiveness of the experimental design two pilot Q-sort interviews were conducted; one with an architect and one with a health and safety professional. The objective of the pilot study was three fold: to verify (i) the suitability of photographs – that they included sufficient details, absence of unnecessary imagery and representing a range of façade systems; (ii) the effectiveness and clarity of the interview process and the associated written instructions; and (iii) that the duration of the Q-sort posed an acceptable and reasonable time commitment from the industry participants. At the end of the pilot studies the researchers sought feedback from the participants regarding the photos, instructions, sorting process and the time consumed and verified the Q-set is suitable and Q-sort is effective, acceptable and the time commitment is reasonable.

Q-sort with participants

27 participants completed the Q-sort. These include architects, engineers, constructors, and safety professionals working in the Australian construction industry. The demographic data of the participants was also collected and included their profession, current role, overall experience, façade experience and the industry sector. This information is detailed in Table 2.

ANALYSIS AND RESULTS

Frequency of ranks analysis

The frequency of ranking of each photo against each column (least safe, less safe, moderate, safer and safest) was investigated. The following observations were noted.

- None of the participants ranked F05 as safer or safest.
- None of the participants ranked F06, F07 and F12 as the least safe
- None of the participants ranked F11 or F14 as the safest
- None of the participants ranked F19 as the least safe or the safest

Photographs relating to the above observations are shown in Figure 1. The rationale behind the observed common agreements among the participants was further investigated. The common reasons for the sort selection of the photos are given below:

- F05 façade system's complex geometry and a complicated shape, large number of small elements, dangerous element of work, access issues, requirement of non standard/ specialised trade and construction sequencing were perceived as high risks. Hence, none of the participants ranked F05 as safer or safest.
- F06 façade system includes small, systemised and standardised components which outweigh the risks associated with the mix of two systems, mixture of internal and external fixing and wind effects. Majority of the participants (10/27) ranked F06 as safer.
- F11 façade system is composed of heavy, large and wide concrete panels, is fixed by cranes resulting in high-risk injury. Hence, commonly seen as a high risk system. More than a third of the participants (10/27) ranked F11 as the least safe. The rationale also includes bearing capacity of small props, proximity and access issues (crane and working platforms), ground stability and impact and consequences in case of an accident.
- F19 façade system was perceived as having a mid-range risk. The reasons for ranking towards safer include panelised, standard system. The reasons for ranking towards less safe include external installation and overlapping of components with mix of materials. More than a half of participants (16/27) agreed that F19 has a moderate risk.

Table 2: Demographic data of participants

Participant	Role	Years of experience	Years of façade experience
P01	Senior Project Manager	20	None
P02	Architect	25+	Limited
P03	Principal Mechanical Engineer (buildings)	8	0
P04	Project Leader, Architect	20	15
P05	Project Architect	12	12
P06	Interior Designer	10	0
P07	Senior Project Manager	10	10
P08	Technical Leader-Structural Engineer	30+	10
P09	Mechanical Engineer	4.5	0
P10	Managing Director (Buildings)	20	0
P11	Q/A & Systems Manager	25+	Limited
P12	Project Manager	16	12
P13	National H&S Manager	10	0
P14	Project/Construction Manager	12	12
P15	Façade Consultant & Architect	13	6
P16	GM Safety	20	3
P17	Architect	10	7
P18	Health, Safety & Environment Manager	9	9
P19	Project Coordinator	5 months	0
P20	Project Architect	10	10
P21	Project Architect	13	10
P22	Graduate Architect	6 months	6 months

P23	Senior Project Architect	8	2
P24	Graduate Architect	10 months	4 months
P25	Graduate Architect	2	2
P26	Project Designer	8	6
P27	Graduate Architect	2	1.5

Descriptive statistics

The rating scales used for each column range from -2 to +2. In using this scale, the higher the negative number, the higher the risk associated with the façade. The higher the positive number, the lower the risk. Descriptive statistics were obtained based on this rating scale. Table 3 shows the mean rank, standard deviation, maximum and minimum values.

Based on the mean score results, F05 has the highest risk rank (-1.14815). This aligns with the results of frequency analysis above where all the participants agreed that the F05 is neither safest nor safer. F11 scored the second highest risk rank (-0.8889) while none of the participants ranked F11 as the safest. Similarly, F14 also records a relatively high-risk rank (-0.5185). F07 scored the lowest risk rank or highest safety rank (1.1111) with a minimum score of -1, where none of the participants ranked F07 as the least safe. F12 also records a relatively high safety rank (0.9259) and the second safest system. Even though none of the participants ranked F06 as the least safe, its mean score is relatively low (0.2963). It is important to further analyse the within group consensus and differences to further investigate the reasons for these results.

F 05

Description: Cast glass panel facade system

F 06

Description: Mixed metal/glazed panel facade system
courtesy of the School of Property, Construction, and Project Management at RMIT University

F 11

Description: Precast concrete panel system for a car park
Source: NOAA Center for Weather and Climate Prediction, University of Maryland

F 19

Description: Mixed concrete and glass panel facade system
courtesy of the School of Property, Construction, and Project Management at RMIT University

Figure 1: Selected photographs relating to the frequency analysis

CONCLUSIONS

The objective of the research study presented in this paper is to develop and evaluate an innovative graphical knowledge based infographic for use by designers to improve construction WHS. This paper presents the design and the results related to Phase Two of the project which aims to evaluate the effectiveness of the infographic. As part of this, Q-sort was conducted with 27 professionals to solicit factors they use to assess façade safety. These factors were used to understand pre intervention risk perception levels of the participants. The paper discusses the process used to adopt Q-methodology and the preliminary results of the Q-sort data.

Table 3: Descriptive statistics

Photograph code	Mean Rank	Std. Deviation	Minimum	Maximum
F01	.1852	1.00142	-2.00	2.00
F02	-.4444	1.12090	-2.00	2.00
F03	-.2593	.94432	-2.00	2.00
F04	.2963	1.03086	-2.00	2.00
F05	-1.1481	.76980	-2.00	.00
F06	.2963	.91209	-1.00	2.00
F07	1.1111	.80064	-1.00	2.00
F08	.0741	1.20658	-2.00	2.00
F11	-.8889	1.12090	-2.00	1.00
F12	.9259	1.10683	-1.00	2.00
F14	-.5185	.89315	-2.00	1.00
F15	.7778	1.08604	-2.00	2.00
F16	.6296	1.30526	-2.00	2.00
F17	-.4074	1.11835	-2.00	2.00
F18	-.6667	1.38675	-2.00	2.00
F19	-.1111	.64051	-1.00	1.00

Data was collected from stakeholder groups including architects, engineers, constructors, and safety professionals working in the construction industry in Australia who have a substantial influence on the safety in construction planning and design decisions. Given the small sample size, without robust experiments the results may not be generalized.

Further analysis of the second stage data will be conducted in the future. This will include the analysis of: (i) the Q-sort data at group level (to find out whether different groups such as designers, non-designers, experienced professional and novice professionals share similar understanding of WHS risk and whether there are differences among these groups); (ii) the quantitative Q-sort data (rationale for ranking); and (iii) the workshop data to evaluate the effectiveness of the infographic.

ACKNOWLEDGEMENTS

Authors would like to acknowledge and thank Professor Helen Lingard for her valuable comments and suggestions for this research work.

REFERENCES

ASSE (2011). ANSI/ASSE Z590.3-2011 Prevention through Design Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes.

Block J (1956) “A comparison of the forced and unforced Q-sorting procedures.” Educational and Psychological Measurement, 16: 481-493.

Block, J. (1961). The Q-sort method in personality assessment and psychiatric research (No. 457). Springfield, IL: Thomas.

Brouwer M. (1999) Q is accounting for tastes. Journal of Advertising Research;39(2): 35-39

Brown S R (1980) Political subjectivity: Applications of Q methodology in political science, New Haven, Yale University Press.

Brown S R (1993) “A primer on Q methodology.” Operant Subjectivity, 16: 91-138.

CCWHSR (2013), Design for Safety Knowledge Sheet, Centre for Construction Work health and Safety Research, RMIT University, http://mams.rmit.edu.au/awq1056vosef.pdf, Accessed 02 January 2015.

Cooke, T., A. Stranieri, N. Blismas and H. Lingard (2008). "ToolSHeD: The development and evaluation of a decision support tool for health and safety in construction design Engineering." Construction and Architectural Management, 15(4): 336-351.

European Construction Institute (1996). "Total Project Management of Construction Safety." Health and Environment 5.

Gambatese, J. A., J. W. Hinze, , and C. T. Haas, (1997). Tool to design for construction worker safety. Journal of Architectural Engineering, 3(1), 32-41.

Green, R. (2005). “Community perceptions of environmental and social change and tourism development on the island of Koh Samui, Thailand.” J. Environ. Psychol., 25(1), 37–56.

Hinze, J. and J. A. Gambatese (1994). Design decisions that impact construction worker safety. the Fifth Annual Rinker International Conference on Construction Safety and Loss Control, University of Florida, Gainsville, FL.

Kaetzel, L. J. (1993). HIGHWAY CONCRETE (HWYCON) EXPERT SYSTEM USER REFERENCE AND ENHANCEMENT GUIDE.

Shields, A., & Cicchetti, D. (1997). Emotion regulation among school-age children: the development and validation of a new criterion Q-sort scale.Developmental psychology, 33(6), 906.

Smith NW (20010Current systems in psychology(history, theory, research, and applications. Wadsworth.

Szymberski, R. (1997). "Construction Project Safety Planning." TAPPI Journal 80(11): 69–74.

Turner M, and Lingard H (2011) “Demands and resources of workers in the Australian construction industry: Identification and exploration using Q methodology”, Proceedings of the ARCOM Twenty-seventh Annual Conference, 5-7 September 2011, Bristol, UK.

Watts, S., and Stenner, P. (2005). "Doing Q methodology: Theory, method and interpretation." Qual. Res. Psychol., 2(1), 67–91.

WorkCover NSW, (2001), CHAIR safety in design tool. New South Wales, Australia.

Zhang, P., Lingard, H., Blismas, N., Wakefield, R., & Kleiner, B. (2014). Work-Health and Safety-Risk Perceptions of Construction-Industry Stakeholders Using Photograph-Based Q Methodology. Journal of Construction Engineering and Management.

SAFETY REGULATIONS – STIFLING OR ENHANCING CREATIVITY AND INNOVATION?

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What opportunities do safety regulations present designers to be creative (thinkers) and/ or innovators (action the thoughts) in design safety analysis? 2015 sees the update of the Construction (Design and Management) regulations, and this has brought about several changes to the 2007 standards, not least of which is the role of Principal Designer. Lofstedt (DWP 2011), reporting to UK government regarding the quality and relevance of UK regulations referring to Approved Codes of Practice (ACoP) said "*They can be updated more easily (than regulation) and provide flexibility to cope with innovation and technological change without a lowering of standard*". This is the solitary reference to the ability for innovation or creativity used in Lofstedt's report. With the 2015 CDM update there is no mention of the ideology that the regulations and associated guidance can be used to encourage innovation within the design stage.

This study examines a number of the construction-related regulations/ ACoPs to determine whether or not recently enacted ones have the ability to influence or inhibit the amount of creativity and innovation that a designer brings to a project. With no mention of innovation in the newest regulations the question must be asked whether this inhibits the designer's natural propensity to be creative. Have the CDM regulations missed an opportunity to be the catalyst for expansion of the prevention through design (PtD) approach and furthering a principal that they were trying to initially encourage? Does the lack of encouragement to involve innovative practices in the design mean that these designers, over time, will become less creative with their designs?

Keywords: creativity, innovation, CDM, designers, safety

INTRODUCTION

2015 sees a major shift in one of Health and Safety Executive (HSE) UK's most well-known construction regulations, the Construction (Design and Management) Regulations 2015. The previous iteration of the regulation, 2007, had one single mention of its potential for designers to use it in a creative and innovative way. The updated version of the regulation, or in the adjoining Approved Code of Practise (ACoP), doesn't include any mention of the possibility that this legislation can potentially bring rise to innovative practices that can have a lasting effect for not just the safety of the process but have other benefits for the company and business itself. This paper explores HSE regulations and ACOPs and determines whether they have the same aversion to using them as the potential to enable designers to innovate and create addition benefits for those involved in the life cycle of a process.

Although creativity and innovation have similar connotations and are often used interchangeably the specific definitions are distinguishably different. Creativity, Business Insider (Marshall 2013)

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suggests, is "about unleashing the potential of the mind to conceive new ideas". This is the thought process that goes into the development of new ideas that can be used in construction to benefit those designing a structure. On the other hand innovation is a measurable outcome and again *Business Insider* (Marshall, 2013) describes innovation as a way of "introducing change into relatively stable systems" and the work that needs to be done in order "to make an idea viable". In other words creativity is allied to the thinking process while innovation pertains to the actioning of those thoughts. Actively creative people have the ability to get to core of a problem, without becoming embroiled in the standards or the details (McAleenan 2015). That is not to say that once an innovative solution, born out of the creative process, has been established that it should be developed in a manner that ignores statutory obligations. Competent designers will take full cognisance of the regulatory requirements and the established design standards in finalising their innovative designs. The benefit of creative thinking, leading to innovative design solutions, gives advantages to both the individual and the design company. Innovative ideas are considered a leading cause for success within companies whether it is in product design, systems and processes development, service delivery or in the advancing of organisational ideas. It is becoming increasingly important for construction companies to be able to adopt new ideas and to adapt to changing conditions as they arise. Innovative ideas are one of the more effective ways of achieving this goal.

In the search for creativity and innovation encouragement in the standards and or the statutes some other words related to 'creative' including: visionary; inspired; Inventive; and original were included. Also when searching for references to innovative/ innovation other related words were included, such as: cutting-edge; state-of-the-art and 'leading edge'. And although these synonyms have their similarities there are distinct differences between them. Those relating to creativity are all words that have no tangible or measurable outputs, whereas those relating to innovative can be measured, resulting in the ideas being made tangible and viable.

Prevention through Design (PtD) as a process allows for designers to have had more creative license over their designs. It encourages less conventional thinking in order to design health and safety processes that may be used in design, construction, maintenance, use and demolition of a project. Creative ideas and innovative solutions eventually become beneficial for companies and those who designed them, in terms of profitability, increased reputation, potential shorter construction times and overall greater safety. Newton (1999) considered that construction innovation could be considered as a "fourth performance dimension" in the industry and that it could be ranked alongside "cost, quality and time". It is becoming an increasingly important factor in the construction industry as companies are trying to differentiate themselves from others in order to drive profitability and increase their reputation as market leaders. The question remains: do regulatory requirements restrict the development of innovative solution or do they encourage them?

METHODOLOGY

The method used in this short desktop study of UK Regulations and ACoPs, relevant to the construction industry was to examine the text of each of the documents to determine whether 'creativity' and 'innovation', or related words are used and in what context. The associated words/ phrases used in the study were:

- For Creativity: visionary; inspired; Inventive; and original
- For Innovation: cutting-edge; state-out-the-art and 'leading edge'.

The Code of Ethics from engineering institutions, such as: the Institution of Civil Engineers ICE (2014), the Institution of Mechanical Engineers IMechE (2014) and the Institution of Engineering and Technology (IET) (2008) were also looked at to see whether they encourage creativity and innovation in the design process.

ANALYSIS

Table 1 lists the findings from the study.

Table 1 – Mentions of Creativity and Innovation in Construction-related Regulations and their associated ACOPs

Legislation	Regulations		ACOP	
	Innovation	Creativity	Innovation	Creativity
CDM 2007	0	0	2	0
CDM 2015	0	0	0	0
Managing for Health and Safety	-	-	0	0
Asbestos	0	0	0	0
COSHH	0	0	0	0
Manual Handling	0	0	0	0
Hand arm vibration	0	0	0	0
Personal Protective Equipment at work	0	0	0	0
Acetylene	0	0	0	0
Working at Height	0	0	0	0
Dangerous substances and explosive atmospheres (DSEAR)	0	0	0	0
COMAH	0	0	0	0
Confined spaces	0	0	0	0
LOLER	0	0	0	0
PUWER	0	0	0	0
Electricity at work	0	0	0	0

As can be seen in Table 1 there is no reference to creative or innovative terminology in any of the Regulations that are used within the construction industry and only 2 occasions where innovation gets a mention in the ACoP. The specific ACoP (2007) referring to innovation is the one for the CDM 2007 version of the Regulations:

"Principal contractors should implement a range of mechanisms to ensure that consultation is effective. Possible ways of doing this include:

…(f) procedures to encourage workers to report defects, deterioration in conditions or innovations to raise standards."

Since this particular set of regulations was repealed in GB in April 2015 in favour of a new set of CDM regulations and guidance document the point is now moot. This shows that assuming designers are indeed taught to be creative in their designs that in the health and safety regulations and accompanying ACoPs there is nothing additional to encourage them to be creative or to produce innovative design solutions. That is solutions that could decrease the risks inherent within the life cycle of a construction project; from conception through to its eventual demolition. And while it isn't the role of the regulations to legislate for innovative/ creative designs, their role is to mandate the design and production of safe and healthy products and environments. However taking the opportunity to influence and indeed encourage innovative/ creative designs would not be a hindrance to the HSE's core objective. Lofstedt, on behalf of the Department of Work and Pensions (DWP), reporting to UK government regarding the quality and relevance of UK regulations referring to ACoPs made only one reference to innovation and this referred to a means to limit future regulation development, stating "*They* [ACoPs] *can be updated more easily (than regulation) and provide* *flexibility to cope with innovation and technological change without a lowering of standard*" (DWP 2011)

A similar exercise involving the key design institutions/ professional bodies codes of ethics yielded the results presented in Table 2.

Table 2 – Mentions of Creativity and Innovation in Construction-related Professional Bodies

Institution/ Professional Body	**Code of Conduct**	
	Innovation	**Creativity**
Architects Registration Board	0	0
Royal Institute of British Architects	0	0
Institution of Civil Engineers	0	0
Institution of Mechanical Engineers	0	0
Institution of Engineering and Technology	0	1

Table 2 indicates that the mention of the creative and innovative terminology in each Institutes By-Laws and Codes of conduct only the Institution of Engineering and Technology that has a mention of creative terminology within their By-Laws. This single reference pertains to the Institutions ability… "*to make grant of money, books, apparatus or otherwise for the purpose of promoting invention and research into science, engineering and technology, or their applications, or in subjects connected therewith*" (2008). This is the only example where creative practices are encouraged in any of the construction-related Institution's By-Laws. This is an encouraging example as its intention is to promote research into other areas, such as technology and science, not simply engineering. It encourages its members to think of creative ways in other industries that can have a beneficial effect. Yet while little or nothing is mentioned in the codes of conduct the UK-SPEC (2013) make particular mentions of creative and innovative terminology when it speaks of designer's responsibilities. Examples include:

- "Engage in the creative and innovative development of engineering technology and continuous improvement systems."
- "Chartered Engineers develop solutions to engineering problems using new or existing technologies, through innovation, creativity and change and/or they may have technical accountability for complex systems with significant levels of risk."
- "Use imagination, creativity and innovation to provide products and services which maintain and enhance the quality of the environment and community, and meet financial objectives."

The Seoul Declaration on Safety and Health and Work (2008), while not specifically directed at design professionals states that:

"…A national preventative safety and health culture is one in which the right to a safe and healthy working environment is respected at all levels, where governments, employers and workers actively participate in securing a safe and healthy working environment through a system of defined rights, responsibilities and duties, and where the principle of prevention is accorded the highest priority."

Prevention is at the heart of the Declaration and as such should it not be reflected in the designers' responsibilities under national regulations. The International Engineering Alliances Engineering Accords (2014) make one reference to creativity and that is: "*…and are competent to exercise creative* *aptitudes and skills within defined fields of technology…*" yet this only refers to the education base and roles for engineering technicians.

CONCLUSIONS

The desktop study of the current health and safety regulations and associated ACoPs, relating to construction, identified that encouragement to innovate is none existent. The regulations do not offer any attempts to influence designers to use them to their benefit to create more effective and innovative methods of construction, maintenance and demolition of the process. Neither do they prohibit creativity and/ or innovation yet through fear of legislation it is probable that many opt to err on the side of caution and see creativity and innovation as a step too far. This notion is worthy of investigation, since if true then an opportunity is greatly missed.

And while Codes of Professional Conduct do little to encourage either creativity or innovation UK SPEC is very clear on its expectation that professionally qualified designers be creative and innovative in their approach. The International Engineering Agreements (Washington, Sydney and Dublin Accords) make passing reference only. Although this is the current position in regulations, codes and accords it is the belief from designers "*that safe design has more of a positive influence on innovation and design creativity*" (McAleenan and Behm 2014). This shows that even though the opportunity to encourage designers to design more innovatively and creatively has been missed in the regulations themselves from the HSE. Nevertheless the knowledge and the want to use innovative practices has been instilled in them through other means, in particular through their professional bodies and through the UKSPEC, which determines what is being taught to aspiring designers at university level. Perhaps the Professional Bodies need to be more proactive in promoting these designers' responsibilities.

This short study has found that regulations specific to the construction industry offer no encouragement to use them to develop creative or innovative practises either through the regulations directly or from within the accompanying ACoPs. There appears to be an opportunity missed to encourage more designers to use innovative designs in their regular work. And while this appears to be the case there is still an encouragement to be creative and innovative designers coming from the UKSPEC requirements on universities. The HSE should consider how best they could use their regulations and ACoPs to continue this encouragement in any future derivatives.

Following on from this study there is an opportunity to conduct a more in-depth analysis into the use of the regulations, ACoPs and accompanying design standards across design professionals initially within in the United Kingdom. The aim of the analysis would be to determine the extent of the gap in the encouragement of innovative or creative practices across the industry. The follow up to the UK study would be an international comparative study that would allow for a global analysis to determine whether there is a similar trend in other jurisdictions.

REFERENCES

Department of Work and Pensions (DWP). (2011) "Reclaiming health and safety for all: An Independent Review of Health and Safety Legislation" (The Lofstedt Report) (cm 8219) November 2011, London: DWP

Engineering Council, E. (2013). UK-SPEC - UK Standard for Professional Engineering Competence. Retrieved from Engineering Council.

Health and Safety Executive. (2007). Managing Health and Safety in Construction - Construction (Design and Management) Regulations 2007 Approved Code of Practise. Retrieved from Health and Safety Executive.

I Mech E. (2014). Royal Charter and By-Laws. Retrieved from Institution of Mechanical Engineers.

ICE. (2014). Royal Charter, By-Laws, Regulations and Rules. Retrieved from Institution of Civil Engineers: https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Documents/About%20Us/ice-royal-charter-and-by-laws.pdf

IEA. (2014). International Engineering Alliance - Educational Accords. Retrieved from International Engineering Alliance.

IET. (2008). The Institution of Engineering and Technology Royal Charter and By-Laws. Retrieved from Institution of Engineering and Technology.

ILO. (2008). Seoul Declaration on Health and Safety at Work. Retrieved from Seoul Declaration on Health and Safety at Work. International Labour Organisation

Marshall, D. (2013, April 10). There's A Critical Difference Between Creativity And Innovation. Retrieved 2015, from Business Insider: http://www.businessinsider.com/difference-between-creativity-and-innovation-2013-4?IR=T

McAleenan, R. (2015). Prevention through Design and the Opportunity for Creativity - An International Perspective. In McAleenan, C. and Oloke, D. (2015) ICE Manual of Health and Safety in Construction (2 ed.). London: ICE Publishing.

McAleenan, R., and Behm, M. (2014). Designer's Perceptions of Safe Design and its Potential for Innovation. CIB W099 Conference 2014, Lund, Sweden, May 2014.

Newton, P. (1999). Modelling Innovation in AEC: Understanding the Forth Dimension of Competition. Berkley: University of California Berkley.

CALCULATION OF THE NUMBER OF SYNERGISTIC HAZARDS AND RISKS ON CONSTRUCTION SITES THAT LIMITS THE EFFICACY OF RISK ASSESSMENT MATRICES

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Fatalities, injuries and work-related diseases continue to occur on construction sites some 40 years after the introduction of the Health and Safety at Work Act (HMG 1974). Despite the best efforts of the industry to achieve safe and healthy workplaces, improvements have reached a point where year on year change is minimal. This paper explores a practice that has emerged in the intervening years; 'Risk Management', which has an underpinning ideology that risk be reduced, so far as is reasonably practicable (SFARP), but not necessarily eliminated and makes the case that the risk assessment/risk management approach adopted in the UK has been misinterpreted and is thus a contributory factor (barrier) to the slow down in improvements. In particular it argues that the risk matrix approach leads to unnecessarily excessive risk assessments and documentation that contributes to a cycle of neglect in occupational safety and health (OSH). The paper presents for consideration the concept a mathematical limitation on the efficacy of synergistic hazard analysis.

Keywords: measurement, risk, synergies.

INTRODUCTION

Construction sites are unquestionably hazardous environments; that they are at the same time dangerous is not necessarily an adjunct, a matter legislation accepted with the implementation of the 1974 Health and Safety at Work Act in the UK (HMG 1974) with the duty imposed on employers to ensure the safety, health and welfare of all their employees. Similar duties exist in the USA, Canada, Australia and across Europe. Their impact on construction had generally been positive with a fall in both the absolute number of fatalities and injuries and in the frequency rates (Figure 1). However, despite the best efforts of statutory authorities, the safety professions and the industry, construction sites remain both hazardous and dangerous places of work. In the UK there were 42 fatal injuries in 2014, with 592,000 days lost due to injury and 31,000 new cases of work related ill-health, adding to a total of 76,000 accounting for 1.7 million lost days, (HSE 2015)

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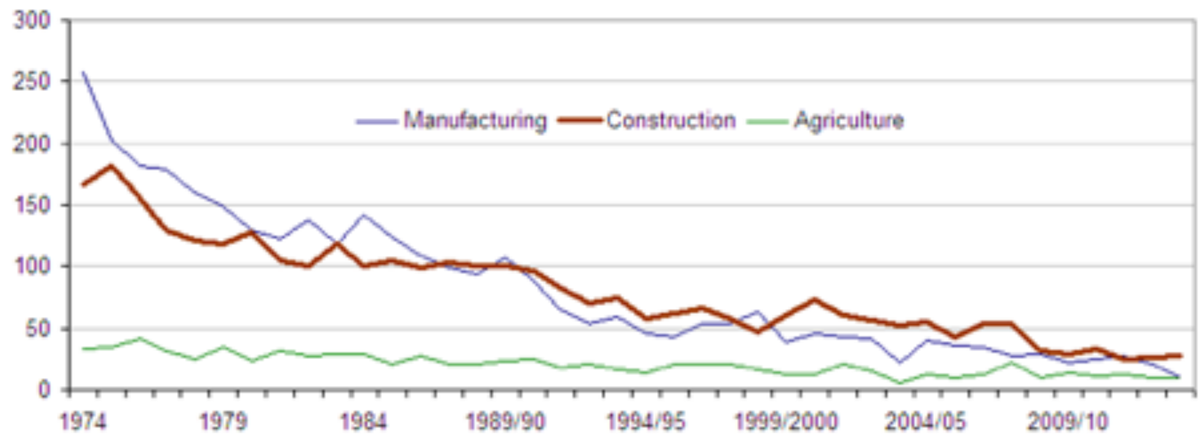

Figure 1: Numbers of fatal injuries to employees (RIDDOR) 1974 to 2013/14

Source: HSE 2015

VISION ZERO

The capacity to achieve injury/fatality free worksites is possible and this vision is the foundation of the International Labour Organisation's (ILO) (2008) strategy for prevention and the Vision for Sustainable Prevention (ILO 2014). It has also been incorporated into UK law (Reg. 4, Management of health and safety at work regulations, 1999). But despite this acceptance, the debate on "vision zero" continues, not in terms of how it is to be achieved, but whether it is realistic or not; a desirable aim or vision but one that may not be achievable in the real world (Hughes 2011, Ormond 2014). The ILO (2014), recognising the progress made in occupational safety and health (OSH) nonetheless stated that amongst some stakeholders the attitude still exists that "*...OSH is at odds with competitive advantage and viability...*" and there is evidence in the construction industry that OSH resources and training suffer when the bottom line is at risk. In other circumstance a negative attitude towards OSH emerges from ignorance regarding the causes of accidents and disease and what can be done to prevent them, creating a cycle of apathy and less demand for addressing the issues, what the ILO terms a "*cycle of neglect*" (ILO 2014).

The factors impinging on the capacity to prevent accidents and diseases are varied; negative attitudes create negative outputs, as illustrated (Figure 1), but it does not automatically follow that positive attitudes achieve the full range of positive outputs hoped for. There is also evidence that contractors and consultants who have adopted the zero harm vision and who implement OSH management systems nonetheless remain vulnerable to having risky work environments despite their leadership, safety programmes, training and the resources that they put into safety (Allen and Clarke 2014, AngloAmerican 2014, EDF 2015).

RISK ASSESSMENT AND RISK MANAGEMENT

Risk assessment and how much risk assessments a contractor carries out is often held up as evidence of good practice. Indeed procurement processes demand evidence of same (McAleenan 2010) as does the CDM 2007 ACoP (HSE 2007). This became problematic when it resulted in the production of voluminous written documentation addressing risk that the UK parliament established a working party to examine the causes and problems of risk assessments, (McAleenan 2008, WPC 2008). A number of issues were addressed including the misinterpretation/over interpretation of legislation, covering all bases just in case of an accident and the need to ensure documentary evidence in case an accident did occur. Löfstedt (2011) reached similar conclusions.

Whereas the UK law requires that employers assess the risks to which their employees may be exposed and put in place such measures as are necessary to comply with the principles of prevention (HMG 1974), and that such processes are managed appropriately (HSE 2013, BSI 2007, ILO 2001) a practice has emerged which is in essence Risk Management, with an underpinning ideology that risk could be reduced, so far as is reasonable practicable (SFARP), but not necessarily eliminated, particularly when the costs in time, effort and resources are grossly disproportionate and the option, with regard to risk, is to fund the loss, (RRC 2004).

A model for risk assessment emerged from the UK's Health and Safety Executive's (HSE 2013) guide to risk assessment (based on the HSG65, originally published in 1991) that included an example of how a simple risk assessment may be undertaken which suggested that employers identify the hazards and who may be harmed by them, decide upon the likelihood of the harm occurring, "i.e. the level of risk", and what to do about it. It was also suggested that employers are not "*expected to eliminate all risks...but make sure they know what to do about the main risks and the things [needed] to manage them properly"* (HSE 2013)

Risk management is a self-contradictory statement that promotes the concept of acceptable levels of risk, i.e. injury and fatality (McAleenan and McAleenan 2001). By definition, "risk" is the possibility or likelihood of harm or danger and containing within it the notion of absence of certainty from which chance determining which of two or more outcomes are likely. Management, on the other hand is the authoritative control of work activities. If there is control of an activity, chance is removed and there is only one possible outcome, that which is established at the outset. If it is not known with certainty what the outcome will be any action becomes a gamble on the outcome being what is desired.

In practice, and following on from HSG65's statement (HSE 2013) that not all risks need be eliminated, risk management posits an acceptable level of risk and becomes then an exercise in manipulating the circumstances to increase the odds in favour of non-injurious outcomes. However the legislation is not aimed with reducing the risk, i.e. increasing the odds in favour of non-injurious outcomes; it is concerned with employers managing work activities in hazardous environments such that there is no risk.

There is no specific requirement to risk manage in the legislation. Common usage of the risk management term appears to stem from loss control in the insurance industry, spreading without full due diligence into the world of workplace safety and health. ILO (2001) refers to risk assessment and the need for OSH management; perhaps the conflation of the two terms coupled with the linkage back to insurance risk has influenced the safety profession's interpretation of risk assessment resulting in the inappropriately named risk management in safety and health circles. Commencing with the objective of a safe outcome, management aims to achieve that objective, safety, not risk, is managed and if we can control the safety of an operation, it is immaterial how hazardous the environment is, the operation itself is nonhazardous, and the outcome will always be non-injurious.

In the analysis of Risk Management, described as a failed paradigm, (McAleenan and McAleenan, 2005 and 2008[68]) the approach adopted was to explore the language that framed the safety discourse and from which safety practice emerged. Ritchie and Thatchuk (2014) also explored the role of language in framing the safety discourse. Risk Assessment and Risk Management had been central to

[68] Expert Ease International organized and hosted a seminar at the ILO's 2008 World Congress on Safety and Health in Seoul entitled, "Risk Management - A Failed Paradigm".

the business and public health discourses throughout the greater part of the 20th century and is an attempt to measure the threats and uncertainties that could potentially disrupt or harm a company's business, insurances or public health in ways that are unacceptable. When it became part of the UK workplace health and safety legislation [69] the language of risk and risk management was adopted and made fit for the circumstances of the worksite, thus concepts such as acceptable risk and tolerable risk, which had a place in the insurance industry, entered the lexicon of the safety profession and were applied to the acceptability or tolerability of accidents and injuries. Missing from the discourse is the question of whether such concepts were appropriately transferable from financial risk to human workplace safety risk. In one sphere the risk was to a consolidated resource (finance) that should a non-catastrophic percentage be lost the remainder of the resource could be sufficient to regenerate the loss; thus an acceptable or tolerable risk. In regard to the workplace, the resource (an unfortunate and dehumanising terminology) is human beings and is not so conglomerated, and the loss of any percentage through injury or fatality could not be regenerated by the remainder. Thus acceptable risk as applied to the firm's financial risk could only go against rationality and morality when the same concept was applied to people. Yet it persisted, sometimes rationalised to mean acceptance of smaller injuries and "near misses". Indeed it was the perception and use of labour as a replenishable resource that led to the horrific conditions that characterised much of 19th industrial work, (Clarke 1908) and which led the legislative base founded on the principles of duty of care and strict liability of the employer for the health and safety of those they engage in their undertakings.

RISK MATRICES, SYNERGISTIC HAZARDS AND RISKS

If Risk Assessment is the attempt to measure the threat of hazards to workplace operations based on identified assumptions and uncertainties, Risk Management is the attempt to manage the work operations in the face of those uncertainties. In engineering practice this process has value when utilised at the design stage, allowing for the development of design improvements and safeguards before being transferred to the contractor for realisation. However, on the construction site the application of Risk Management to human working practices raises epistemological issues with the understanding of "risk". Risk is the likelihood of an event occurring and thus is a concept associated with probability. The assessment of risk is an assessment of probability and the probability of an event being realised lies between 0 and 1. In management terms a controlled event has a zero (0) likelihood of occurring whereas when the likelihood is > 0 and ≤ 1 the event is uncontrolled to an extent commensurate with the likelihood. The process of assessment, even with the most accurate of assumptions and statements about uncertainty cannot with a sufficient degree of certitude determine when the event will be realised. The Risk Assessment process is non-predictive and thus to accept the probability of an event occurring - however unlikely - is to accept the possibility that it will occur at any time. Risk Management can reduce the likelihood but cannot change the unpredictability inherent in the uncontrolled real world events on-site.

Maharaj (2012) has described synergistic hazards as those involving the interaction of the hazards presented by people, the environment in which the work takes place and the tasks being undertaken, (the PET model). The number of hazards that can exist on a construction site is large, for example in Maharaj et al (2012) 40 types of hazard have been categorised. When used in conjunction with the number of workers on site, the number of synergistic hazards to be assessed can rise exponentially.

A standard risk matrix, used not infrequently by the safety profession, and included in core health and safety training programmes utilises a simple likelihood of an event occurring x severity of outcome

[69] The Health and Safety at Work Act 1974 made it a duty not to expose workers to risk to their health and well-being and the Management of Health and Safety at Work Regulations 1999 made it a duty to carry out an assessment of the risks

matrix with a scale normally from 1 - 5 for each component. This gives a 5 x 5 = 25 possible outcomes that are classified as

- Red - requiring immediate action before proceeding
- Amber - requiring some action but can pro ceed with administrative controls,
- Green - can continue but may require further actions

However this matrix fails in that it does not take into account the possibility of multiple non-fatal injuries per worker in any given accident. Using the formula developed by Hand (2014a)

$$2^N - 1$$

where N = the sum of the elements (i.e. possible combinations) in the set, we find that

$$2^4 - 1 = 15$$

possible non-fatal injurious outcomes at each level of likelihood or 15 x 5 = 75 possibilities in addition to fatal outcomes.

When workers are introduced to the matrix the number of possible outcomes increases substantially such that with 5 workers on the site the matrix would have an extra dimension. However the calculation is not 5 x 5 x 5 = 75 but, using Hand's formula and

N_w = the set to be combinations of workers who could be injured, and

N_o = the set of different levels of injury (outcomes) (excluding fatality[70]) that could be sustained, then,

$$(2^{Nw} - 1)(2^{No} - 1) = (2^5 - 1)(2^4 - 1) = 31 \text{ x } 15 = 465 \text{ possible injurious subsets.}$$

When we consider that this is the risk presented by a single hazard, multiple hazards (N_h) with the potential to interact with each other produces a calculation of subsets substantially greater. For example, the same 5 workers exposed to 5 hazards with potentially 4 levels of injury (excluding fatality) produces the following:

$$(2^{Nw} - 1)(2^{Nh} - 1)(2^{No} - 1) =$$

$$(2^5 - 1)(2^5 - 1)(2^4 - 1) =$$

$$31 \text{ x } 31 \text{ x } 15 = 14{,}415 \text{ possible injurious outcomes}$$

Synergistically on a site with 40 types of hazards and 100 workers there are (using the same calculation for subsets):

$$(2^{Nw} - 1)(2^{Nh} - 1) =$$

$$(2^{100} - 1)(2^{40} - 1) =$$

$$(1.268\ldots \text{ x } 10^{30})(1.099\ldots \text{x } 10^{12}) =$$

$$1.393\ldots \text{x } 10^{42} \text{ subsets or synergistic hazards.}$$

[70] Fatal incidents are excluded from the calculation for simplicity. An accident that injures a worker may leave him with several different injuries from minor to severe, all of which need to be treated. However in the case of a fatal accident it adds nothing to the process to calculate what other injuries the deceased may potentially suffer.

This is a truly phenomenal figure of synergistic hazards and all have the potential for the same 4 levels of (non-fatal) injury. Thus there are potentially,

$$(1.393...\text{x } 10^{42}) \text{ x } 15 =$$

$$2.091...\text{x } 10^{43} \text{ subsets of non-fatal injury combinations.}$$

Combined with the potential for fatalities, (100 in this example, there being 100 workers) these are the set of all negative outcomes. There remains to consider that there is another subset to complete the list, namely the positive desired outcome, again 100, being the number of workers on site. Hand's (2014b) Law of Inevitability states that one of the complete set of all possible outcomes of a random event must occur, no matter how improbable or unlikely. Large scale multiple fatalities are low probability events but the following examples (Table 1) illustrate the Law of Inevitability and that they do happen.

Table 1: Large scale multiple fatality/injury incidents

Incident	Fatalities	Injuries/illness	Reference
Bhopal, gas release	>25,000 Mostly public	>120,000 Mostly public	http://bhopal.org
Piper Alpha, explosion	167	-	https://gcaptain.com/piper-alpha-disaster-19-year-anniversary-of-tragedy/
Pemex, explosion	500-600	5,000 - 7,000 Mostly public	http://www.hse.gov.uk/comah/sragtech/casepemex84.htm
Chernobyl, radiation exposure	30 (+19 not fully attributed to radiation)	134	http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Chernobyl-Accident/
Rana Plaza, Bangladesh Structural failure	1,134	≅2,500	www.ranaplaza-arrangement.org

CONCLUSION

The risk management/ risk assessment approach has had some positive benefit in improving OSH on construction sites, particularly when used sensibly and with the thought that it is a tool for achieving worker safety. However ideologies have developed around the requirement to assess risk that have transformed it into a process that achieves voluminous amounts of paper work that are inaccessible to those for whom they are meant and which serve to create a barrier to the achievement of safe practices by opening up OSH to ridicule. The process of risk assessment that has been developed on the back of this perception of what is legally required cannot realistically achieve what it aims to do because of the truly vast numbers of synergies generated, but nonetheless has succeeded in generating substantial amounts of unnecessary paperwork. The achievement of a culture of prevention and continuous improvement requires the re-imagining of the legislative requirements and a jettisoning of the incorrect risk management approach, in favour of managing the activity itself such that it has a favourable outcome at all times.

Hazards exist, often discretely, but in the interaction between the worker when on site, the tasks being conducted and those hazards, new synergistic hazards emerge with increasing degrees of complexity as multiple hazards, workers and activities merge in the developing project. These synergies mean that the hazard cannot be eliminated, they must be controlled in a manner commensurate with the nature of the hazards and the degree of complexity. The mathematics herein illustrates how many synergistic hazards there may be on a construction site, but more importantly it illustrates how ineffectual the traditional risk assessment and risk matrix approach is in accounting for, describing and identifying all the controls for all the synergies. The core requirement is to provide a safe and healthy work environment. Risk assessment is one of many tools to assist in achieving this and the degree to which it is to be used is to be determined by its effectiveness in achieving that core objective, and it is not to be used beyond its rational limits.

REFERENCES

Allen and Clarke (2014). Evaluation of the impact of the business leaders health and safety forum. Business Leaders Health and Safety Forum, Zero Impact Workplaces, NZ, 2014

AngloAmerican (2014). Committed to the safety of every single employee. [online] Available at http://www.angloamerican.com/sustainability/safety-and-health.aspx [accessed 29th March 2015]

Ayers, G and McAleenan, C "Encouraging meaningful and effective consultation about occupational health and safety (OHS) in the construction industry: a recognition of workforce competence" World Congress on Safety and Health, Seoul, Korea. June 2008

British Standards Institute (BSI) (2007). BS OHSAS 18001 Occupational Health and Safety Management. BSI, UK, 2007

Clarke W (1908). Industrial, in ed. Shaw B (1908) Fabian Essays in Socialism, Walter Scott Publishing, London 1908

EDF Energy (2015). To achieve Zero Harm to our people. EDF webpage 2015 [online] Available at http://www.edfenergy.com/about/ambitions/zero-harm [accessed 29th March 2015]

Expert Ease International (2005). Revision of the Construction (Design and Management) Regulations 1994, Response to HSE's Proposed CDM 2006 Regulations. EEI, 2005

Hand DJ (2014a). Never say never, in Scientific American, Vol. 310 No. 2 pps 58-61 Feb 2014

Hand DJ (2014b). The Improbability Principle, [online] Available at http://improbability-principle.com [accessed 12th August 2014]

Her Majesties Government [HMG] (1974) Health and Safety at Act 1974. [online] Available at http://www.legislation.gov.uk/ukpga/1974/37 [accessed 29th March 2015]

Health and Safety Executive (HSE) (2007). Managing health and safety in construction. Construction (Design and Management) Regulations 2007 Approved Code of Practice. HSE UK. 2007

Health and Safety Executive (HSE) (2013). Managing for health and safety (HSG65). HSE UK, 2013

Health and Safety Executive (HSE) (2015). Construction industry statistics, [online] Available at http://www.hse.gov.uk/Statistics/industry/construction/index.htm [accessed 27th March 2015]

Hughes D (2011). Zero harm, - hype or hope. [online] Available at, http://ezinearticles.com/?Zero-Harm---Hype-or-Hope?&id=5715282 [accessed 27th March 2015]

International Labour Organisation (ILO) (2001). ILO-OSH Management Systems 2001. ILO Geneva, 2001

International Labour Organisation (ILO) (2008). Seoul Declaration on Safety and Health at Work. ILO, Seoul 2008

International Labour Organisation (ILO) (2014). Vision for Sustainable Prevention. ILO, Frankfurt 2014

Löfstedt R E (2011). Reclaiming Health and Safety for all: An independent review of health and safety legislation. (Löfstedt Report) (Cmnd. 8219). London: HMSO, 2011

McAleenan C and McAleenan P (2001). Dynamic Safety Management in the Construction Industry. Proceedings, International Safety and Security Association (ISSA), Paris 2001

McAleenan C and McAleenan P (2005). Prevention - A Universal Responsibility. Proceedings, World Safety Congress, Orlando 2005

McAleenan C and McAleenan P (2008). Competence - A Leap of Faith. Proceedings, World Congress on Safety and Health, Seoul, Korea. June 2008

Maharaj R, McAleenan C and McAleenan P (2012) “Managing Safety in Construction – EDF Energy Nuclear New Build”. Manchester: ARMSA Consulting 2012

McAleenan, C. (2010). “Procurement” in: C McAleenan and D Oloke (eds.) 2010 “ICE Manual of Health and Safety in Construction”. London: Thomas Telford Ltd

McAleenan, P. (2008). Risk assessments and significant risks – GB health and safety legislation. Written submission to Works and Pensions Committee Workplace Health and Safety Report, 2008.

Ormond M (2014). Safety target: zero harm. SHPonline, IOSH, 2014. [online] Available at http://www.shponline.co.uk/safety-target-zero-harm/?cid=searchresult [accessed 27th March 2015]

RRC Business Training (2004). NEBOSH Level 4 in Occupational Health and Safety Practice (Unit A). RRC, London 2004

Ritchie M and Thatchuk A (2013) The operation of safety ethics in operationalizing behavior based safety. Tri-lens Safety, Canada, 2013

Robens of Woldingham Alfred Robens Baron. 1972. Safety and Health at Work. Report of the Committee 1970-72 (Robens Report) (Cmnd. 5034), London: HMSO 1972

Works and Pensions Committee (WPC) (2008). Uncorrected transcript of oral evidence, health and safety. UK 2008. [online] Available at http://www.publications.parliament.uk/pa/cm200708/cmselect/cmworpen/uc246-iii/uc24602.htm [accessed 27th March 2015]

AN ASSESSMENT OF THE INFLUENCE OF CONTEXTUAL ENVIRONMENT ON HEALTH AND SAFETY PRACTICES IN THE NIGERIAN CONSTRUCTION INDUSTRY

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This paper presents the results of a survey that appraised the influence of contextual factors on health and safety (H&S) practices in the Nigerian construction industry. This is on the grounds that understanding the environment that construction contractors operate in will help in improving the H&S record of the industry. Some key contextual factors were identified through literature review and questionnaires were distributed to construction practitioners to identify the contextual factors that influence H&S practices in their organisations. The respondents were also asked to score their perceptions on the extent that these factors influence H&S practices in their organisations. The responses of the survey were analysed using descriptive and inferential statistics. The respondents (43.5%) opine that accidents are predestined. The respondents also rank the impact of inadequate H&S regulatory system to be the highest contextual factor that influences H&S practices with relative importance index (RII) of 0.80. This is followed by inadequate governmental attention on H&S with RII of 0.77. Strategies towards improving H&S should be based on contextual issues; yet, this area remains under-examined if not unexamined in Nigeria.

Keywords: construction industry, contextual, factors, health and safety, practices.

INTRODUCTION

It is not news that the accident record of the construction industry in general is poor when compared to other industries. Although some construction industries in developed countries such as Britain report improved accident records, the construction industry in general continues to be a hazardous industry with a high level of risk (Health and Safety Executive (HSE) 2014). The fatal injury rate is disproportionate to the number of employees (*ibid*). Typically, HSE (2014) reports a 13% fatal injury rate and 10% major reported injuries in 2013/14; whereas, it accounts for 5% of Britain's workforce. In Australia, Safe Work Australia (SWA) (2013) reports a fatality rate of about 4.34 per 100,000 employees between 2007/08 and 2011/12, where the national rate is 2.29 (nearly double). This is where the construction industry has contributed only 9% of Australia's workforce (SWA 2012).

Developing countries' construction industries are not exceptions. There is a dearth of accurate statistics in developing countries (Idoro 2008; Smallwood & Haupt 2005).

However, in Nigeria, Idoro (2011) reports that among Nigerian construction contractors, as at 2006, the best accident per worker rate was 2 accidents per 100 workers, and the best injury per worker rate was 5 injuries per 100 workers. This is based on a study of 42 construction contractors. Similarly, Windapo and Jegede (2013) also report that of the 61 respondents of construction professionals in Lagos state of Nigeria, the employees have witnessed 23 fatalities.

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The poor record of H&S is blamed on many factors such as poor H&S regulatory system (Idoro 2008, 2011; Umeokafor et al. 2014b), lack of governmental commitment to H&S, corruption, beliefs and values (Umeokafor et al. 2014b), the internal and external environment that construction organisations operate in (Kheni et al. 2007, 2010). The aforementioned and many in this paper are the contextual factors that influence construction companies in terms of H&S in Nigeria. Authors contend that the solution to the poor state of H&S in developing countries lies in understanding the internal and external environment of construction companies (Kheni et al. 2010). This view is supported by studies (Aniekwu 2007; Ayres & Braithwaite 1992; DiMento 1999). This may explain why Kheni et al. (2007) present an earlier study that examines the influence of politics, institutional arrangements and socio-culture on H&S management in Ghana's construction industry. It is opined that organisations are susceptible to the environment that they exist in (Hofstede 1980); this means the contextual environment. Considering the contextual environment of an organisation, community or country when developing policies, strategies or promulgating laws is pertinent in ensuring the effectiveness of the aforesaid. Nonetheless, this area remains under-examined if not unexamined in developing countries' construction industry (Nuwayhid 2004 in Kheni et al. 2010).

In view of the above, this study examines the contextual environment of Nigeria, assessing its influence on construction H&S practices. In doing this, literature review of contextual issues and H&S practices are presented. The methods that have been adopted in this study are also presented. This is followed by the results, analysis and discussion of the survey. The concluding part of this paper is the final section to be presented. While this study contextualises Nigeria, as Kheni et al. (2010) demonstrate using the works of authors such as Hillebrandt (1999), Ofori (1999) and Thomas (2002); this study can be relevant to other developing countries because they share the same characteristics in terms of technology, method of construction, regulation and cultural environment.

LITERATURE REVIEW

Health and safety practices

Studies report on the H&S practices of construction companies in Nigeria (Okeola 2009; Windapo & Jegede 2013). These H&S practices cover areas such as accident reporting and investigation, safety meetings, safety training, use of personal protective equipment (PPE) and provision of first aid boxes (Windapo & Jegede 2013). Deplorably, the performances of Nigerian construction firms in terms of the aforesaid are not encouraging. In particular, Okeola (2009) found that over a four-year period, out of 13 projects he reports on, 92% have not provided PPE to their employees. Also, none of the sites in Okeola's study has provided first aid boxes (2009).

The will to engage in H&S practices may be based on understanding the perceived benefits and cost of engaging in H&S practices (Windapo & Jegede 2013). Also, Windapo and Jegede (2013) corroborate the study of Weil (2001) to demonstrate the impact of enforcement and compliance with H&S standards in accident and injury prevention. Most H&S practices through one way or the other suggest or demonstrate relationships with compliance and/or enforcement with H&S standards. Nonetheless, socio-political, cultural, institutional, and economic factors influence organisations in every locality, accounting for their performance in terms of H&S practices. These aforesaid factors are conceptualised in this study to be contextual factors.

Identifying and relating contextual factors to health and safety in Nigeria

Institutional and legal context

Most pieces of H&S legislation in Nigeria have originated from developed countries (Aniekwu 2007; Idoro 2011). However, there is no national institutional arrangement for the Nigerian construction industry in terms of H&S. Indeed, Idoro (2011) demonstrates that the Nigerian construction industry is not covered by any local legislation. This is because the existing Factories Act of 2004 exempts the industry in its definition of premises (Diugwu et al. 2012; Idoro 2011). Consequently, Idoro (2011) argues that construction contractors adopt legislation from developed countries but remain largely unregulated. It is then argued that construction contractors allocate little resources to H&S (Idoro 2008) alongside little attention. This does not only show the lack of management commitment to H&S (Umeokafor et al. 2014b), but also the lack of governmental commitment to H&S.

In addition, view holds that the adoption of legislation from developed countries, which are not contextualised to Nigeria, leaves some of the provisions impracticable or irrelevant to the Nigerian construction industry (Aniekwu 2007). Therefore, there is the need to ensure that H&S concepts and provisions are designed based on the contextual environment of Nigeria (Aniekwu 2007). The same is applicable to regulatory strategies (Ayres & Braithwaite 1992; DiMento 1999).

Conversely, adopting legislation from developed countries shows positive global influence on Nigeria in terms of H&S especially from UK, the colonial masters. This can also help to improve H&S in Nigeria.

Economic context

Economically, Nigeria is evidenced to be performing very well (Nigerian National Bureau of Statistics 2014). Typically, it is the largest economy in Africa (*ibid*) and the 26th largest worldwide. Despite the economic growth of Nigeria, some construction firms are not performing as expected (Odediran et al. 2012). Some sectors of the industry benefit more than others. For instance, Idoro (2010) and Olugboyega (1998) allude that large construction firms, which are mostly multinational firms, execute a high number of construction projects. These projects have values of up to 90% of the construction projects in Nigeria (Ministerial Committee on Causes of High Government Contracts 1982 and Olateju 1991 in Idoro 2010). This is despite that indigenous construction contractors are legally required to be prioritised during allocation of contracts (Public procurement Act of 2007: section 32 paragraph 1).

Arguments by authors may explain the above premise. For instance, it is opined that multinationals have better H&S management procedures (Windapo & Jegede 2013) and provide higher quality of works than their indigenous counterparts. Multinationals are also believed to have better planning and managerial skills than indigenous contractors (Odediran et al. 2012). Further, indigenous construction firms who are mostly SMEs are unable to compete in the international market (Kheni et al. 2007). The local building materials are undeveloped and SMEs have low foreign earnings (Kheni et al. 2007). SMEs in turn operate only in the local market while the large firms (mostly multinationals) operate in both local and international markets (Kheni et al. 2007). The aforementioned challenges result to low revenue for SMEs, which in turn results to the lack of funds for SMEs and in turn affect them in terms of H&S (Kheni et al. 2007). The impact of these challenges may be increased by inadequate infrastructure such as bad roads, constantly interrupted power supply, bureaucracy at both private and public levels. After all, lack of basic amenities make business operations in Nigeria expensive (Angaye & Gwilliam 2008).

Socio-political context

In the Nigerian socio-political context, power relationship is crucial in every day activity. The powerful people in the society can withstand any opposition. As such, H&S may not be a priority. Umeokafor et al. (2014a) demonstrate the influence of the powerful in the society on H&S regulation by citing an instance where H&S inspectors were pulled out of work because of political influence. Angaye and Gwilliam (2008) also discuss *inter alia* power relationships on regulatory practices at both corporate and state levels in Nigeria.

More importantly, the poor level of governance and leadership (Abe 2014), and corruption in Nigeria do not support organisations in terms of H&S (Idubor & Osiamoje 2013; Umeokafor et al. 2014b). Durotoye (2014) and Abe (2014) discuss the impact of corruption, inconsistency in policies, poor governance, and poor utilisation of capacities on the economic development of Nigeria. The implications of the aforesaid are not limited to organisations allocating little resources and attention to H&S, and inadequate governmental attention to H&S.

Culture and belief

Developing countries such as Nigeria have strong cultural values that inspire the actions of the residents. This means that the norms, values and perceptions of people towards H&S can influence their actions (Idubor & Osiamoje 2013; Kalejaiye 2013). In fact, it is possible that the influence of culture in developing countries exceed the one apparent in developed countries (Kheni et al. 2010). As such, it can be argued that the features of the cultural dimension of Nigeria that emphasise positive attitude towards H&S should be impactful in Nigeria. To illustrate, the cultural dimension of Nigeria is collectivism. A society with collective cultural dimension engages in the collective understanding way of life (Hofstede 1980). This suggests that Nigerians should look after one another. They may also show a higher level of concern to relatives than people of individualism cultural dimension. The findings of Kheni et al. (2007) support the notion in that some construction firms in Ghana may adopt H&S measures because of family values.

Contrary to expectations, the state of H&S in Nigeria suggests that the collective cultural dimension of Nigeria has not been positively impactful. There is ample evidence that in Nigeria, there is poor safety culture from the educational sector to the family sector (Kalejaiye 2013). Despite that the cultural dimension of Nigeria upholds family values, most construction firms view safety as what is to be left for only multinational construction firms. Employers and clients can be argued to care less about the H&S of their employees. The influence of culture on H&S management is discussed in detail in Kheni et al. (2007, 2010).

However, the poor positive impact of the cultural dimension of Nigeria on H&S may be explained by the fact that the beliefs of Nigerians may have overpowered the collective feature of the cultural dimension. These beliefs also extend to religious beliefs, superstitious beliefs (Idubor & Osiamoje 2013; Kheni et al. 2010; Smallwood 2002). In particular, Smallwood (2002) and Idubor and Osiamoje (2013) argue that some people in developing countries believe that accident is an act of God. Analogously, Idubor and Osiamoje (2013) note that some people can adopt fetish means to prevent accidents. This makes them not to take safety precautions believing that accidents are inevitable or that they are protected by fetish powers (Umeokafor et al. 2014b).

In contrast, it is also possible that the religious position of people can even influence their moral positions (see Umeokafor et al. 2014b). It can also be a means of tackling problems in the society, especially through involving religious leaders (Pukenis 2014). It is vital to note that Nigerians are religious people, but the extent that religious beliefs influence H&S practices remain unexamined or under-examined in the Nigerian construction industry.

Relating demographic characteristics of Nigeria to health and safety

Demographically, while the population of Nigeria and ethnicities can be strengths, they can also be challenges in terms of H&S. Adequate communication, positive norms and values towards safety are vital in H&S, but as there are over 250 ethnic groups in Nigeria and the dialects are in some cases different, adequate communication and common values and norms may be challenging in terms of H&S. Conversely, Tutt et al. (2013) show that language may not hinder H&S as earlier anticipated. In a study in England, Tutt and his colleagues found that construction gangs from different ethnicities develop effective means of communication for effective H&S practices (2013). This demonstrates a hidden means of communication that occur in daily construction activities (Tutt et al. 2013). However, the demographic characteristics of Nigeria in terms of H&S are worth examining.

The influence of the construction industry on health and safety practices

The 70% contribution of the informal sector in the construction industry of Nigeria (Tanko & Anigbogu 2012) can be a benefit and at the same time an area of concern. Kalejaiye (2013) states that the informal sector has little H&S experience. As a result, Umeokafor et al. (2014b) suggest that they engage in informal construction procurement method and this in turn hinders H&S.

Also, the arguments that H&S is viewed as cost in the construction industry is made by studies not limited to Umeokafor et al. (2014b) and Windapo (2013). This in turn may make the construction organisations to spend little on H&S (Diugwu et al. 2012). Equally important are the predominant presence of casual workers and the fragmented nature of the construction supply chain.

METHODS

Eight-five questionnaires were hand distributed to construction practitioners such as project managers, civil engineers, safety officers, builders, quantity surveyors in the following states: Abuja, Anambra, Enugu, Kogi, Rivers and Lagos. A total of 62 questionnaires were returned; hence, a response rate of 72.9%. Purposeful sampling was adopted, as a comprehensive list with the contact details of construction firms was not available. The questionnaires were in three parts. Section A identified the demographic characteristics of the respondents. Section B assessed the influence of economic growth, religion and beliefs on H&S. In section C, the respondents were asked to rank their perceived level of influence of the key contextual factors that have been identified through literature review. Likert scale rating was adopted, ranging from 1 to 5 where 1 is negligible, 2 very low, 3 low, 4 high and 5 very high. The data obtained were analysed using descriptive and inferential statistics. The calculation of the relative importance index (RII) has been informed by Lim and Alum (1995) in Aibinu and Jagboro (2002) thus:

$$RII = \frac{1n1 + 2n2 + 3n3 + 4n4 + 5n5}{5N}$$

where n1 = number of respondents that noted ‘negligible’; n2 = number of respondents that noted ‘very low’; n3 = number of respondents that noted ‘low’; n4 = number of respondents that noted ‘High’; n5 = number of respondents that noted ‘very high’; N = total number of respondents.

ANALYSIS AND DISCUSSION OF SURVEY RESULT

The demographic characteristics of the respondents evidence that they have sufficient years of experience and academic qualifications, suggesting the level of their competence. In particular, most of the respondents (58.1%) have undergraduate qualifications, while 41.9% of the respondents have post-graduate qualifications. Also, the respondents (80.7%) noted to have over 6 years of work experience in the industry and 19.3% claimed to have 5 years of work experience or below. The job designations of the respondents cover: civil engineering (19.4%), project management (22.6%), quantity surveying (3.2%) and architecture (3.2%). Safety officers made up 9.6% of the sample and builders made up 19.4%. Others such as lecturers made up 22.6% of the sample. Most of the respondents come from SMEs (small-scale firms 22.6% and medium scale firms 45.2%), which are indigenous firms, and 32.3% of the respondents come from large firms that are mostly multinationals.

Table 1: *Economic growth as a facilitator for health and safety management efforts: A comparison of the perceptions of respondents in various categories of the construction industry.*

	Small-scale firms		Medium scale firms		Large-scale firms			
	No of respondents	%	No of respondents	%	No of respondents	%	Total no of Respondents	%
Yes	8	44.4	16	66.7	9	45	33	53.2
No	10	55.6	8	33.3	11	55	29	46.8
Total	18	100	24	100	20	100	62	100

According to Table 1, while 53.2% of all the respondents opine that the economic growth in Nigeria encourages their H&S management efforts, 46.8% of all the respondents disagree.

The respondents (45%) who are from large firms perceive that economic growth encourages their organisations’ H&S management efforts, but 55% disagree (Table 1). This finding may be explained by the fact that large firms may already have steady financial allocations to H&S thus may not be largely encouraged by the economic growth.

Among the small firms, 44.4% mention that economic growth of the country encourages their organisations' H&S management efforts (Table 1). This is not surprising as Kheni et al. (2007) note that lack of funds affects SMEs in terms of H&S. The same can be said of medium firms where 66.7 % opine that economic growth of the country encourages their organisations' H&S management efforts (Table 1). Conversely, Table 1 also shows that 55.6% of small firms and 33.3% of medium firms disagree that economic growth encourages H&S management efforts of their organisations.

The question that Table 1 presents its result stems from the premise that large construction firms benefit more from the economic growth of Nigeria (see the literature review section). As such, it is thought that small and medium firms may not be encouraged by the economic growth, as they do not enjoy the same level of benefits in terms of awarding contracts.

Table 2: *Key identified contextual factors, extent of importance and ranking*

Identified factors	RII	Rank
Inadequate H&S regulatory system	0.80	1
Inadequate governmental attention on H&S	0.77	2
Inadequate H&S legislation in Nigeria	0.75	3
Poor safety culture	0.75	3
Insecurity	0.72	4
Influence of members of organisations from countries of high safety culture	0.72	4
Ineffective institutional arrangements in Nigeria	0.71	5
Perception of Nigerians towards safety	0.70	6
Lack of management commitment of indigenous construction firms	0.70	6
Constant change of policies	0.70	6
Influence of organisations with strong safety culture	0.69	7
Poor safety standards in informal construction projects	0.69	7
Informal procurement route in the industry	0.68	8
Corruption at public sector level	0.68	8
Dysfunctional regulatory environment of Nigeria	0.68	8
Corruption at private sector level	0.67	9
Corruption at industry level	0.66	10
Attitude, values and perception of the management of organisations	0.66	10
Bureaucracy	0.65	11
Low level of employee commitment towards safety	0.65	11
Failed leadership of the country	0.64	12
Industrial issues	0.63	13
Attitude, values and perception of the construction industry	0.63	13
Supply chain issues	0.63	13
H&S is only for the big construction firms	0.63	13
Global influence on management systems	0.63	13
Preference to multinationals in awarding contracts	0.63	13
High level of management commitment of multinational firms	0.61	14
Influence of non-governmental organisations	0.60	15
Culture: norms, value & perceptions of Nigerians	0.59	16
Colonial influence	0.55	17
Diversity in religion of employees	0.52	18
Religious beliefs	0.46	19
Diversity in language of employees	0.43	20
Political influence	0.35	21

Table 2 contains a list of key identified contextual factors, their perceived level of importance and ranking. In Table 2, the respondents opine that inadequate H&S regulatory system has the most impact on H&S practices in the industry with a RII of 0.80. This is despite the fact that Table 2 also shows that the respondents perceive the regulatory environment of Nigeria in general which is dysfunctional to have a lower impact on H&S practices with a RII of 0.68, thus ranking eighth. This suggests the level of confidence that the respondents have on adequate H&S regulatory system as a key driver for improving H&S practices in Nigeria irrespective of the dysfunctional regulatory environment of Nigeria in general. Also, this premise is supported by the fact that regulatory related factors also rank high: for example, inadequate H&S legislation in Nigeria ranks third with a RII of 0.75 and ineffective institutional arrangement in Nigeria ranking fifth with RII of 0.71.

Table 2 also shows that inadequate governmental attention towards H&S ranks second with a RII of 0.77 and this is followed by poor safety culture, which ranks third with a RII of 0.75.

One insightful aspect of this study is that the result suggests that the impact of external influence in terms of strong or high safety culture on organisations may be higher when it comes from individuals than when it comes from organisations. This is on the grounds that among the factors that rank fourth is the influence of members of organisations from countries of high safety culture, with RII of 0.72 (Table 2). A similar factor 'the influence of organisations with strong safety culture', which also suggests the impact of strong safety culture but at organisation level ranks seventh with RII of 0.69 (Table 2). Consequently, it is thought that the responses of the respondents are suggestive of the fact that in this context, individual impact may be more effective than organisational impact. Nonetheless, further studies can examine this area.

Additionally, the influence of members of organisations from countries of high safety culture does not only show global influence on H&S, but also suggests that despite the negative impact of some contextual factors, some have positive influences.

Insecurity is also opined to highly influence H&S practices with a RII of 0.72, ranking fourth. This may be considered to be revealing, as it may be argued to be unexpected. However, the high level of insecurity in Nigeria makes organisations spend a lot in providing security for their employees and properties. Insurance is not commonplace in Nigeria thus increasing the level of insecurity in all aspects. Political influence is perceived to have the lowest influence on H&S practices in the industry with a RII of 0.35. All the factors in Table 2 have been discussed in the literature review section.

Table 3: In-depth assessment of selected contextual factors

		Belief		Religion		Corruption	
		No of respondents	%	No of respondents	%	No of respondents	%
Responses	Yes	27	43.5	5	8.1	7	11.3
	No	35	56.5	57	91.9	55	88.7
	Total	62	100	62	100	62	100

Table 3 provides in-depth assessment of selected factors that literature shows to have significant impact on construction activities in Nigeria. It also examines some factors in Table 2 further.

Table 3 shows that 43.5% of the respondents opine that accidents are predestined and nothing can be done to stop them, but 56.5% of respondents disagree. This premise has been discussed earlier in this paper.

Furthermore, according to Table 3, 8.1% of the respondents mention that there is no need to prevent accidents because God or black magic protects them. This is against 91.9% of the respondents who disagree. This is consistent with the degree of importance that the respondents attach to religious beliefs in Table 2 as it ranks nineteenth with RII of 0.46. This suggests that contrary to expectation, the strong religious background of Nigerians does not largely influence the respondents in terms of H&S. This may also be the case in the whole country.

The respondents (11.3%) claim to have encountered corruption relating to H&S issues in the last three months while 88.7% of the respondents claim the opposite (Table 3). The high number of negative responses to the test of corruption may be because Nigerians have redefined corruption to mean terms such as 'appreciation'. It may also be that the frequency of encountering corruption relating to H&S

in the industry may be low so the three-month range used for the test may be too short. However, it can be argued that, perhaps, it is more like a culture to engage in corrupt practices and so many respondents may not consider many corrupt practices to be acts of corruption. Also, the respondents may have answered positively to this question because of its the sensitive nature, but provided their sincere views in Table 2. This is because in Table 2, corruption rankings at various levels in the society are 8, 9 and 10. After all, corruption is also noted to highly impact on H&S (Idubor & Osiamoje 2013; Umeokafor et al. 2014b) and social development (Abe 2014; Durotoye 2014).

CONCLUDING REMARKS

The legal, economic, institutional, socio-political and cultural issues that make up the contextual environment of Nigeria as it relates to influencing H&S have been assessed in this study. This is with the view that understanding the internal and external environment that Nigerian construction firms operate in will help in developing effective strategies for improving H&S. It is found in this study that regulatory related factors rank high where inadequate H&S regulatory system is the topmost ranking contextual factor that influences H&S practices in the industry with a RII of 0.80. This is against political influence that ranks low with a RII of 0.35. This study also reveals the extent that beliefs influence H&S practices in the industry in that 43.5% of the respondents perceive that accidents are predestined so little or nothing can be done to prevent them. Irrespective of the strong religious background of Nigerians, only 8.1% of the respondents opine that they have faith in God or black magic to protect them in the construction industry. Furthermore, the redefinition of corruption by Nigerians may explain the low response rate of the respondents to facing corruption in terms of H&S within the past three months. While the H&S record of the Nigerian construction industry remains poor with little efforts towards improving it, strategies towards improving H&S should be based on contextual issues.

Just like other studies, this study faced limitations as follows. First, the generalisation of this study may be challenging because of the small sample, but no claim has been made that the small sample is a true representation of the population of construction professionals in Nigeria. Second, lack of funds and time has also limited this study. Third, the sampling has only covered the educated and skilled construction professionals; thus, this may be considered to be skewed to the aforesaid group. However, it is possible to argue that the group that this study covers mostly have the required level of knowledge in terms of management and H&S issues.

As this study measures perspectives of respondents, further studies of qualitative paradigm will help in providing a deeper understanding of the discourse. Also, further studies can examine the influence of religion on H&S, understanding why its influence on H&S is low despite the strong religious background of Nigerians.

REFERENCES

Abe, T (2014) Governance and leadership in Nigeria. ‘Developing country studies’, 4 (14), 104–108.

Aibinu A A, and Jagboro G O (2002) The effects of construction delays on project delivery in Nigerian construction industry. ‘International Journal of Project Management’, 20(8), 593–599

Angaye, P E G and Gwilliam, D (2008) Corporate governance in infancy and growth – An interview-based study of the development of governance and corporate regulation in Nigeria. ‘Research in Accounting in Emerging Economies’, 8, 359 – 407.

Aniekwu, N (2007) Accidents and safety violations in the Nigerian construction industry. ‘Journal of Science and Technology’, 27(1), 81 – 89.

Ayres, I and Braithwaite, J (1992) ‘Responsive regulation: transcending the deregulation debate’. Oxford University Press, New York

DiMento, J F (1999) 'Can social science explain organizational noncompliance with environmental laws?' In Hutter, B. M (Eds). A Reader in Environmental Law. New York, Oxford University Press.

Diugwu I A, Baba D L, and Egila A E (2012) Effective regulation and level of awareness: An expose of the Nigeria's construction industry. 'Open Journal of Safety Science and Technology', (2), 140-146.

Durotoye, A (2014) The mint countries as emerging economic power bloc: Prospects and challenges. 'Developing Countries Studies',4 (15), 99-106

Health and Safety Executive (HSE 2014) Health and safety in construction in Great Britain, 2014. Retrieved on 22-11-14 from http://www.hse.gov.uk/statistics/industry/construction/construction.pdf

Hofstede, G (1980)'Culture's consequences: International differences in the work related Values', Sage Publications, Beverly Hills, CA.

Idoro, G I (2008) Health and safety management efforts as correlates of performance in the Nigerian construction industry. 'Journal of Civil Engineering and Management', 14(4) 277-285.

Idoro, G 1 (2010) Influence of quality performance on clients' patronage of indigenous and expatriate construction contractors in Nigeria. 'Journal of Civil Engineering and Management', 16(1), 65–73

Idoro (2011) Comparing occupational heath and safety (OHS) management efforts and performance of Nigerian construction contractors. 'Journal of Construction in Developing Countries', 16 (2), 151 – 173.

Idubor, E E, & Oisamoje, M D (2013) An exploration of health and safety management issues in Nigeria's efforts to industrialize. 'European Scientific Journal', 9 (12), 154-169.

Kalejaiye, P (2013) Occupational health and safety: issues, challenges and compensation in Nigeria. 'Peak Journal of Public Health and Management', 1(2),16-23.

Kheni, N A, Dainty, A R J and Gibb, A G F (2007) Influence of political and socio-cultural environments of health and safety management within SMES: A Ghana case study. In: Boyd, D (Ed) 'Procs 23rd Annual ARCOM Conference, 3- 5 September 2007, Belfast, UK, Association of Researchers in Construction Management, 159 – 168.

Kheni, N A, Gibb, A G F and Dainty, A R J (2010) The health and safety management within small- and medium-sized enterprise (SMEs) in developing countries: Study of contextual influence. 'Journal of Construction Engineering and Management',136(10), 1104 – 1115.

Nigerian National Bureau of Statistics (2014) 'Measuring better: presentation of preliminary results of the rebased nominal gross domestic product (GDP) estimates for Nigeria 2010 to 2013'. Retrieved from http://www.nigerianstat.gov.ng/pages/NBS%20eLibrary#!

Odediran S J, Adeyinka B F, Opatunji O A and Morakinyo K O (2012) Business structure of indigenous firms in the Nigerian construction industry. 'International Journal of Business Research & Management (IJBRM)', 3(5), 255 -264.

Olugboyega, A A (1998) Indigenous contractors' perceptions of the importance of topics for contractor training in Nigeria. 'Habitat International,' 22(2),137-147.

Pukenis, R (2014) Christian religion in the globalised world of The XXIst Century. 'European Scientific Journal', 10(17), 37-19.

Safe Work Australia (2013) Construction. Retrieved on 20-12-14 from http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/430/Construction-Fact-Sheet-2011-12.pdf

Smallwood, J J (2002) The Influence of health and safety (H&S) culture on H&S Performance. In: Greenwood, D (Ed), '18th annual ARCOM conference, 2-4 September 2002, University of Northumbria. Association of Research in Construction Management', 1, 217-226.

Smallwood, J J and Haupt, T (2005) The need for construction health and safety (H&S) and the construction regulations: Engineers' perceptions. 'Journal of the South African Institution of Civil Engineering', 47(2), 2 – 8.

The public procurement Act (2007) Retrieved on 19- 02- 15 from http://www.bpp.gov.ng/index.php?option=com_joomdoc&view=documents&path=Public_Procurement_Act_2007.pdf&Itemid=614

Tutt, D, Pink, S, Dainty, A R J and Gibb (2013) 'In the air' and below the horizon: migrant workers in UK construction and the practice-based nature of learning and communicating OHS. 'Construction Management and Economics', 31(6), 515 – 527.

Umeokafor, N I, Igwegbe, O, Umeadi, B, Evanggelinos, K, Lundy, S, Isaac, D, Jones, K, and Umeokafor, K (2014a) The pattern of occupational accidents, injuries, accident causal factors and intervention in Nigerian factories. 'Developing Countries Studies' 4(15) 119-127.

Umeokafor, N I, Umeadi, B, & Jones, K G (2014b) Compliance with occupational health and safety regulations: A review of Nigeria's construction industry. In Ejohwomu, O & Oshodi, O (eds) 'proceedings of the 3rd International Conference on Infrastructure Development in Africa ICDIA 2014', 70-84.

Windapo, A (2013) Relationship between degree of risk, cost and level of compliance to occupational health and safety regulations in construction. 'Australasian Journal of Construction Economics and Building',13(2), 67- 82.

Windapo, A O and Jegede, O P (2013) A study of heath, safety and environment (HSE) practices of Nigerian construction companies. 'The Professional Builder', 4(1), 92- 103.

CAUSES AND EFFECTS OF BUILDING COLLAPSE: A CASE STUDY IN SOUTH AFRICA

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The paper is an exposition of the contributing issues that have led to increased injuries and fatalities among construction workers in South Africa due to the collapse of buildings at various stages of development. The exposition juxtaposes the implementation of construction regulations in South Africa with the H&S issues that underlay collapsed buildings. The exposition has been done using the collapsed Tongaat Mall in South Africa as a case example. Although the larger study is a single case design that is examining the remote and immediate causes of injuries and accidents in the Mall that was under construction at the time of the collapse, this particular paper report on a qualitative content analysis of the inquiry of the collapse. The media coverage of the inquiry was analysed to identify insights dominating the reports. The analysis was then linked to the role of actors in the collapsed building. The issues that have emerged from the textual analysis show that fatalities and injuries to construction workers were recorded because the approach to H&S by project actors in terms of compliance to legislation appear to be sub optimal. The exploratory study shows that there is certainly a need to address construction H&S matters that are associated with building collapse in South Africa.

Keywords: Building collapse, Construction, Health and Safety, South Africa

BACKGROUND

The collapse of buildings under construction is an issue in various countries around the world. For example, at 7:05 pm on Friday, July 17, 1981, the atrium of modern hotel in Kansas City, Missouri, United States of America (USA) collapsed with resultant 144 fatalities and approximately 200 injuries (Levy & Salvadori, 2002). In this accident, it was discovered that suggestions were made by the contractor with the intent of simplifying the construction of the collapsed walkways. The alteration was fatal. It must be noted that neither the quality of workmanship nor the materials used in the walkway system played a major role in initiating the collapse (Levy & Salvadori, 2002). Rather, the Missouri licensing board and the Missouri Court of Appeal found fault with the design engineers because they did not notice the essential differences between their original design and the new design used by the contractor that they acknowledged reviewing (Levy & Salvadori, 2002).

Windapo and Rotimi (2012) recently note that the issue of building collapse has failed to receive the attention it deserves from stakeholders. The construction industry development board (CIDB) (2009) in South Africa record that the industry is not deficient in terms of legislation and regulations that should prevent accidents and injuries. Rather, there is a strong indication that contractors in South Africa are failing to comply fully with the regulations (Geminiani & Smallwood, 2008). As a result, the decrease in injuries and accidents in South African construction has been marginal (CIDB, 2009).

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Fatalities relative to motor vehicle accidents and building collapse have not decreased, and this forms a major concern in the industry. The frequency of building collapses in South Africa has been on the increase. For example, a building collapsed during renovation in the Meyersdal Eco Estate, Johannesburg, South Africa on the 18th of August 2014 (News24, 2014: online). In this accident, seven fatalities and nine severe injuries were recorded. The focus of this research project is however on the Tongaat Mall, which collapsed on the 19th of November, 2013, in the town of Tongaat in South Africa. It was recorded that a concrete slab collapsed on top of workers that were busy with activities beneath it. The incident killed 2 workers and injured 29 others. The severity of the accident is depicted in Figure 1. From an H&S perspective, Figure 1 points to many questions. But the aspect focused upon in this paper is seeking responses to: "what are the contributing factors that led to the collapse". Responses to the question would start highlighting a problem that appears to be malignant in South Africa. The research problem is that building collapse has increased with its associated cost of accident in South Africa (CIDB, 2009). The purpose of this paper is to disseminate contributing factors that may precipitate building collapse so that the apparent inadequate attention to these factors can be addressed by stakeholders. Such stakeholders include the client, consultants, contractors, regulatory bodies, subcontractors, and researchers in South Africa. The study will create needed awareness that should prevent future accidents. Concerning the overall research study in which the preliminary findings are herein presented, the determination of both economic and social cost of building collapses in South Africa through the analysis of the Tongaat Mall is the aim.

Figure 1: Visuals for the collapsed mall in South Africa

EFFECTS OF BUILDING COLLAPSE

Ayedun, Durodola and Akinjare (2012) mention that loss of life and financial loss is associated with building collapses. Dyrud (2013) and Ayedun et al. (2012) contend that several causes of building failure can be attributed to either natural or man-made conditions. A natural phenomenon may be attributable to seismic tremors, typhoons, and tsunamis. However, man-made related causes of building collapse may arose through laxity in areas, which are not limited to geo-technical investigations, design and planning for dead loads. Furthermore, inadequate foundation design, poor quality building materials (so as to save money), and poor monitoring of craftsmen and improper quality of workmanship could lead to the collapse of buildings. Windapo (2012), Dyrud (2013), and Ayedun et al. (2012) observe that the predominant reasons for building collapse include structural failure, poor supervision and workmanship, the use of sub-standard materials, lack of competency in building techniques and supervision skills, and faulty design. Other causes include excessive loading and adaptation and disdain for approved drawings. The deliberation of these causes points to the fact that the Tongaat Mall building collapse, which is the focus on this study, occurred not because of natural causes but man-made causes. Such man-made causes are traceable to human activity or the lack thereof; given the non-occurrence of a natural phenomenon that led to the collapse.

METHODOLOGY

Similar studies on the collapse of buildings at the construction stage in which fatalities and injuries were recorded have used a case study approach to gain insights so as to evolve interpretations of the event (Aini et al., 2005). The study of the Tongaat Mall collapse is also aimed at insights and interpretations that can inform policy and practice. Although the case study approach has been adopted for this study in order to acquire insights and gain analytical comprehension of the events (Thomas, 2011), the findings herein presented in the next section are based on the analysis of content - official inquiry of the collapse. In content analysis, counting the frequency with which certain terms appear is a core aim of the analytic process (Ritchie et al., 2014). To appreciate the content analysis method, it is important to realise that inferences are neither inductive (moving from particulars to generalisations) nor deductive (moving from generalisation to particular incidences, but abductive, which is about moving from one kind of incidences (readable text in this case of this paper), to another kind of incidence (another case of building collapse) (Krippendorff and Bock, 2009). Krippendorff and Bock (2009) suggest that analytical constructs connect the data of a content analysis to the answers it hopes to provide. Analytical construct is the relationship between textual matter and the empirical domain.

The content and context relative to the Tongaat Mall collapse were thus analysed to identify issues dominating the media coverage of the accident. The media coverage refers to both online and printed news materials that were systematically evaluated in terms of text (words) and images (such as Figure 1) that have been recorded without the interference of the researchers. Online materials were accessed through the press releases of the Department of Labour (DoL) in South Africa, whereas printed materials mainly focus on newspaper clippings of the DoL inquiry. The analysis was then linked to the role of actors in the collapsed building. The analysis utilised the textual data to elicit meaning, gain understanding, and develop empirical knowledge on the collapsed mall (Corbin and Strauss, 2008). Prior to the content analysis, building collapse literature was reviewed to provide background information relative to the problem. The reviewed literature aided the identification of themes. The analytical procedure that follows the literature review entails locating, selecting, making- sense-of, and synthesising the textual data. The iterative process thus involves superficial assessment of the reports, in depth reading of the reports and eventual interpretation (Bowen, 2009). In brief, the research procedure is akin to the flowchart for content-analytic research process provided by Neuendorf (2002: 50-51). The flowchart, which begins with the research question and ends with tabulation and reporting of findings, has nine steps that mirror the common steps for research in the scientific method.

RESEARCH FINDINGS

Based on the analysed documents, the notable failures pertain to structural design, quality of construction work and supervision and noncompliance to the requirements of regulations (Table 1). The data shows that the mall developer ignored court orders to stop construction six days prior to the collapse of the slab that led to fatalities. Before the court order, the concerned municipality had been expending efforts to stop construction for a range of contraventions. A major contravention is the lack of 'go-ahead' approval for the mall as the municipality did not grant permit to build to the developer. As shown in Table 1, slab sagging was recorded before the collapse of the mall. The general foreman (GF) for the general contractor (GC) on the project site, who has no formal qualifications when the event occurred, confirms that one of the concrete slabs sagged by almost 70mm before the event. The foreman also confirms that the responsible engineer for the project was notified about the sagging incident. The engineer instructed the contractor to support the sagged slab with two beams. The beams were promptly built to support the slab, but the GF opine that the beams were too small in sizes, hence the collapse occurred. The data further shows that the GF raised his concern with his manager, but the manager supported the decision of the engineer. The sagged slab eventually collapsed while striking the formwork. The concrete for the collapsed slab was poured 21 days before the striking began. The removal of the formwork led to the crack and disintegration of the portion of the column under a beam, which was used to support the slab.

Table 1: Insights from the Tongaat Mall collapse inquiry

Failure (s)	Themes / Insights
Construction work / supervision	Slab sagged before collapse
Construction work / supervision	Scaffold / formwork / false work removed too soon
Construction work / supervision	Weak concrete used for construction on site
Construction work / supervision	Severe lapses in construction work and supervision
Construction work / supervision	Reasons for construction failure - beams
Structural design	Reasons for construction failure - design
Structural design / construction work	Steel bars are missing in the elements - slabs, beams, etc.
Construction work / supervision	Lack of H&S audit on project site
Regulatory control	Mall plans rejects / failed approval four times
Regulatory control	Demolition of the site was never approved
Regulatory control	Developers was consistently fined for failures
Regulatory control	Workers instructed to keep working despite official notice

One of the construction workers on the project was of the view that curing of the concrete was not sufficient before the formwork striking began. The question mark on the used concrete was even made clearer through various failed credibility tests. The findings show that the strength of the concrete was less than a third of stipulated strength in the contract data. This concrete has been used for the sagged slab despite its questionable strength with the 28-day curing period. It appears that the varying strength of the concrete was properly communicated to all concerned, especially the GC. Although the weakness of the concrete may be due to water-cement-aggregate ratio, the analysed data did not specifically indicate a reason. However, the concrete was tested at 3-, 7-, and 28-days; and at the 28-days, the concrete should have 30Mpa strength. The GC was duly notified about the issues with the concrete been used on site. In fact, test results shows inconsistencies that indicate that only 21% of 64 tested sample met the required concrete strength. Further test on the cement brand that was used eliminated the possibility of faulty cement, and place the likely problems on site as the GC mixed all used concrete on site. The strength of concrete issue was not limited to the collapsed slab as the documents points to other affected structural elements, which are inclusive of beams, columns, and even finishes. The GC was criticised for severe lapses on site due to the quality of construction work and supervision.

Criticism such as this leads to different reasons for the collapse. Expert witnesses in the inquiry opine that there are three possible weaknesses that contribute to the collapse in November 2013. Two major weak links are relative to the beam and columns shown in Figure 1. An expert witness observes that the foundation of one of the columns that supported a beam have only one pile, which was not deemed to be adequate. It was reported that the pile should have been three instead of one. The experts that have visited the site for investigative reasons points to one beam and two columns as the trigger for the collapse. First, concerning the beam, it was perceived that it was not poured once due to the visible joints. The joints are points of weaknesses that may have led to eventual disintegration. While the design of the beam was not criticised, the fact that its construction deviated from the construction drawing was a concern in which only the GC can elaborate upon. The structural dimension to the beam case, is the observation that only six reinforcing steel had been casted in the concrete instead of 19. Thus, from a structural point of view, the beam was unable to withstand the load and it failed. More reasons for the beam failure are illustrated in Figure 2.

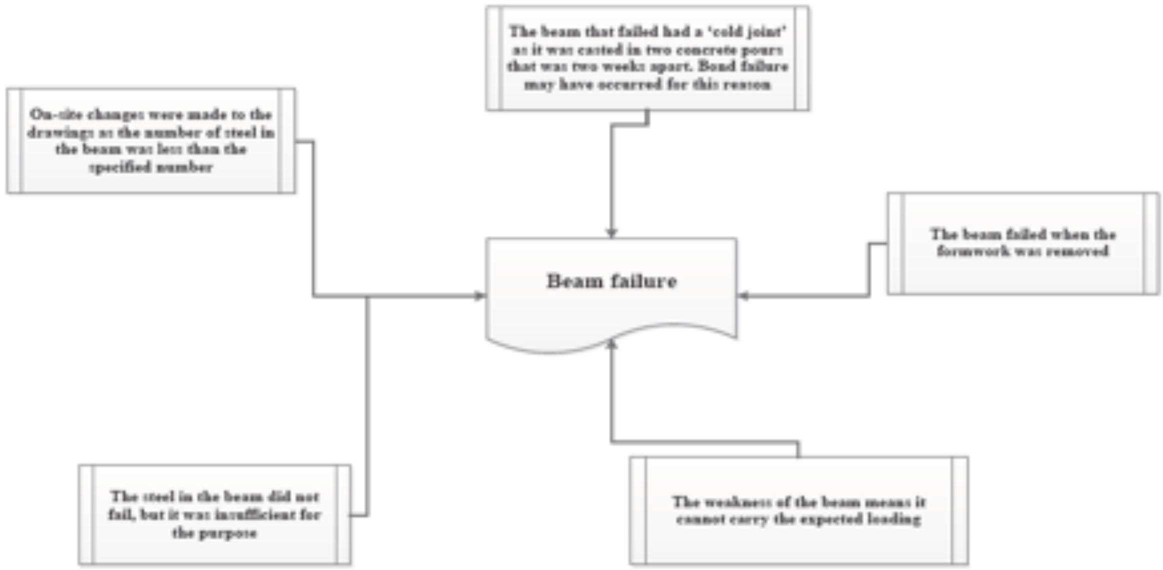

Figure 2: Insights into a failed support beam in the collapsed mall

Second, the columns were close to their carrying capacity, and as such, the ability to support the slab was questioned. It was also noted that the columns' capacity to provide the necessary support to the slab may have also reduced since the columns were not perfectly vertical and their conditions were considered to be on the upper limits of "slender". Therefore, the columns were deemed to have been inadequately designed for their purpose and had also not been built in accordance with specifications in terms of strength. The highlighted dilemma was that the loads from the slab and other associated elements have made the column with a single pile to fail. Other reasons for the failed columns are shown in Figure 3. It is however notable that for almost four months before the collapse of the building, H&S audits was not conducted. In particular, the appointed H&S consultant confirms that scaffolds, formwork and other false work were not sign off, either for installation or removal, on the site. In a related development, the H&S file of the project cannot be found on the day of the collapse; and the H&S officer was not confirmed to be at work on the fateful day. This may not be unconnected to the fact that the GF on the project is reportedly in charge of six H&S duties, a situation that is at variances with the construction regulations (Republic of South Africa, 2003).

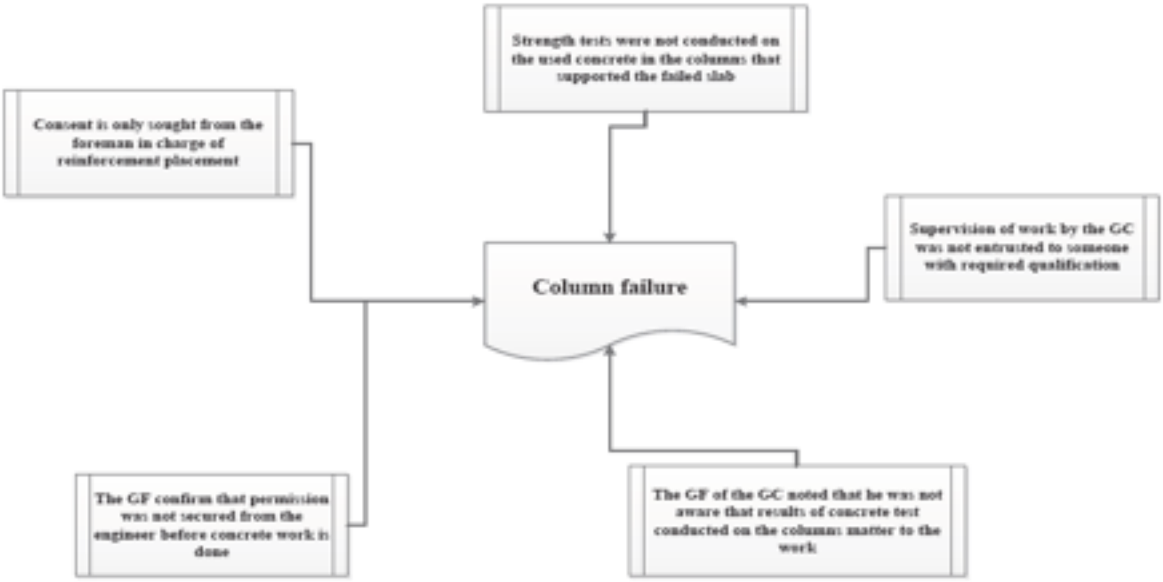

Figure 3: Insights into failed columns in the collapsed mall

The structural integrity of a building is subject to periodic inspections of on-going site work for a range of reasons. However, the analysed documents show that the engineer has not been diligent in this regard. For instance, it was discern in the data that the engineer had been present in only two of the ten inspections relative to post-tension cables in concrete slabs. Pre concrete pour inspections were not therefore undertaken as at when required. This is evident in the missing reinforcing bars and incorrectly laid cables that were flagged a month before the collapse. More worrisome is the information that on the day that the building collapsed, all construction work on the site should have stopped based on a court order. The GF on site notes that he stopped the work upon the receipt of the order, but he was later instructed to continue the work. Thus, the GF instructed the workers to continue working despite the order. Beside the court order, the GC had been fined for building without the permission of the municipality as noted earlier. In broad terms, the project recorded notable regulatory failures as shown in Figure 4. The GC failed to comply with the notices to stop work, but paid fines through the actions of law enforcement agents. Law enforcement also failed to stop the work and thereafter referred the matter to a legal department for onward actions. It is notable that the concerned GC that ignored a compliance order stopping it from proceeding with the construction project is a general building contractor with years of work experience in the industry. The GC is qualified in terms of experience and finance to obtain work to the value of R40m-R130m. It is therefore expected that firms at this level of contracting capacity would up hold the tenets of the construction regulations (Republic of South Africa, 2003). Compliance to the requirements in the regulatory environment is a start in this context.

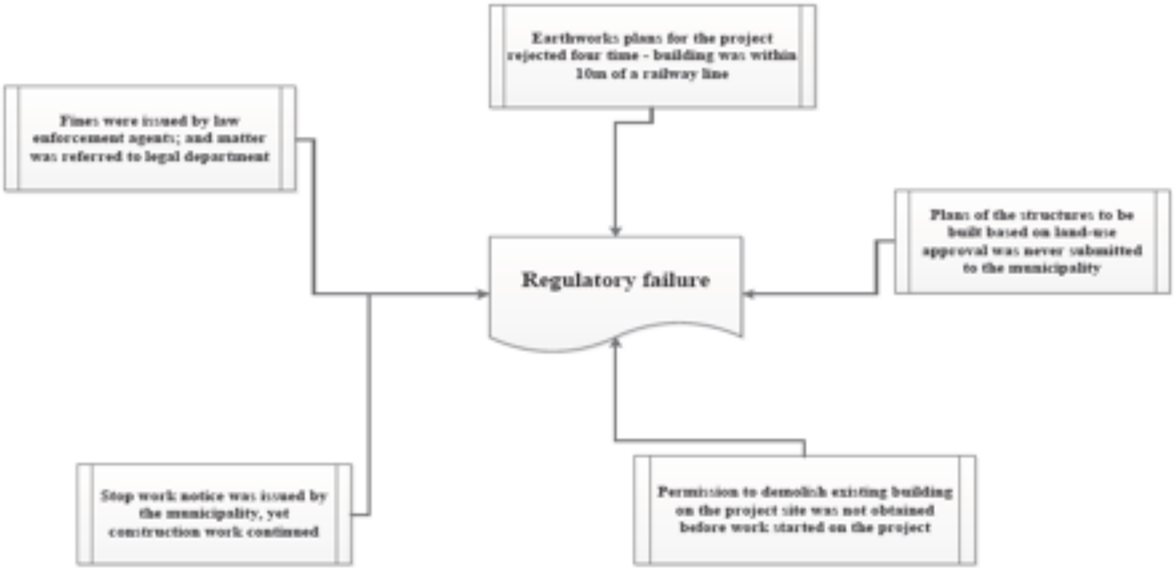

Figure 4: Insights into regulatory failure experienced on the project

COMPARISON OF EXPLORATORY RESULTS WITH OTHER BUILDING COLLAPSES

The regulatory failures experienced on the Tongaat Mall collapse involve multiple parties to the project. The failures mirror the causes of the collapse of a four story building close to its completion in Kuala Lumpur, Malaysia (Aini et al., 2005). The collapsed of the four story building recorded seven fatalities and eleven injuries. The inquiry into the causes of the collapse mentioned under design of the building (column related problems), and the poor quality of reinforced concrete work. Concerning the second cause of collapse, the inquiry flagged (1) improper curing of concrete, (2) premature striking of key formwork, (3) inadequate supervision in terms of compliance of used materials to specifications, and (4) deviations from structural design details. It is notable that inferences can be drawn between this collapse that happened in 1968 and the Tongaat Mall collapse that occurred in 2013. Similar causes of the collapses show that the industry in developing countries need to address H&S behaviours of project actors. In both collapses, triggers for the accident point to the functionality of columns and poor workmanship related to concrete work. Inadequate supervision by the engineering team involved collapsed buildings are another observed pattern. As noted in Kansas City, Missouri, USA and Kuala Lumpur accidents, the supervisory role of the engineer has been flagged in the Tongaat Mall.

IMPLICATIONS OF TONGAAT MALL BUILDING COLLAPSE

The increase in building collapse accidents in South Africa highlights the H&S issues facing the construction industry, particularly in project implementation. In general, the analysis shows that constant revision of design was rampant on the project as designs were altered to make room for support on several occasions. The gaps in practice that led to the building collapse are multiple in that the client, the GC and the design engineer through various actions and inactions failed to mitigate the causes of the collapse. The design of a slender column that was unable to carry the dead weight of the collapsed slab is a case in point. This example supports the arguments that opportunities to reduce H&S risks are highest at the preconstruction stage and become less as the project progress through implementation (Toole, 2007). Designers, especially structural engineers, should respond to H&S situations at the pre-construction stage more strongly (Toole, 2007). According to Lingard et al. (2015), these arguments corroborate the import of the time-safety influence curve, which describes the relationship between the progression of a project through its phases (initiation, design, procurement, implementation, etc.) and the ability to influence H&S as the project passes through the classical stages of product realisation. In other words, at the commencement of a construction project site work, the ability to influence H&S is expected to be very low. This is evident in the reported quality of work and supervision that occurred on the Tongaat Mall project.

Clients have key roles to play in providing and achieving optimum standards in H&S. This is particularly important when compliance is required. As shown in the findings of this building collapse, the client may have averted loss of lives in the site if compliance was adhered to as required. The Health and Safety Executive (HSE) (2002) confirms that clients have overall control of contracts and how projects are undertaken. The disappearance of the H&S file, which should contain documented H&S plan and specifications for the project, is another area where the construction regulations flagged the contributions of client / developer. In fact, the CIDB report of 2009 noted that in an August 2007 'Blitzes' in which over a thousand construction sites were inspected by the DoL in South Africa, 52.5% of the sites failed to comply to one requirement or the other.

Following the client is the role that the design engineer has played on the project. It is not clear the extent to which the design engineer complied with section 9 of the construction regulations, which states that "the designer of a structure shall inform the contractor in writing of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is subsequently altered". This clause is relevant to the roles of the design engineer in terms of addressing the mentioned triggers of the collapse - beam and columns. The need for design to consider H&S has been highlighted in the literature. The link between design and fatalities has been observed by Behm (2005) as well as Cooke and Lingard (2011). For instance, a review of over two hundred fatalities in the construction industry in the United States of America (USA) by Behm (2005) suggests that 94 cases can be linked to design. Among the construction 258 fatalities assessed by Cooke and Lingard (2011), 40% were linked to the design of the work place. These statistics underscore the importance of design influence on H&S performance.

Compliance matters are also heightened when the roles of the GC are examined. Given that the H&S performance of the GC is influenced by management commitment, communication and feedback, supervisory environment, H&S rules and procedures, training and competence levels, and work pressure (Teo et al., 2008), the construction work and supervision related issues discussed earlier could be linked to the GC on site. For instance, the lack of relevant qualification by the GF may have contributed to his responses to issues on the site. In addition, the perception that H&S is the responsibility of everyone on site is contrary to what happened when the GF asked the workers to continue to work despite a notice to stop. Among others, section 5 of the construction regulations mandate a principal contractor to "stop any contractor from executing construction work which is not in accordance with the principal contractor's and/or contractor's health and safety plan for the site or which poses a threat to the health and safety of persons". The interpretation of this clause and its compliance is important and it requires the GF, assuming he is in the know, to take steps to mitigate possible failures on the project site.

CONCLUSION

Fatalities and injuries that accompany building collapse is a justification for optimum construction management practice. The collapse of the Tongaat Mall in South Africa is not different. The practice highlighted in the analysed reports is indicative of several deviations from acceptable H&S actions. The triggers for the collapse, a beam and two columns, has been linked to poor supervision of construction work, and the quality of the final product (elements of the building such as the failed slab) in the reports. In response to the research question, this content analysis based paper suggests that poor construction work, poor supervision of work, and non-compliance to H&S regulations constitute the major contributing factors that led to the Tongaat Mall collapse. These contributing factors were also reported when buildings collapsed in Malaysia and the USA. As such, it is important to note that certain causes of building collapse are not restricted to a location in the construction industry.

This exploratory aspect of the study is not without limitations. Recommendations for further study are underpinned by such limitations, which pertain to insufficient details as the analysed documents were not originally produced for research purposes. To address this limitation, open ended questions shall be used to interrogate the issues around the poor H&S audits and the role of the GC in terms of H&S management on the site. Another limitation is that the contributing factors are not exhaustive given the fact that only inquiry reports have been examined in this paper. The possibility of other latent factors, yet to be identified, would inform the collection of future data in the study. The future empirical study would also examine the collapse in the light of its impact on legislation such as the Compensation for Occupational Injuries and Diseases Act Number 130 of 1993 in South Africa. The project actors, who are already paying for the direct and indirect cost of accidents, would have to address the legislative impact of the collapse. Apart from legislative impact, the socio-economic cost of the collapse is a limitation of the current study that shall be addressed in future field work. When a building collapses, there are questions regarding what is responsible for the accident, what went wrong in a management system, what is the cost of the accident, and what are the lessons learnt that should prevent a reoccurrence. These questions are all inclusive in future data collection efforts. Another limitation to be recognised is 'biased selectivity' because the analysed documents were sourced from the official inquiry alone. This limitation should also be addressed at the start of the field work in 2015.

REFERENCES

Aini, M.S., Fakhru'l-Razi, A., Daud, M., Adam, N.M. & Abdul Kadir, R. (2005) Analysis of Royal inquiry report on the collapse of a building in Kuala Lumpur: implications for developing countries. Disaster Prevention and Management, Vol. 14(1), pp. 55-79.

Ayedun, C., Durodola, O. & Akinjare, O. (2012) An Empirical Ascertainment of the Causes of Building Failure and Collapse in Nigeria. Mediterranean Journal of Social Sciences, 2039-2117

Behm, M. (2005) Linking construction fatalities to the design for construction safety concept. Safety Science, Vol. 43(8), pp. 589-611.

Bowen, G.A. (2009) Document analysis as a qualitative research method. Qualitative Research Journal, Vol. 9(2), pp. 27-40.

Construction Industry Development Board. (2009) Construction Health and Safety in South Africa: Status and Recommendations. Pretoria: CIDB.

Cooke, T. & Lingard, H. (2011) A retrospective analysis of work-related deaths in the Australian construction industry. In: Proceedings 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK. Association of Researchers in Construction Management, pp. 279-288.

Corbin, J. & Strauss, A. (2008) Basics of qualitative research: techniques and procedures for developing grounded theory. 3rd ed. Thousand Oaks, CA: Sage.

Dyrud. (2013) Ancient Structural Failures and Modern Incarnations. In: Proceedings of the 120th ASEE Annual Conference and Exposition (pp. 1-15). Atlanta: American Society for Engineering Education.

Health and Safety Executive (HSE) (2002) Revitalising health and safety in construction. London: HSE.

Geminiani, F. & Smallwood, J. (2008) A critical review of the effectiveness of the Department of Labour (DoL) Occupational Health and Safety(OH&S) Inspectorate in relation to the construction industry in South Africa. Acta Structilia, Vol. 15(2), pp. 1-28.

Krippendorff, K. & Bock, M.A. (2009) The Content Analysis Reader. London: Sage.

Levy, M. & Salvadori, M. (2002) Why Buildings Fall Down: How Structures Fail. [e-book]. New York: W.W. Norton.

Lingard, H., Saunders, L., Pirzadeh, P., Blismas, N., Kleiner, B. & Wakefield, R. (2015) The relationship between pre-construction decision-making and the effectiveness of risk control: testing the time-safety influence curve. Engineering, Construction and Architectural Management, Vol. 22(1), pp. 108-124.

Neuendorf, K.A. (2002) The content analysis guidebook. London: Sage.

Ritchie, J., Lewis, J., Nicholls, C.M. & Ormston, R. (2014) Qualitative research practice: a guide for social science students and researchers. 2 ed. London: Sage.

Republic of South Africa (2003) Construction Regulations. Government Gazette No. 20095. Pretoria: RSA.

Teo, E.I.L., Haupt, T.C. and Feng, Y. (2008) Construction health and safety performance in developing and developed countries: a parallel study in South Africa and Singapore. In: Proceedings of the CIB W99 14th International Conference on Evolution of and Directions in Construction Safety and Health, 9-11 March 2008, Gainesville, Florida, USA.

Thomas, G. (2011) How to do Your Case Study: A guide for students & Researchers. London: Sage.

Toole, T.M. (2007) Design engineers' responses to safety situations. ASCE Journal of Professional Issues in Engineering Education and Practice, Vol. 13(2), pp. 126-131.

Windapo, A. & Rotimi, J. (2012) Contemporary Issues in Building Collapse and its Implications for Sustainable Development. Buildings, 283-299.

ADOPTION OF A WORKING ENVIRONMENT INNOVATION: "ROLLOUT BAR CARPETS"

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Work environment problems associated with reinforcement work at constructions sites are often great and difficult. This applies especially to the ergonomic situation. The situation is particularly difficult in connection with reinforcement in horizontal structural elements such as slabs and foundation slabs on the ground, where several of the most difficult load factors occur. Since about 15 years there is an innovation (rollout bar carpets) available on the Swedish market. This innovation can many times be used at these structural elements and gives both time savings and working environmental benefits. Despite this the innovation has been and is adopted rather seldom. The reasons for this have been studied through semi structured interviews with with design-engineers, site-managers, workers and persons working at a reinforcement manufacturing company. The main results from the study are as follows: i) Rollout bar carpets have a potential of improving both work environment and time consumption on site. However, this may not be enough in itself to achieve a general adoption of the technology. ii) The implementation and adoption of innovations in construction may be more complex than the novelty of the innovation may suggest. This is due to the contextual delimitations of a project-based industry and the different roles in the construction process.

Keywords: adoption, innovation, reinforcement work, rollout bar carpets

INTRODUCTION

Reinforcement work on construction sites is characterized by a severe working environment. The work is often physically demanding, it is often executed in awkward postures and contains a lot of manual material handling (Buchholz et al 2003), (Forde and Buchholz 2004). A comparison of the current situation with the situation about 30 years ago as described in Hjort (1982), shows that the situation has not improved significantly. The innovations that have been introduced in the area have, for various reasons, not had a decisive impact. One reason is that they only improve confined parts of the reinforcement work, another is that they are not used to the extent that should be possible.

One innovation, among others, that is not used to its potential is rollout bar carpets (RBC). It is a working method that is partially based on advanced IT technology and that gives both production time savings and working environmental benefits (Ålander, 2004), (Simonsson and Rawamara 2007). The traditional reinforcement originally designed by the design engineer is redesigned into carpets. This is done at a reinforcement workshop at which the carpets are produced. RBCs are primarily used in horizontal structural members such as concrete slabs and concrete slabs on ground.

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The fact that the innovation RBCs are not used to the extent that is possible is remarkable because the method provides significant ergonomic improvements in connection with horizontal structural members, an area which is especially problematic from a working environment point of view (Sandberg and Hjort 1998). From an innovation science perspective there can be many reasons for a slow diffusion of innovation, both in relation to health and safety and in general. From the perspective of health and safety it is urgent to succeed in increasing the adoption of innovations that prevent or reduce injury, illness and disability in the construction industry (Kramer *et al*. 2010). It has been described that it may be difficult to get new ideas out on site (Rinder *et al*. 2008). The aim of the research presented in this paper is, from an innovation science point of view, to describe and discuss the factors that influence the adoption of rollout bar carpets in particular and health and safety innovations in general. The empirical material presented in this paper has been collected by semi-structured interviews. Different stakeholders, i.e. design-engineers, site-managers, workers and persons working at a reinforcement manufacturing company have been interviewed. All interviews were recorded.

ADOPTION OF INNOVATIONS WITHIN CONSTRUCTION

Innovation is the process through which firms seek to acquire and build upon their distinctive technological competence, understood as the set of resources a firm possesses and the way in which these are transformed by innovative capabilities (Dodgson & Bessant 1996). It has been defined as "the implementation/adoption of new or significantly improved production or delivery methods" (OECD 1997) and "a non-trivial improvement in a product, process or system that is actually used and which is novel to the company developing or using it" (Slaughter 2000). The OECD definition of innovation is useful as it links innovation to value creation and recognize this in a broader sense than short-term economic perspectives (Loosemore 2014). According to traditional innovation theory, innovation is dependent on long-term, economic strategies (Drucker 2001, Porter 1998, Freeman and Soete 1997). Innovation requires financial commitment so that high fixed-costs investments in physical and human resources can be transformed into high quality, low cost products (Lazonick and West 1996).

The diffusion of an innovation is a social process and includes the negotiation of interests (Weisenfeld 2003). There are different models for analysing diffusion patterns, see for example Stoneman (2001), Tidd et al. (2001) and Rogers (2003). The models aim to analyse and explain different perspectives of the diffusion process. Throughout the models' development, some common areas of importance for the diffusion process have emerged (Stoneman 2001):

- learning and information spreading
- cost of acquiring new technologies and changes therein
- performance of new technologies and changes therein
- price expectations and change therein
- technology expectations and changes therein
- firm characteristics and their distributions
- discount factors and attitude to risk
- extent of product differentiation and changes therein
- extent of first mover advantage and the economic return being an early adopter

- impact of other firm’s adoption upon users’ and non-users’ profits
- extent to which realised profits generate new investments.

Subsequent studies have only been able to empirically show three factors as being important; relative advantage, compatibility and complexity (Greenhalgh *et al*. 2004). Increased interaction in a social network may increase the rate of diffusion, and is affected by opinion leaders and change agents (Deroïan 2002; Pittaway et al. 2004).

The innovation process in construction may vary from models developed for manufacturing business sectors, due to the project-based nature of construction (Widén 2006). In contrast to manufacturing, where new ideas may flow fairly easy through a well-established vertically integrated value-chain, construction is characterized new ideas are implemented in projects where the value-chain may vary from project to project. This also has the potential of having a negative effect on the amortization of the development cost (Loosemore 2014). Strategies for innovation must involve customers, who should be educated in construction procurement practices and be capable of stimulating innovation (Atkin, 1999). Innovation in construction has been defined too narrowly as on-site activity and the focus has been on the firm rather than the project, this has caused problem to really understand innovation in construction (Shields, 2005). The innovation process in construction easily becomes very complex, it may be influenced by manufacturers, changing regulations as well as users’ behaviors (Manseau 2005). Attempts at systematic innovation may therefore prove to be problematic, because of such factors as a discontinuous process, organizational variety and span, i.e. the number of specialized teams involved (Taylor and Levitt 2005).

Innovation and innovation diffusion in a project-based sector such as construction should be seen in the light of the specific characteristics of doing business in a dynamic multi-organizational context (Hobday 1998). Diffusing an innovation may be frustrated if one or more affected stakeholders do not want the innovation in question to be adopted. During the development phase, it will be necessary to assess the likelihood of this occurrence and then to limit that possibility (Widén and Hansson 2007). Another reason for integration is that the more people taking part in the successful development of an innovation, the more people can spread the word. If these people happen to come from different social networks the information about the innovation will have an even larger potential audience (Widén 2006).

The development of a collective understanding of the innovation and building trust at the operational level where individuals are more likely to encounter it is important. A critical success factor is involvement, from the early stages of development, of those who will be responsible for implementation, possibly requiring mediation between new development and existing routines and duties within the organizations affected (Barlow et al. 2006). Manufacturers that have developed an ability to understand the innovation from the perspective of different actors through interaction with them are more successful in the development and diffusion of new products (Manley 2008). Communication across organizational boundaries becomes crucial, not least for the purpose of diffusion (Widén et al. 2008).

Communication between different actors in a building project is complicated (Rundquist, et al, 2013).and communication problems depend on factors as: i) different professions with different competences are involved in a building project, ii) project actors enter the project in different phases of the building project and iii) project actors have very different decision power in a building project. However, the communication will be far more complicated if it deals with development, diffusion and adoption of new products. The project has one time scale and the innovation process a totally different scale – when the building project is finished the innovation process is often not halfway. A special situation arises when the innovation process is about a working environment innovation. As the innovation then directly involves the labour force the communication also must involve those who will use the innovation.

Manufacturers and suppliers who are unaware of the changes required to implement their innovations, either in the links to other components, processes, or systems or in the product itself are likely to meet resistance in the spread of their products (Slaughter 2000).

Larsson (1992) described the adoption process according to Rogers and Shoemaker (1971) in a four step sequence: knowledge, persuasion, decision and implementation. The site manager was the key person in the adoption process and he was a constant problem solver in the construction project. Innovations also have to show multiple advantages to be considered to be adopted. In relation to health and safety, that aspect was rarely considered as the mayor reason for adopting an innovation (Kramer *et al*. 2010).

THE CASE STUDY: ROLLOUT BAR CARPETS

RBC – a general description

The concept rollout bar carpet is more or less synonymous with the product

BAMTEC ("Bewehrungs-Abbund-Maschinen-Technologie"). It is a reinforcement system that was invented in Germany in the early 1990s (Ålander 2004; BAMTEC 2015). The innovation was introduced on the market in 1998 (Häussler and Häussler 2007). It has spread to several countries in Europe and beyond, and it is now licensed and manufactured in 24 countries (BAMTEC 2015).

RBC is a system based on conventional reinforcement, where the design, manufacture and assembly are tied together in an advanced and computerized way. It is used primarily in horizontal structural elements such as concrete beams and slabs on the ground, but it can also be used, for example, for wall reinforcement.

By this system traditional reinforcement, which basically consists of individual, loose bars is replaced by carpets that are prefabricated in a reinforcement workshop, and after transport to the site are rolled out on the site. The system is often used in connection with cross-reinforced slabs with reinforcement both in the bottom side and in the top side. The application of the RBC system then means that this reinforcement is obtained with four “one-way spanning carpets”, two at bottom side and two on the top side. The carpets are composed of individual reinforcing bars mutually fixed by means of welded-steel bands. Usually these RBC rollout bar carpets are installed at a right angle to each other, (BAMTEC 2015). The RBC system allows production of carpets with a width of 15 m. In the roll-direction the length can be larger, but the length is usually limited by the weight of a roll which should not exceed 1500 kg.

The core of the RBC system is that the phases of design, manufacturing and assembly at site are tied together in an advanced way. This is accomplished through the use of advanced IT technology and production technology. The reinforcement is designed and detailed with the help of computer programs. Hereby the required reinforcement in two directions, for the top, and for the bottom, is calculated. With the help of the program a number of carpets with specific reinforcement content and specific measurements are designed. There are alternative software packages available for the design of the RBCs. They offer various options including for optimization of the amount of reinforcement in the structural element in question. Common to them all is that they produce the input data needed for the production of the carpets (Ålander 2004).

The design results in three different planning documents (BAMTEC 2015):

- A site plan drawing showing the layout and position of the calculated reinforcement. The purpose of this plan is to guide the following planning and implementation.
- A production plan that specifies the individual carpets, with a list of production data for the subsequent production.
- An installation plan, which in principle is an assembly drawing for the different carpets. It specifies the different carpets position in the concrete structure, detailing the rolling direction, etc.

Once the design has been carried out with appropriate software, the input data for the subsequent production has been developed. Depending on the production unit's equipment and level this production can be labeled fully automatic or semi-automatic; (Ålander 2004). Whether the production is semi-automatic or fully automatic the result is rolled-up carpets ready for transport to the construction site.

The work on the construction site contains basically four parts: (Ålander 2004)

1. The current carpet is identified and lifted by crane into position on the slab.
2. The carpet is placed with great precision in position with the first bar exactly in a starting line. Packing tape that holds together the rolled carpet is removed.
3. The carpet is rolled out.
4. Spirals or rings that carpet has been rolled up on are removed.

Four workers are mostly required to roll out large carpets. Small carpets can be rolled out by two workers (Ålander 2004).

The literature highlights two main advantages of the use of rollout bar carpets in comparison with traditional reinforcement:

1. Time savings at the building site.
2. Improved working environment.

Ålander (2004) indicates that the laying of carpets is about ten times faster than the use of traditional methods and the use of carpets in real projects led to that the total time required for reinforcement work was reduced by 75-80%.

The work environmental benefits of using prefabricated reinforcement instead of traditional have been studied by Simonsson and Rawamamara (2007). In the study observations along with video filming and informal interviews were performed. With a sequence-based activity method, ErgoSAM, an ergonomic risk analysis was conducted. The analysis showed that the use of what is called industrialized methods reduced ergonomic workload on the reinforcement workers. The results presented by Simonsson and Rawamamara (2007) covers obviously both the use of reinforcement cages prefabricated at the site and the use of rollout bar carpets. The authors presents quantitative results and claim that the use of prefabricated reinforcement leads to an improved working environment as risk factors such as heavy lifting and work in a forward, downward bent posture is reduced significantly. It can be anticipated that this to a great extent applies to the use of rollout bar carpets. This assumption is strongly supported by interviews with reinforcement workers who had worked with rollout bar carpets, (Bertilsson and Ekstrand 2008).

Interviews

Six semi-structured interviews were made. All interviews were held at a construction site or at a design-office and were recorded. An overview of the interviewees as regards their profession and professional experience and previous knowledge about and experience from rollout bar carpets is given in Table 1.

Table 1. Executed interviews – an overview

Interviewee:	1	2	3	4	5	6

Profession:	Reinforce-ment worker	Design engineer	Site manager	Site manager	Site manager	Design engineer
Professional experience (years)	7	16	10	5	12	1,5
Knowledge about ”RBC”*	Yes	Yes	Yes	Yes	Yes	Yes
Experience from ”RBC”	Yes	No	Yes	No	No	Yes
Use of ”RBC”* at current site	Yes	-	Yes	No	No	-

The main results from these interviews can be summarized as follows:

- Two of the three interviewed site managers had never used RBC. They both knew that there is a rollout bar carpet method on the market but they both thought that it was not popular by the workers and that the method should not fit to their project.
- The site manager who currently used rollout bar carpets was very positive about the method and emphasized that it provides an improved working environment for the workers. He also stressed that the time-savings provided by the method are important. In addition to this he underlined that certain conditions must be fulfilled as regards the detail design of the structure if the method shall be fully beneficial and that the design engineer has an important role as regards providing these conditions.
- The decision to use rollout bar carpets is taken by the contractor. This is done after a dialogue with the reinforcement manufacturer and possibly also after a dialogue with the responsible design engineer. Time savings appear to be the main reason behind the use of rollout bar carpets.
- The interviewed reinforcement worker stressed emphatically that the use of rollout bar carpets will lead to an improved working environment. He also stressed that some problems may arise at the site if the reinforcement rolls are not loaded and unloaded properly.
- The reinforcement manufacturer possesses a great knowledge about rollout bar carpets, a knowledge that the building site and the design office do not normally possess, and which preferably should be transferred, both to construction sites and to design offices.
- Even if a design engineer knows about the rollout bar carpet method and its benefits he does not propose this method but stick to traditional reinforcement such as loose bar reinforcement or reinforcement consisting of wire mesh. He knew that the method was faster but thought that the cost was a major obstacle for the use of the method. The improved work environment was nothing he mentioned.
- The re-design of traditionally designed reinforcement into rollout bar carpets is performed by the reinforcement manufacturer. It can be a pretty extensive work. The work is greatly facilitated if the reinforcement manufacturer can enter into the project at an early stage and thus can adapt the detailed design of the project so that it becomes suitable for rollout bar carpets.

ANALYSIS AND DISCUSSION

There are clear benefits from using rollout bar carpets. There are both the potential for production benefits and work environment benefits on site. This accounts for one of the three aspects on diffusion, relative advantage. One problem though is that this may not be understood or spread among the parties of the construction industry. From the interviews carried out it is clear that the understandings of the potential benefits as well as difficulties are to some extent built on pre-conceived ideas. It seems to be especially true for those respondents who have no practical experience of the use of rollout bar carpets.

From a compatibility perspective, rollout bar carpets can be seen as both compatible and not depending on what level it is looked at. The rollout bar carpets have no new technical demands, they are used in the same way as traditional rebar. But if it is looked at from a process perspective there are a number of issues to deal with, that does not fit straight into the construction process. For example, to fully utilize the benefits of rollout bar carpets the structural designers need to address the constraints it may mean on the design.

Complexity is also very much related to process issues, technically there are no big issues with the utilization of rollout bar carpets adding to complexity. For the contractor to start using it a number of different aspects need to be right. The layout of the concrete slab need to be right, the design of the rebar and in general need, either, to be adapted for or adaptable for the use of rollout bar carpets. Additionally, the contractor need to be sure that the cost of implementing the innovation can be covered in the single project, or be sure that it may be used in consecutive projects and the cost can be covered through those. Atkin (1999) argued that to achieve innovation in construction it is important to consider the context and the organizational infrastructure in which the innovations are to be implemented.

From an innovation perspective rollout bar carpet is to be seen as a systemic innovation. This is both with regard to technical aspects but mainly related to the construction process aspects. System innovations are innovations both in their concept as such but also in the relationship to other components that together perform new functions. The relationship in-between the innovations are explicit, but most often there will be effects on other components or systems as well (Slaughter 1998).

CONCLUSIONS

Rollout bar carpets have a potential of improving both work environment and production technical issues. It has also been shown that this may not be enough in itself to achieve a general adoption of the technology. The study presented in the paper suggests that implementation and adoption of innovations in construction may be more complex than the novelty of the innovation may suggest. This is due to the contextual delimitations of a project-based industry and the different roles in the construction process.

The study presented is an initial study aiming at identifying the areas of interest for further studies in relation to diffusion and adoption of health and safety innovation in the construction industry. Two areas have been identified to study further:

- To what extent the added complexity of the project-based context as well as the different roles in the construction process influence the implementation and adoption of health and safety innovations
- To what extent other potential relative advantages are necessary for successful implementation and adoption of health and safety innovations

REFERENCES

Ålander C. (2004) Advanced Systems for Rational Slab Reinforcement. Proceedings of the Conference “Heading for concrete solutions”, Helsinki

Atkin, B. (1999). “Innovation in the Construction Sector.” Brussels, ECCREDI.

BAMTEC: http://www.Bamtec.com/index.htm (March 2015)

Barlow, J., Bayer, S. and Curry, R. (2006). “Implementing complex innovations in fluid multi-stakeholder environments: Experiences of 'telecare'.” Technovation, 26(3), 396–406.

Buchholz, B., Paquet V., Wellman H. and Forde. M (2003): Quantification of ergonomic hazards for ironworkers performing concrete reinforcement tasks during heavy highway construction. “AIHA journal”, 2003 - Taylor & Francis

Deroïan, F. (2002) Formation of social networks and diffusion of innovations. “Research Policy”, 31, 835-846.

Dodgson, M. & Bessant, J (1996) “Effective innovation Policy: A New Approach”, London, ITP London

Drucker, P. F. (2001) “The Essential Drucker, New York”, Harper Business.

Ekstrand, M och Bertilsson, T. (2008) ”Rullarmering – ett rationellt sätt att armera”. B Sc Thesis. Halmstad University. 2008. (In Swedish)

Forde, M. and Buchholz, B. (2004). Task content and physical ergonomic risk factors in construction ironwork. “International Journal of Industrial Ergonomics” 34 319-333

Freeman, C. & Soete, L. (1997) “The Economics of Industrial Innovation”, Cambridge, MIT Press.

Greenhalgh, T., Robert, G., Bate, P., Kyriakidou, O., Macfarlane, F. and Peacock, R. (2004) How to spread good ideas: A Systematic Review of the Literature on Diffusion, Dissemination and Sustainability of Innovation in Health Service Delivery and Organization. “National Coordinating Centre for NHS Service Delivery and Organization R & D (NCCSDO)”, London.

Hjort, B., (1982). “Reinforcement work on construction sites. A general study”. CBI research 3.82. Swedish Cement and Concrete Research Institute.

Hobday, M. (1998). Product complexity, innovation and industrial organisation.”Research Policy”, 26(6), 689–710.

Häussler, C. and Häussler, F. (2008). Der profiteur muss entscheiden. ”Zeitschrift Führung und Organisation”, 77(5), 282-291.

Kramer, D.M., Bigelow, P.L., Carlan, N., Wells, R.P., Garritano, E., Vi, P. and Plawiniski, M. (2010) Searching for needles in a haystack: Identifying innovations to prevent MSDs in the construction sector, “Applied Ergonomics”, 41, 577-584.

Larsson, B., (1992) ”Adoption av ny produktionsteknik på byggarbetsplatsen,. (Adoption of new Technology on the Building Site)”. Report 30, Chalmers. (Doctoral Thesis)

Lazonick, W. & West, J. (1996) “Organizational Integration and Competitive Advantage: Explaining Strategy and Performance in American Industry”, in (Eds) Dosi, G., Teece, D. J. and Chytry, J., Technology, Organization, and Competitiveness, Oxford, Oxford University Press

Loosemore, M. (2014) “Innovation Strategy and Risk in Construction – Turning Serendipity into Capability”, Routledge, London

Manley, K. (2008). Implementation of innovation by manufacturers subcontracting to construction projects. “ Engineering, Construction and Architectural Management”, 15(3), 230–45.

Manseau, A. (2005) Redefining Innovation, in (Eds.) Manseau, A. & Shields, R., “Building Tomorrow: Innovation in Construction and Engineering”, Ashgate, Aldershot, 43-55.

Oecd/Eurostat (1997) “Proposed Guidelines for Collecting and Interpreting Technological Innovation data - Oslo Manual.” Paris, OECD.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. & Neely, A. (2004) Networking and innovation: a systematic review of the evidence. “International Journal of Management Reviews”, 5/6, 137–168.

Porter, M. E. (1998) “The competitive advantage of nations”, New York, The Free Press.

Rinder, M.M., Genaidy, A., Salem, S., Shell, R. and Karowski, W. (2008) Interventions in the Construction Industry: a systematic review and a critical appraisal. “Human Factors and Ergonomics in Manufacturing”, 28, 212-229…..

Rogers, E. M. (2003) “Diffusion of Innovations”, New York, Free Press.

Rogers, E.M. and Shoemaker, F.F., (1971). “Communication of Innovations: A Crosscultural approach”. New York, Free Press.

Rundquist, J.,Emmitt, S., Halila, F., Hjort, B. and Larsson, B. (2013). Construction Innovation: Addressing the Project Product Gap in the Swedish Construction Sector, “International Journal of Innovation Science” 5(1).

Sandberg, J and Hjort, B. (1998) ”Rationell armering”. (In Swedish)

Shields, R. (2005) A Survey of the Construction Innovation Literature, in (Eds.) Manseau, A. & Shields, R.,” Building Tomorrow: Innovation in Construction and Engineering”, Ashgate, Aldershot, 5-22.

Simonsson, P och Rwamamara, R (2007) Consequence of Industrialized Construction Methods on the Working Environment. “Proceedings IGLC-15”. July 2007. Michigan, USA

Slaughter, E. S. (2000). Implementation of construction innovations. ”Building Research and Information”, 28(1), 2-17.

Slaughter, S. (1998). Models of Construction Innovation. “Journal of Construction Engineering and Management”, 124(3), 226-31.

Stoneman, P. (2001) “The Economics of Technological Diffusion”, Oxford, Blackwell Publishers Ltd.

Taylor, J.E. and Levitt, R. E. (2005). Inter-Organizational Knowledge Flow and Innovation Diffusion in Project-Based Industries. System Sciences, 2005. HICSS '05. “Proceedings of the 38th Annual Hawaii International Conference on Systemic Sciences, IEEE”, 247–56.

Tidd, J., Bessant, J. & Pavitt, P. (2001) “Managing Innovation”, Chichester, Wiley & Sons Ltd.

Weisenfeld, U. (2003). Engagement in Innovation Management: Perceptions and Interests in the GM Debate. “Creativity and Innovation Management”, 12(4), 211–20.

Widén, K. (2006) “Innovation Diffusion in the Construction Sector”, Lund, Division of Construction Management, Lund University.

Widén, K, Atkin, B. and Hommen, L. (2008) Setting the game plan: the role of clients in construction innovation and diffusion, in (Eds.) Brandon, P. & Lu, S.-L., “Clients Driving innovations”, Wiley-Blackwell, Chichester, 78-87.

Widén, K. and Hansson, B. (2007). Diffusion characteristics of sector financed innovation. “Construction Management and Economics”. 25(5), 467–76.

FACTORS INFLUENCING WORKERS' SAFETY RISK TOLERANCE IN CONSTRUCTION PROJECTS: A CASE OF CHINA

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While external factors such as safety culture, leadership, defective risk management have been considered as the factors contribute to workers' unsafety behaviors, the understanding of risk tolerance, which is highly related to workers themselves and act as an internal factor, is still limited. This paper aims to investigate the critical factors affecting construction workers' safety risk tolerance. Literature reviews, interviews, and questionnaires were used for identification of critical influencing factors. Statistical methods of ranking analysis and factor analysis were implemented for verification and for further analysis. The results show that there are 14 critical factors, and the most important ones are (in ranking): time constraints for decision-making, safety regulation, and peers behaviors. The results from factor analysis which were based on the identified critical factors reveal that they can be grouped into four categories, namely: (1) personal subjective perception; (2) knowledge and experiences; (3) work characteristics; and (4) safety management. The significance of this research is that the findings do not only contribute to the knowledge body of construction safety, but also lead to more efficient use of resources by providing critical factors that project teams should give focus.

Keywords: Risk tolerance; Construction worker; Safety risk; Critical factors; Decision making

INTRODUCTION AND RESEARCH AIM

In studies of construction safety management, workers' unsafe behavior has been considered as the direct reason for accidents, many research tried to develop workers' safety performance by investigating its relationships with external factors, such as risk management (Feng, 2013), safety culture (Sunindijo and Zou, 2011), supervisor's leadership (Fang et al., 2015) and working environment. It should be noted that most of the identified reasons are not directly related to workers themselves. In other words, they are external factors, and cannot be controlled or be changed by devoting efforts away from workers.

Individuals' poor risk decision-making has been implicated as a leading factor for accidents, and poor risk perception can contribute significantly to poor risk decision-making (Hunter, 2002, Baloi and Price, 2003). A great diversity of factors has been found making people perceive differently even confront the same risk situations, such as national culture (de Camprieu et al., 2007, Liu et al., 2014), risk attitude (Wang and Yuan, 2011, Acar and Göç, 2011), personality traits (Hallowell, 2010) and environment they belong to (Lu and Yan, 2013, Taroun, 2014).

Among these influencing factors, risk tolerance is one of the driving forces for irrational risk perception. Studies have shown that non-objective risk assessment would happen if taking no considerations of individuals' risk tolerance (Hopkinson, 2012, Mu et al., 2014). Lichtenstein et al. (1978) pointed out that people tend to overestimate their ability to control or prevent accidents, thus

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leads to an underestimation of risks. Balaz and Williams (2011) emphasized the effect of risk tolerance on immigrants' risk perception, and showed that the more uncertainties immigrants can accept, the more likely they underestimate the seriousness of potential risks. Basically, individuals with higher (lower) risk tolerance are more (less) likely to take a risk. Therefore, objective assessment of risk tolerance plays a critical role in effective and successful safety behavior. Decisions made without considering decision makers' risk tolerance might not be persuasive nor reliable. Nevertheless, what factors influence workers' safety risk tolerance in construction projects remains as an important and unsolved problem.

Research aim

This paper aims to identify the critical factors affecting workers' safety risk tolerance, which pervade in a large number of decision making activities in construction projects. This research starts from reviewing the previous studies related to risk tolerance. Then it moves on to introducing the research methodology adopted in this study. Afterwards, the results of the interviews and survey questionnaire are presented. Subsequently, a factor analysis is employed to categorize the identified critical factors. Finally, this paper reaches a conclusion with a summary of the key findings, as well as highlighting some issues worth further research.

LITERATURE REVIEW

Individual's risk tolerance was defined as the amount of risks that they are willing to accept in the pursuit of some goal (Hunter, 2002). Basically, risk tolerance is a personality trait (Hunter, 2002), which can reflect individuals' willingness to take risks and bear potential losses. After a search of current literature, it is found that there is not much relevant research in construction safety, but more in financial investment. In the financial field, investors' tolerance towards financial risk refers to the amount of uncertainty or investment return volatility that an investor is willing to accept when making a financial decision (Grable, 2000). Irwin Jr (1993) also defined financial risk tolerance as the willingness to engage in "behaviors in which the outcomes remain uncertain with the possibility of an identifiable negative outcome".

Factors influencing risk tolerance

It is difficult to predict a person's risk tolerance due to it is such an elusive and multidimensional concept (Trone et al., 1996). Based on the review of the literature on this topic, it is evident that most of the research focuses on financial domain. With regard to financial risk tolerance (FRT) literature, the factors influencing FRT were mainly derived from two aspects: (1) demographic characteristics, such as age, gender, education, income and wealth, and marital status; (2) financial variables, for example, assets, non-financial assets, level of income, employment status (Sung and Hanna, 1996, Grable et al., 2004, Yao and Hanna, 2005). Specifically, although debate remains on some issues, a range of common findings are generally observed. First, FRT decreases with age (e.g., Morin and Suarez (1983)); second, females have a lower preference for risk than males (e.g., Grable (2000)); third, FRT increases with education (e.g., Haliassos and Bertaut (1995)); fourth, FRT increases with income and wealth (e.g., Bernheim et al. (2001)); fifth, single (i.e., unmarried) investors are more risk tolerant (e.g., Roszkowski et al. (1993)). It can be concluded that the amount of risks individuals can afford really depend on their situations which include a number of predisposing factors.

Relationship between risk tolerance and decision-making behavior

The relationship between risk tolerance and decision making behavior has been studied in many fields. In financial investment, many researchers agreed that risk tolerance affects a lot in a household's portfolio decisions. Faff et al. (2008) stated that individuals' financial risk tolerance is inversely related to the economists' notion of risk attitude. That is, individuals' who have a lower (higher) risk tolerance for financial risk are more (less) risk averse. Sung and Hanna (1996) and Grable et al. (2004) pointed out that women with lower risk tolerance may have difficulty in achieving an adequate retirement and reaching others goals due to their less willingness to take financial risks. In aviation safety, Hunter (2002) emphasized the importance of risk tolerance in pilots' risk decision behaviors by showing higher risk tolerance can lead to pilots to choose courses of action that unnecessarily expose them to hazards and increased likelihood of accident. Ji et al. (2011) examined effects of risk perception and risk tolerance on pilots' safety behavior, and indicated that high scores on risk tolerance are associated with both hazardous attitude and less safety operation behavior (risky operation behavior). In general, individuals' risk tolerance plays an important role in shaping their behaviors. Decisions made without considering the decision maker's risk tolerance might not be persuasive or reliable

Risk tolerance in construction safety

In the domain of construction project, risk tolerance is still a developing area of research. Rawlinson and Farrell (2009) pointed out that high risk tolerance amongst workers is unavoidable due to the danger, complexity of construction works; as a result, it would be difficult to achieve zero accidents. Hallowell (2010) compared risk tolerance between managers and workers, and found that the level of current perceived risk is approximately five times higher than the tolerable risk value, and there is a statistically significant difference in the risk tolerance between workers and managers. Furthermore, Li et al., (2015) showed how managers' risk tolerances make bias in their RBDM by presenting that individuals' risk tolerance has the greatest negative effect on their safety risk perceptions; besides, it can act as an intermediate factor between external factors (such as safety culture, safety legislation and policies) and decision makers' risk assessment.

Based on the above discussion, researchers have realized the importance of risk tolerance in risk decision making behavior, however, less attention was given to the identification of important factors influencing workers' risk tolerance in construction project. As the worker's risk assessment would, to a large extent, be influenced by the amount of risks they can bear, identifying factors critical to their risk tolerance is of great importance before one could better understand risk decision making behavior under risky working environment.

RESEARCH METHOLODGY

In the stage of survey questionnaire design, a thorough literature examination, including Frank (2011), Moreschi (2004), Rawlinson and Farrell (2009), Abdelhamid and Everett (2000) and Acar and Göç (2011), was applied to develop an in-depth understanding of the influencing factors that related to workers' behaviors, and the risks construction workers may confront. Then, semi-structured interviews with 10 workers from 2 construction companies were carried out to develop the tentative-critical factor list in which all factors can influence workers' safety risk tolerance. At the end of the interviews, a list of 27 factors was obtained, which from the main basis for questionnaire design. All factors are tabulated in Table 1 with detailed description.

In stage two, survey questionnaire is adopted for data collection. It contains two main sections: the first section is designed to collect the background information about respondents; the second section consists of 27 factors with potential effects on workers' safety risk tolerance. The Likert scale was used to quantify these effects and was ranged as 1, 2, 3, 4 and 5, which is correspondingly represent respondents' attitude from (1) = this factor has the least effect on risk tolerance, and (5) = this factor has the most effect on risk tolerance (the effects grow with number increases). In total, 383 sets of questionnaires were distributed to workers, who were employed in 11 construction companies in China. Finally, 297 valid responses were received.

The software of Statistic Package for the Social Sciences (SPSS) version 23.0 was used to process the empirical data and make statistical analysis. The Cronbach's coefficient alpha was first calculated to measure the internal consistency among the factors. The result of the test was 0.741, which was greater than 0.5, indicating that the measurement scale was reliable at the 5% significance level (Norusis, 2007).

Table 1: Descriptions of factors in questionnaire survey

No.	Factors	Descriptions
F01	Physical health	It means workers physical condition. This factor influences the pressure workers can endure, the working quality, and the corresponding ability to confront risks
F02	Emotion	Means whether workers are happy or not, sometimes working with anger or sadness may result in irrational of risk decision making (Segal et al., 2005)
F03	Judgement ability	It refers to workers' abilities of analyzing and judging problems according to their own knowledge and experience. this ability plays an important role within the process of risk tolerance assessment
F04	Professional knowledge	The degree of professional knowledge will affect workers directly while dealing with professional project issues, result with different risk tolerance (Wang and Yuan, 2011)
F05	Working experiences	Rich working experiences make workers are more familiar with potential risks regarding projects, thus will likely reduce risk taking behavior
F06	weather	High temperature in summer, stronger wind, these may influence workers' judgment of their risk tolerance
F07	Noise	Louder noise from operation of machines, may make workers feel fidget, then, unreasonable assessment of self-risk tolerance happen
F08	Interested in their work	To what degree are workers interested in their construction job can influence their willingness to finish it with good quality rather take risk. Thus influence their degree of risk tolerance
F09	Workload	Too much work may make workers feel boring, thus want to finish the job as soon as possible, then higher level of risk tolerance could happens
F10	Availability of safety protection equipment	The employer provide enough safety protection equipment and workers can get them at any time. Enough protection equipment enhance their confidence in dealing with risks
F11	Safety training	Effective and comprehensive safety training make workers awareness of the seriousness and consequences of accidents, thus lower their risk tolerance
F12	Supervision	Supervision from government or supervisor may lower workers' willingness to take risks, then lower their risk tolerance
F13	Safety regulations	Clear and specific safety regulation help workers realized the punishment of against safety regulation, then lower their risk tolerance
F14	Peers behaviors	The effect of peers behavior refers to workers would do as same as the other workers. If other workers complete work earlier by taking risks, it will enhance individuals' risk tolerance to take the same risks
F15	Age	Older worker seems have less willingness to take risk which resulted in lower risk tolerance
F16	Education background	Workers with higher education tend to be more rational and cautious, while those who received little education tend to be more fearless and impulsive
F17	Perception of risks	It means how serious do workers perceive the confronted risks. If workers believe the confronted risks are more serious, they will not want take risks
F18	Trust of self-capability	Workers with strong belief of they can handle most of the uncertainties would have higher degree of risk tolerance
F19	Time constraints for decision making	In some abrupt cases, quick response and decision making are required, as little time left for thorough discussion and consideration. In these cases, workers' risk tolerance vary a lot depending on time permission for making a decision
F20	Completeness of project information	Engineering information is vital in making the right decision, and it can, to some extent, enhance contractors' confidence while making the decision
F21	Boldness	Boldness means the traits of being willing to undertake tasks that involve risk or danger. Decision makers with this trait always have the ability to determine the right scheme timely and resolutely
F22	Attitude of Immediate supervisor	This immediate supervisors' attitude safety issues would have considerable effect on workers' tolerance of safety risks
F23	Emphasis on safety	This means how much workers realize and emphasis their safety
F24	Decision motivation	With specific decision motivation, the decision is of significant directivity, which results in the fact that the decision activity will move on toward expected direction and objective

F25	Safety knowledge	More safety knowledge make worker know clear about the seriousness of risk taking in construction project, then lower risk tolerance may happen (Pohjola, 2003)
F26	Risk preference	The more willingness to take a risks, the stronger risk tolerance an individual may have (Hunter, 2006)
F27	Sensitivity to the potential risks	It refers to that workers can make quick response and judgment to potential risks by analyzing relevant information. More sensitive means the workers emphasis more on safety issues, thus they have lower willingness to take risks (Wang et al., 2014)

RESULTS

In order to identify the critical factors affecting workers risk tolerance in construction projects, several statistical analysis techniques, including ranking analysis and factor analysis, are adopted for data analysis.

Ranking of the factors

The aim of this section is to identify the important factors affecting workers' risk tolerance. The mean and standard deviation of each factor are derived from the total sample to determine the level of importance. Factors with higher mean values and lower standard deviation indicate they have greater impacts on workers' risk tolerance. In this paper, the factors with mean values that are greater than the average value of all mean values (3.1178) are classified as critical factors in affecting workers' risk tolerance. The ranking results of these factors are shown in Table 2.

As shown in Table 2, there are 14 factors among the initial 27 factors receive a mean value of greater than 3.1178, which are therefore determined as critical factors influencing workers' safety risk tolerance in construction projects. "Time constraints for decision-making", "Relevant safety regulations", and "Behaviors from peers" are the top-three critical factors, each of which has a mean value above 3.680. It should be also noted that among the 14 factors, there are 9 regarding the external environment, while only 5 highly depend on workers' personal knowledge and experiences.

Table 2: Ranking of important factors affecting workers' risk tolerance

Factors	Mean	Standard deviation	Ranking
F19 Time constraints for decision making	4.1414	0.962	1
F13 Safety regulations	3.7677	1.002	2
F26 Peers behaviors	3.6936	0.978	3
F25 Safety knowledge	3.6835	0.897	4
F20 Completeness of project information	3.6800	0.860	5
F14 Risk preference	3.5286	0.818	6
F11 Safety training	3.5219	0.825	7
F04 Professional knowledge	3.5017	0.832	8
F12 Supervision	3.4579	0.898	9
F22 Attitude of immediate supervisor	3.3131	1.047	10
F03 Weather	3.2054	0.934	11
F10 Availability of safety protection equipment	3.2054	1.198	12
F27 Sensitivity to the potential danger	3.1825	1.101	13
F21 Working experiences	3.1178	0.942	14

Factor analysis of the important factors

This section aims to explore the groupings that might exist among the 14 critical factors. Factors analysis is applied to address the problem of analyzing the structure of the interrelationships (correlations) among a large number of variables.

After analyzing the survey data of critical factors with principal component analysis, which is a common method in factor analysis. The results show that the Bartlett test of sphericity is 4733.668 with significance level of 0.000, and the value of the Kaiser-Mayer-Olkin measure of sampling adequacy is 0.809 (higher than 0.50), which demonstrate that the sample meets the fundamental requirements for factor analysis (Hair, 2010). The principal component analysis generated a four-factor solution with eigenvalues greater than 1.0. The component matrix after rotation is presented in Table 3. Each factor belongs only to one of the four clusters generated by factor analysis, with the loading on each factor exceeding 0.50. Table 4 shows the total variance explained, from which it can be seen that the four components account for 66.17% of the variance.

Based on the critical factors in each cluster, the four components can be renamed as: (1) personal subjective perception; (2) knowledge and experiences; (3) work characteristics; (4) safety management, as shown in Figure 1. Meanings of these components are interpreted in the following sections.

Table 3 Component matrix after varimax rotation

Factors	Components			
	1	2	3	4
Sensitivity to the potential danger	0.732			
Risk preference	0.669			
Professional knowledge		0.751		
Safety knowledge		0.588		
Working experience		0.668		
Time constraints for decision making			0.784	
Completeness of project information			0.719	
Weather			0.746	
Relevant safety regulations				0.779
Available of safety protection				0.765
Safety training				0.704
Supervision				0.645
Attitude of Immediate supervisor				0.582
Behaviors from peers				0.752

Table 4 Total variance explained for critical factors

Component	Extraction sums of squared loadings		
	Total	% of variance	Cumulative (%)
1	6.373	25.495	25.492
2	4.724	17.896	43.391
3	3.372	13.947	57.338
4	2.237	8.829	66.167

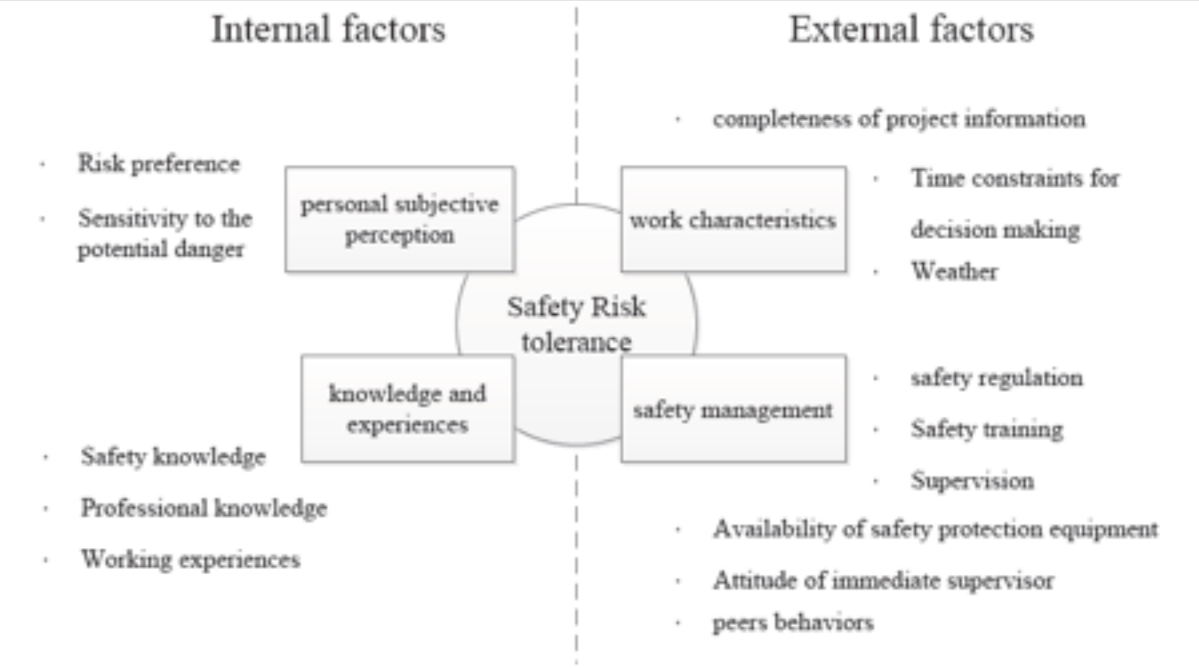

Figure 1. Influencing factors of workers' safety risk tolerance

Component 1: personal subjective perception

The "sensitivity to the potential danger" and "risk preference" consists of this component. "Sensitivity to the potential danger" is highly related to workers' safety awareness, which can help workers avoid unnecessary injuries by reminding them the existences of safety risks. Specifically, workers who are more sensitive to potential danger are likely to behave carefully and take more active attitudes towards identifying and handling confronted risks, rather than "just do it" without taking the potential outcomes into consideration. As for risk preference, risk averters may feel more "danger" and care more about negative effects than risk seekers, and as a result, less willingness to gain risky benefits by compromising or losing something (Brockhaus, 1980). Thus, lower risk tolerance occurs.

Component 2: knowledge and experiences

The "professional knowledge", "safety knowledge" and "working experiences", are all in relation to the hard strength of workers. Workers with these three aspects show good professional quality. On the one hand, the knowledge and experiences provide workers clear understanding about the seriousness of taking safety risks, and making them realize the limitation of their capability to handle such serious safety risks; on the other hand, rich experiences may tell workers "this work is not that dangerous", safety knowledge would remind them of the possible losses of taking risks may be get injuries. As a result, workers with rich experiences and professional knowledge are more rational and less likely to increase risk tolerance when confronted with safety risks.

Component 3: work characteristics

In this component, "time constraints for decision making", "completeness of project information" and "weather", play significant role in workers' risk tolerance. Time constrains happened frequently in construction processes. In order to complete project on time, workers are assigned more work than usual, resulting in hurried through construction works without thinking more on a specific working procedure, especially with potential risks. Thus, higher risk tolerance formed under such pressures. As for the project information, it is hard for workers to get access to all information of the project they are working on, such as geological conditions, material features and design deficiencies, etc. Therefore, not fully understanding of potential risks in corresponding workings (e.g. excavation, erection of scaffolding) brings relative higher risk tolerance. Weather also has considerable effects on workers' risk tolerance. According to interviews with workers, "high temperature", "storm", "snow" and "fierce wind" would significantly reduce their willingness to go on working, let alone behave unsafely.

Component 4: safety management

There are six critical factors belong to this component: "safety regulation", "availability of safety protection equipment", "safety training", "supervision", "attitude of immediate supervisor" and "peers behaviors". These six are factors contribute a lot to building sound safety environment and improving workers' safety awareness. Safety regulation and supervision are compulsory ways, generally with harsh punishments for unsafe behaviors, and thus, lower safety risk tolerance happens due to unwillingness to be punished. In contrast, availability of safety protection equipment and safety training are soft ways to develop higher safety awareness. More safety protection equipment and targeted safety training bring awareness of the work they are doing is much more dangerous than usual, as a result, the judgement of self- capability to respond to risks tend to be more rational and objective. Effects from co-workers' behaviors are also of great importance. Specifically, when other workers completed more works or doing faster than them， imitations of risky behaviors may happen. As a result, "doing better than others" may increase their willingness to take risks. As for attitude of immediate supervisor, Huang et al. (2004) indicated that managers' attitude towards safety plays an important role in influencing workers' behavior. Managers with higher safety conscious tend to talk more with workers, supervise more carefully and less willingness to bear potential risks. Since immediate supervisors are the ones that have the most contact with workers, how much they emphasize on safety issues contribute a lot to workers' risk tolerance.

DISCUSSION

It is noticeable that among the identified critical influencing factors, there are more external factors (such as safety regulation, safety training, peers' behaviour, etc.) than internal factors (such as professional knowledge, risk preference, sensitivity to potential risks, etc.) making contribution to workers' safety risk tolerance. This finding is different from the study by Wang and Yuan (2011), based on their findings, individuals' internal factors (personal traits, characteristic, motivation, etc.) play a dominant role in their attitude towards risks. Thus, risk tolerance and risk attitude, both as the subjective part of an individual, affected by factors belong to different aspects. The reasons behind this difference may result from the meaning of these two conceptions. Risk tolerance focuses on the amount of potential losses a person can bear; this means it depends on individual's resources which can be used for overcoming uncertainties. This reflects more about the capability to response and bear losses. However, risk attitude is more like personal preference. When a person evaluate his/her capability in a specific situation, personal preference is less important than the recourses they have, that means to what extent could they compensate the effects from external factors is the key thing needs to be taken into consideration. Thus, the findings of this paper can serve as a useful reference for better evaluating individuals' capability to bear losses.

In addition, the findings of this research are critical for construction practices by leading to more efficient construction management. Managing safety risks can be a very expensive, complicated and time-consuming scheme. It is important to prioritize risks and focus on the most crucial ones (Kwak and LaPlace, 2005). Based on the findings of this research, more attention should be paid on how to develop safety management. For example, more safety protection equipment, more targeted safety training and comprehensive safety education. Besides, effects from construction work characteristics needs to be avoided by providing specific information of relevant work and reducing crashes. Accordingly, the usage of limited resources such as money, manpower, time, and management efforts can be maximized.

CONCLUSION AND FUTURE RESEARCH

In this research, 27 factors with the potential to affect worker's safety risk tolerance in construction projects were initially identified. Through statistical ranking analysis, 14 factors are identified as the critical ones. Among them, there are 9 related to external environment, while 5 highly depend on workers' internal characteristics. Based on factor analysis, four categories are formed, namely: (1) personal subjective perception; (2) knowledge and experiences; (3) work characteristics; (4) safety management. Thus, resources and efforts should be allocated more on these four components for better enhancement of safety management.

The research reported in this paper tried to explore the reasons behind construction accidents by investigating influencing factors of workers' risk tolerance. This is just the first step, in the next step, more research should focus on: (1) how the identified critical factors influence workers' risk tolerance. (2) What relationships between these influencing factors. (3) How to quantify their effects on risk tolerance. (4) What effect of rewards may have on workers' risk tolerance and risk taking behavior? It is believed that the rewards offered by managers can have two different influencings: on the one hand, appropriate incentive from rewards can increase workers' safety awareness by encouraging them to finish work safely (Shin et al., 2014); on the other hand, perverse incentive (e.g., too much money) may be the trigger of unsafe behaviors, for example, offering triple pays for extra working hours. As a result, how awards affect workers' safety risk tolerance is worthy of study. (5) Do the same factors affect risk tolerance of management staff? Hallowell (2010) proved that there is a statistically significant difference in the risk tolerances between workers and managers. Accordingly, different level of risk tolerance may lead to different perceptions of the same risks, thus, investigating what factors lead to the differences is of great importance in safety management.

As a personality trait, risk tolerance is hard to observe and measure directly. However, as the same as risk attitude and risk perception, they are all subjective factors and play important role in individuals' risk behavior. Exploring why they behave differently with different decision situations and how they make bias in safety decision making are worthy of serious consideration.

ACKNOWLEDGEMENT

This study was supported by the National Natural Science Foundation of China (71272088). Part of the data was collected by Jiang Wu, a master student of College of Civil Engineering, Shenzhen University.

REFERENCES

ABDELHAMID, T. S. & EVERETT, J. G. 2000. Identifying root causes of construction accidents. Journal of Construction Engineering and Management, 126, 52-60.

ACAR, E. & GÖÇ, Y. 2011. Prediction of risk perception by owners' psychological traits in small building contractors. Construction Management and Economics, 29, 841-852.

BALAZ, V. & WILLIAMS, A. M. 2011. Risk attitudes and migration experience. Journal of risk research, 14, 583-596.

BALOI, D. & PRICE, A. D. 2003. Modelling global risk factors affecting construction cost performance. International Journal of Project Management, 21, 261-269.

BERNHEIM, B. D., SKINNER, J. & WEINBERG, S. 2001. What accounts for the variation in retirement wealth among US households? American Economic Review, 832-857.

BROCKHAUS, R. H. 1980. Risk taking propensity of entrepreneurs. Academy of Management Journal, 23, 509-520.

DE CAMPRIEU, R., DESBIENS, J. & FEIXUE, Y. 2007. 'Cultural'differences in project risk perception: An empirical comparison of China and Canada. International Journal of Project Management, 25, 683-693.

FAFF, R., MULINO, D. & CHAI, D. 2008. On the linkage between financial risk tolerance and risk aversion. Journal of Financial Research, 31, 1-23.

FANG, D., WU, C. & WU, H. 2015. Impact of the Supervisor on Worker Safety Behavior in Construction Projects. Journal of Management in Engineering.

FENG, Y. 2013. Effect of safety investments on safety performance of building projects. Safety Science, 59, 28-45.

FRANK, W. 2011. Challenges in developing and implementing safety risk tolerance criteria. Process Safety Progress, 30, 232-239.

GRABLE, J., LYTTON, R. & O'NEILL, B. 2004. Projection bias and financial risk tolerance. The Journal of Behavioral Finance, 5, 142-147.

GRABLE, J. E. 2000. Financial risk tolerance and additional factors that affect risk taking in everyday money matters. Journal of Business and Psychology, 14, 625-630.

HAIR, J. F. 2010. Multivariate data analysis.

HALIASSOS, M. & BERTAUT, C. C. 1995. Why do so few hold stocks? the economic Journal, 1110-1129.

HALLOWELL, M. 2010. Safety risk perception in construction companies in the Pacific Northwest of the USA. Construction management and economics, 28, 403-413.

HOPKINSON, M. M. 2012. The project risk maturity model: Measuring and improving risk management capability, Gower Publishing, Ltd.

HUANG, Y.-H., CHEN, P. Y., KRAUSS, A. D. & ROGERS, D. A. 2004. Quality of the execution of corporate safety policies and employee safety outcomes: Assessing the moderating role of supervisor safety support and the mediating role of employee safety control. Journal of Business and Psychology, 18, 483-506.

HUNTER, D. R. 2002. Risk perception and risk tolerance in aircraft pilots. DTIC Document.

HUNTER, D. R. 2006. Risk perception among general aviation pilots. The international journal of aviation psychology, 16, 135-144.

IRWIN JR, C. E. 1993. Adolescence and risk taking: How are they related.

JI, M., YOU, X., LAN, J. & YANG, S. 2011. The impact of risk tolerance, risk perception and hazardous attitude on safety operation among airline pilots in China. Safety Science, 49, 1412-1420.

KWAK, Y. H. & LAPLACE, K. S. 2005. Examining risk tolerance in project-driven organization. Technovation, 25, 691-695.

LICHTENSTEIN, S., SLOVIC, P., FISCHHOFF, B., LAYMAN, M. & COMBS, B. 1978. Judged frequency of lethal events. Journal of experimental psychology: human learning and memory, 4, 551.

LIU, J., MENG, F. & FELLOWS, R. 2014. An exploratory study of understanding project risk management from the perspective of national culture. International Journal of Project Management.

LU, S. & YAN, H. 2013. A comparative study of the measurements of perceived risk among contractors in China. International Journal of Project Management, 31, 307-312.

MORESCHI, R. 2004. Incorporating investor risk tolerance into the financial planning process. Journal of Personal Finance, 3, 89-98.

MORIN, R.-A. & SUAREZ, A. F. 1983. Risk aversion revisited. Journal of Finance, 1201-1216.

MU, S., CHENG, H., CHOHR, M. & PENG, W. 2014. Assessing risk management capability of contractors in subway projects in mainland China. International Journal of Project Management, 32, 452-460.

NORUSIS, M. J. 2007. SPSS 15.0 guide to data analysis, Prentice Hall Englewood Cliffs, NJ.

POHJOLA, V. J. 2003. Fundamentals of safety conscious process design. Safety science, 41, 181-218.

RAWLINSON, F. & FARRELL, P. The vision of zero risk tolerance in craft workers and operatives: an unattainable goal. Proceedings of the 25th Annual ARCOM Conference, Association of Researchers in Construction Management, Reading, 2009. 1203-12.

ROSZKOWSKI, M. J., SNELBECKER, G. E. & LEIMBERG, S. 1993. Risk tolerance and risk aversion. The tools and techniques of financial planning, 4, 213-225.

SEGAL, G., BORGIA, D. & SCHOENFELD, J. 2005. The motivation to become an entrepreneur. International journal of Entrepreneurial Behavior & Research, 11, 42-57.

SHIN, M., LEE, H.-S., PARK, M., MOON, M. & HAN, S. 2014. A system dynamics approach for modeling construction workers' safety attitudes and behaviors. Accident Analysis & Prevention, 68, 95-105.

SUNG, J. & HANNA, S. 1996. Factors related to risk tolerance. Financial Counseling and Planning, 7, 11-20.

SUNINDIJO, R. Y. & ZOU, P. X. 2011. Political skill for developing construction safety climate. Journal of Construction Engineering and Management, 138, 605-612.

TAROUN, A. 2014. Towards a better modelling and assessment of construction risk: Insights from a literature review. International Journal of Project Management, 32, 101-115.

TRONE, D., ALLBRIGHT, W. & TAYLOR, P. R. 1996. The management of investment decisions, McGraw Hill Professional.

WANG, J., LI, P. & YUAN, H. 2014. A Critical Review on Risk Decision-making and its Attributes. Journal of Engineering Management, 28, 27-31.

WANG, J. & YUAN, H. 2011. Factors affecting contractors' risk attitudes in construction projects: Case study from China. International Journal of Project Management, 29, 209-219.

YAO, R. & HANNA, S. D. 2005. The Effect of Gender and Marital Status on Financial Risk Tolerance.

PROACTIVE EVALUATION OF OCCUPATIONAL HEALTH AND SAFETY PERFORMANCE IN CONSTRUCTION PROJECTS USING THE HIERARCHY OF CONTROLS CONCEPT

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Injury and accident statistics are widely used as 'lagging' indicators and descriptors of occupational health and safety (OHS) performance, despite questions about their reliability due to high levels of under-reporting. In addition, 'lagging' OHS indicators are 'retrospective' measures of things that have already happened and their validity as direct measures of OHS is questionable, especially when studying proactive approaches to improve OHS performance such as Prevention through Design (PtD). Thus, the use of 'leading' indicators of OHS performance has been encouraged. Leading indicators measure the state of OHS before the emergence of OHS risk rather than after the occurrence of undesirable events, or "near misses". As such, they are more direct measures of OHS than injury and accident rates. In an international research study (Lingard et al., 2014 & 2015), an attempt was made to use the Hierarchy of Controls (HOC) as a method to measure the effectiveness of OHS related decision making in construction projects. The results suggested that classifying risk control outcomes using the HOC can provide a reliable and practical measure of the quality of the OHS performance. Building on the findings of the previous research, a tool is developed to evaluate OHS performance and compare the quality of OHS risk control solutions both within and between different construction projects. This paper describes the tool. We argue that the HOC tool provides a more reliable and proactive measure of OHS performance in construction projects. The tool can help decision makers decide on and evaluate the OHS outcomes of their decisions during the early stages of construction projects, or to compare the OHS performance of different design scenarios or decisions.

Keywords: construction, hierarchy of controls, proactive evaluation, work health and safety.

INTRODUCTION

Measuring occupational health and safety (OHS) performance provides the necessary information to evaluate the effectiveness of OHS initiatives and to understand whether objectives are being met so that true control can result. It also enables the detection and resolution of problems. There is ongoing debate and discussion about how to measure OHS in construction projects. In this paper we present a tool which uses the hierarchy of controls (HOC) to measure OHS performance outcomes. We argue

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that this tool is particularly well-suited for measuring the effectiveness of proactive OHS management activities, such as those relating to Prevention through Design (PtD) or Design for Safety/Safety by Design. At present, objective measures of PtD effectiveness are not widely available.

Lagging OHS indicators

Hale (2009: 479) notes that 'lagging' indicators "lag the occurrence of harm or, at least, the loss of control in the scenario leading to harm". They often indicate the absence of OHS by highlighting the presence of harm (Arezes & Miguel, 2003; Lofquist, 2010). Injury and accident statistics have been widely used as 'lagging' indicators and descriptors of OHS performance.

According to Stricoff (2000), validity refers to how accurately a measure predicts the endpoint event. Because lagging indicators measure the absence, rather than the presence of OHS they are not a direct and accurate measure of the level of OHS in a system, and represent a surrogate at best. Lingard et al. (2013) question the sensitivity of OHS performance measurements based on injury and illness rates because these rates have a statistically low probability of occurrence. In addition, they mention that lagging OHS measures are 'after the fact' records of failures, so they do not permit the timely implementation of preventive or corrective actions. As such, they are not valid measures of the effectiveness of OHS improvement actions.

At the same time, reliability issues have been raised about the use of injury and accident rates as OHS indicators due to high levels of under-reporting, especially when used in safety incentive programs (Cadieux et al. 2006; Sparer and Dennerlein, 2013, Daniels and Marlow, 2005). To overcome these limitations, the use of 'leading indicators' has been encouraged (see, for example, Lingard et al. 2011; Hinze et al., 2013).

Leading OHS indicators

According to Mearns (2009: 491) leading indicators "provide information that helps the user respond to changing circumstances and take actions to achieve desired outcomes or avoid unwanted outcomes". Kjellén (2009) notes that leading indicators of OHS change before the change in the actual level of risk to which people are exposed. Thus, "near misses" as measures of OHS, while popular, are closer to lagging than leading indicators since they suggest an event "could have" or "should have" occurred, resulting in a reactive and rather negative approach. In addition, similar to accident rates, there are reliability issues in using "near misses". Due to the inconsistency in defining a "near miss", some organisations do not record them.

In OHS management systems, 'leading indicators' are theoretically based on accident-causation models (see, for example, Reason, 1997; Gibb et al. 2014). These models suggest that undesired OHS outcomes are produced as a result of latent problems which are not mitigated by management controls or defences (for example, due to functionality problems or system design issues).

In comparison to accident rates, leading indicators provide a more direct (and more valid) measure of the effectiveness of OHS management activity. Hinze et al. (2013) also note that the immediate feedback mechanism provided by leading indicators provides lead time for organisations to improve OHS management processes, before deficiencies result in undesired outcomes.

Hale (2009) emphasises validity, reliability, and sensitivity as important criteria in defining indicators; however, he notes that the extent to which these criteria should be operationalized in practice depends on the purpose of the indicator. There is prevailing acceptance among OHS researchers (see for example Grote, 2009; Dyreborge, 2009) that a causal link should exist between leading indicators and negative OHS outcomes.

Moreover, Kjellen (2009) and Reiman and Pietikäinen (2012) believe that leading indicators should also be able to measure things that contribute to OHS in positive terms. This mindset is more in line with proactive approaches to improve OHS.

Proactive approaches to safety improvement

Proactive management of OHS is recommended as a way to produce strong and sustained OHS improvements in construction (Rajendran and Gambatese, 2009; Hallowell et al., 2013). Prevention through Design (PtD) is one particular proactive approach that has gained widespread acceptance (See for example Gambatese et al., 2008). In construction, PtD relates to the practice of anticipating OHS hazards inherent in the design of a building or structure and taking proactive steps to eliminate or reduce OHS risks through making changes to the design. However, although it has been adopted as a philosophy in many organisations, the effectiveness of PtD is not systematically measured or understood. There is an urgent need to identify and develop indicators to measure the effectiveness of PtD in construction projects and organisations.

According to Grote (2009), the effectiveness of OHS indicators is dependent on the level of analysis at which they are applied. Most of leading OHS indicators identified in the construction literature measure the effectiveness of OHS management processes (e.g. project management team safety involvement, number of safety audits etc.) in the construction stage. Very little emphasis is placed on measuring performance in the design stage of a project. Measuring OHS effectiveness at the design stage of projects provides enough lead time for interventions to address problems and make improvements. In addition, because PtD focuses on the positive aspects of safety (e.g. constructability), leading indicators of PtD have the capacity to show improvement in OHS performance, beyond the reduction in negative outcomes. This is important because having no accidents does not necessarily mean that a workplace is safe and OHS risks are being controlled effectively (Cadieux et al., 2006).

The overriding emphasis of currently used OHS performance indicators is on the quantity or frequency of events. For example, PtD is sometimes measured in terms of the number of design safety review meetings that have taken place. However, management activity is an indirect indicator of the effectiveness of a management system and, in construction, management indicators might not be sensitive or specific enough to evaluate OHS performance inherent in the design of a building element or component, for which different technical options are available. A more direct basis for comparing the OHS performance of these technical options is needed. Furthermore, measuring the occurrence of management activity does not evaluate the quality or effect of improvement actions (e.g. counting the number of PtD review meetings without consideration of the intent or content, or the effectiveness of solutions). We argue that measurement methods should move beyond frequency counts and begin to consider the quality of OHS outcomes realised. As Reiman and Pietikäinen (2012) suggest, for an indicator to be sensitive to changes in a proactive risk control system, the indicator has to provide information on the quality of organisational activities and the organisational means of controlling risk.

AN APPROACH TO MEASURE OHS EFFECTIVENESS

The outcomes from implementing PtD processes are expected to be technical solutions that proactively design OHS hazards out of workplaces, processes plant and equipment (Lingard et al., 2015). Although PtD is now widely accepted as a proactive approach to improve OHS, past research has failed to propose a systematic and objective method to indicate and measure the effectiveness of PtD outcomes. However, recent research (Lingard et al., 2014; 2015) used the Hierarchy of Controls concept (HOC) to objectively evaluate the effectiveness of design solutions in 23 construction projects in Australia and the USA. The research concluded that using a 'leading indicator' which is based on the HOC can provide a more direct measure of the quality of OHS risk management than relying on accident frequency rates as the indicator of PtD effectiveness (Lingard et al., 2015). Based on the findings of this research, a tool has been developed to evaluate OHS performance and compare the quality of OHS risk control solutions using the HOC.

The Hierarchy of Controls

The HOC is well-established in OHS thinking and a staple among safety researchers and some practitioners. According to Manuele (2006: 186), the "hierarchy of controls sets forth a way of thinking about taking actions in a feasible order of effectiveness to reduce risks…Risks [which] derive from exposure to hazards". The HOC classifies methods of dealing with OHS hazards/risks according to the level of effectiveness of the risk control actions (Lingard et al., 2014). The most effective risk control action is to eliminate the exposure to a hazard which will also remove all the risks associated with that hazard. Thus, elimination is at the top of the HOC. The second level of control involves replacing a hazard with something less hazardous or identifying ways of achieving the same outcomes with less exposure to hazards. The next level in the HOC is using engineering controls. Engineering controls are intended to isolate people from exposure to hazards. The top three levels of control (i.e. elimination, substitution and engineering) are categorised as technological controls because they involve changing the physical characteristics of work environment to make it safer. The advantage of technological controls is that they do not rely on the behaviour of workers who are prone to mistakes. In contrast, the last two levels of controls are categorised as behavioural controls because they rely on workers' behaviour to control risks. The behavioural controls are most effective when they are used in conjunction with the technological controls. The first type of behavioural control, on level four of the HOC classification, is administrative in nature and deals with work procedures and the ways in which work activities are undertaken. These include controls such as developing safe work procedures or implementing job rotation schemes to reduce exposure to hazards. The last level of the HOC, at level five, is personal protective equipment (PPE) which is the lowest, and the least effective form of control. At best, PPE should be seen as a 'last resort', which should always be used in combination with higher levels of control.

The HOC TOOL

The effectiveness of risk management interventions is directly linked to the effectiveness of risk controls implicit in those interventions. The HOC provides a framework for classifying risk controls according to their effectiveness. Thus, it provides a framework to directly measure the quality of risk management interventions. However, to effectively use such a measurement framework, it needs to be embedded within an accepted problem solving technique (see Manuele, 2006). This has resulted in development of an OHS performance evaluation tool (described below). The tool uses the HOC framework in combination with a problem solving methodology to evaluate the effectiveness of the OHS risk control outcomes in construction projects. It provides a step-by-step process for generating a quantitative performance score based on the HOC concept.

Process for classifying OHS risk controls based on their effectiveness

The process recommended for using the HOC to evaluate and improve OHS outcomes consists of five steps:

Step 1: Identifying "features of work"

Construction projects can be divided into 'features of work'. A self-defined feature of work is a group of activities which are distinct from other activities in terms of control requirements, location, work crews or disciplines. Depending on the nature of the project and the purpose of an OHS evaluation, the definition of features of work can be based on structural elements (e.g. placing cast-in-place concrete foundation, erection of steel columns) or based on items in the work breakdown structure or work packages (e.g. pipe works, roof framing, HVAC) and are often linked to items within a project schedule (e.g. erecting first floor steel framing, install second floor overhead piping and electrical). A feature of work should be defined narrowly enough to ensure adequate identification of OHS hazards and controls, yet be not so narrow that it overlooks hazards not readily apparent in a too narrowly defined feature of work.

Step 2: Identifying construction activities and tasks with OHS implications

Next, the construction activities and tasks performed for each feature of work are reviewed. The significant OHS hazards associated with each of these tasks and activities are identified. It is best if this identification involves people with appropriate construction experience and knowledge of construction processes and OHS. Due to the differing risk perceptions of diverse stakeholders, this step can be enhanced by working towards consensus among a group of people.

Step 3: Categorising hazards associated with the construction activities

Next, OHS risks are categorised according to their type (e.g., fall, slip, trip; struck by object or equipment, etc.). An OHS risk categorisation scheme, such as the National Institute for Occupational Safety and Health (NIWHS) Occupational Injury & Illness Classification System (OIICS) (Bureau of Labor Statistics, 2012), can be used in this step.

Step 4: Identifying the risk control options for each of the hazards

The next step is to identify the methods by which OHS risks in each hazard class are to be controlled. The methods are in fact the OHS risk controls proposed or implemented by the risk management system.

Step 5: Classifying and scoring the risk controls using the HOC

Finally, the selected or implemented controls are rated according to the level of the HOC that they represent. Each level of control is given a rating (i.e. 1= personal protective equipment, 2= administrative control, 3= engineering control, 4= substitution, 5= elimination). The controls implemented for hazards/risks presented by each feature of work are assigned a score on this five-point scale. In the event that no controls are planned or implemented, a value of zero is assigned. Using these values the average hierarchy of control score for a particular feature of work can be generated. Thus, if two hazards are identified, one was eliminated and the other controlled by administrative methods, the mean score would be 3.5. The average hierarchy of control score reflects the quality of risk control solutions implemented for this feature of work.

Case Study: Assessing the quality of OHS risk control in the construction of a basement mausoleum

A basement mausoleum was to be constructed in a cemetery. The site was surrounded by existing graves and established trees planted among them. To maximise the usable area the client proposed a setback of just over two metres from the adjoining grave sites and trees.

The temporary works design required that a retaining wall and bored concrete piles be constructed, at 1800mm centres, around the perimeter of the excavation to retain the soil. External propping using ground anchors was then to be installed to prevent rotation of the wall. The exposed soil between the piles would then be retained using shotcrete. Once the temporary works were completed construction of the permanent works could commence from the bottom up.

However, once engaged, the constructor proposed a safer ‘top down’ approach in which the construction of a retaining system would start at ground level and progressively work its way down as excavation continued in stages until the required depth was reached. The constructor also proposed eliminating the rock anchors due to a number of risks associated with them. To ensure that the anchors posed no threat to any construction activities that may occur next to the mausoleum in the future, the ground anchors would need to be de-stressed. Gaining access to the anchors to de-stress in the original design would require the constructor to enter the ‘gap’ between the temporary wall and the mausoleum wall, remove the anchor’s cap and then de-stress or cut the steel rods in a small, confined space. This would create ergonomic hazards for workers having to manoeuvre within a confined space. The potential for the stressed bars to react when released and hit the workers created extra OHS risk.

The internal propping required for the system had to be designed to provide enough clearance for the machinery to move safely around without the danger of running into and knocking over props. To achieve this, the constructor proposed to use “Megaprops”. Unlike alternative internal propping systems that connect to the face of the wall and are anchored back down into the bottom of the excavation, taking up a lot of valuable space, Megaprops are large steel beams installed at the top of the excavation and span the width of the excavation, pushing back against opposing walls. This requires fewer props to be installed and frees up the base of the excavation so that a clear and unobstructed area is available to undertake excavation.

For ease of installation, the connection brackets were cast on to the top of the ring beam rather than on the walls. This eliminated the need to drill into the concrete at a later stage to secure the props. To assist with the Megaprop installation each connection plate was made with a 'lip' that provided temporary support to the props once they were lowered onto the connection plate. The connection bolts could then easily be threaded through the prop and into the connection plate without the need for a crane to hold it in position until such time as the prop was fixed at both ends. All fixing could be done at ground level due to the connections being located on the top of the capping beam. Table 1 shows the application of the HOC evaluation method to the mausoleum case study. Only tasks related to excavation of the basement are included in the table and the mean HOC score is calculated.

Mean HOC score = 2.13

Mean HOC score = 4.25

Table 1: Evaluation of OHS risk controls for the construction of basement mausoleum

Task Description	Hazard	Original Design solution	Original HOC Level & Score	Original Mean HOC Score	Revised Design/ OHS Intervention	Revised OHS Control Level & Score	Mean HOC Score
Excavation using small machinery	Struck by object or equipment	Establishing exclusion zones, appointing spotters	Administrative (**2**)	**2.13**	-	-	**4.25**
Deep excavation (8.5 m)	Caught in or compressed by equipment or objects	Temporary works to retain the soil	Engineering control (**3**)		-	-	
Installation of temporary works in the excavation ditch	Caught in or compressed by equipment or objects	Bored concrete piles, propping, shotcrete (trained workers working in the excavation ditch)	Administrative (**2**)		Top-down excavation and installing temporary works simultaneously, No temporary work after excavation	Elimination (**5**)	
Temporary works, Propping inside the excavation ditch	Struck, caught, or crushed in collapsing structure, equipment, or material	Trained workers enter the excavation ditch and install props	Administrative (**2**)		Installing Megaprops, No need to enter the ditch, Workers to install Megaprops from ground level	Substitution (**4**)	
Excavation using machinery	Caught or compressed by collapsing material	Machinery working close to props, appointing spotters to avoid hitting props	Administrative (**2**)		Using Megaprops, No need for props in the excavation ditch	Elimination (**5**)	
De-stressing the rock anchors	Struck by object or equipment	Trained workers remove the anchor's cap and then de-stress or cut the steel rods	Administrative (**2**)		Using Mega props, No need for rock anchors	Elimination (**5**)	
De-stressing the rock anchors	Working in a confined space	Trained workers enter the 'gap' between the temporary wall and the mausoleum wall	Administrative (**2**)		Using Megaprops, No need for rock anchors	Elimination (**5**)	
Temporary works, Installing Megaprops	Fall from height; Overexertion in holding, carrying, or wielding	Form work around the brackets as well as sealing	Administrative (**2**)		Cast brackets on to the top of the capping beam no need for installation	Elimination (**5**)	

Feature of Work	**Excavation for basement**

Ussing HOC evaluation tool for comparison and benchmarking

The tool can be used for comparison between projects or features of work. The average HOC score for each feature of work indicates the quality of risk control solutions implemented for that feature of work. However it does not reflect the extent of the OHS risk controls selected or implemented. Thus, two similar features of work might incorporate totally different combinations of OHS risk controls in terms of effectiveness, yet show the same average HOC score.

To gain a comprehensive view of the OHS risk control solutions, it is useful to look at the distribution of the HOC scores for all the OHS risk controls implemented or identified for each feature of work. This can be done by counting the number of risk controls under each HOC category and developing a histogram for each feature of work. The horizontal axis of the histogram will show the five HOC categories and the vertical axis will show the frequency count of the OHS risk controls. The tool can be used retrospectively by mapping the implemented OHS risk control solutions to evaluate past OHS risk management performance. It can also be used prospectively to help to decide on, change, and improve OHS risk control solutions during the design stage, review them during the design development, and communicate them with other stakeholders.

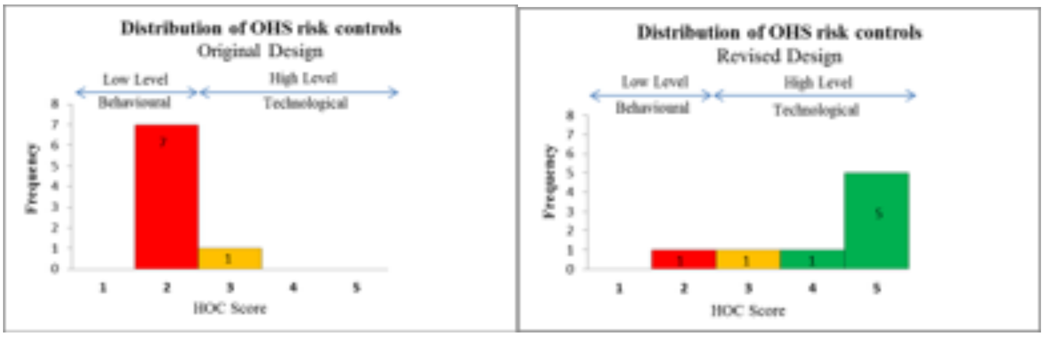

Figure 1: Histograms indicating the distribution of OHS risk controls

The histograms for the excavation task in the case study project are shown in figure 1. The left histogram shows the OHS risk control levels associated with the original design solutions while the right histogram shows the risk control levels related to the revised design. As the histogram shows, the original design relied on workers' behaviour and on-site controls to address OHS risk with the majority of the OHS risk controls (87%) being behavioural controls. As a result, the original design creates a quite low mean HOC score (2.13). The distribution of risk controls can be used to compare the risk control performance of the original design solution with the revised design solution. As the distribution of risk controls suggests (see the histogram on the right side), after the design interventions proposed by the constructor were adopted, the majority of the controls were technological risk controls. This is indicated by the change in the HOC score from 2.13 to 4.25 (see table 1 for the list of design changes). The advantage of using the HOC method is that the distribution of risk controls can be analysed, understood and reviewed when design decisions are made. Thus they can help compare different design options in terms of the quality and effectiveness of their OHS outcomes and identify the areas with poor risk controls, so interventions to improve these risk controls can be implemented.

DISCUSSION

The HOC measurement technique is based on the simple yet well-established concept of HOC. The HOC score can be measured at different points in time during the project lifecycle (upstream and downstream), so it can provide a clearer and longitudinal view of the effectiveness of safety related decisions. The major benefit of the HOC tool is that it objectively measures the quality of OHS risk controls with consideration of the actual construction process to be implemented. As such, the HOC score is a leading indicator directly related to construction OHS and at the same time it is an indicator of how effective the upstream controls have been in terms of eliminating underlying hazards or reducing risks. Its proximity to the actual construction activity makes it a valid leading indicator of how systematically construction OHS has been considered in upstream decision-making. It is argued that without measuring technical OHS outcomes, it is not possible to check if the OHS management processes (such as those relating to PtD) are effective. The HOC tool provides the opportunity to move beyond just checking OHS compliance by ensuring that effective OHS risk controls are in place. It offers an objective framework to look at how effective the technical outcomes from the OHS management activities are.

By focusing on the effectiveness of OHS improvement interventions, the HOC tool measures the presence of OHS rather than its absence. Thus, it can be used to improve OHS beyond the zero-incident level. Having a low incident rate on a project does not necessarily suggest that effective OHS risk controls are in place. As Reiman and Pietikäinen (2012:1993) note, "If safety is understood as something more than the absence of risk and the negative, the indicators should also be able to focus on the positive side of safety". In other words, they should represent the presence of something positive and "reach a higher value as safety improves" (Hollnagel, 2008:75).

Finally, in proactive approaches to OHS, like PtD, the HOC tool can be used to evaluate and compare the effectiveness of different potential design solutions. Thus, it can be a tool with common vocabulary for designers, constructors and engineers. It can also offer checks and balances whereby for example, the engineer or constructor evaluates a design for OHS prevention. As illustrated in the case example, the OHS risk control histograms are a quick and easy to interpret representation of the quality of OHS outcomes realised by PtD activities. Similarly, the histograms can be used to compare the effectiveness of OHS interventions between similar features of work in different projects. In addition, the HOC tool can be used to assess the effectiveness of the implemented risk control solutions and the resulting outcomes at construction level (as an outcome indicator). This can assist OHS professionals and construction decision makers to evaluate the OHS outcomes of their decisions, or to compare the OHS performance of different construction projects with comparable features of work. As Manuele (2006: 186) observed, "a good number of safety professionals do not have in place, systems to determine whether the actions taken in accord with their recommendations achieve the risk reduction intended."

CONCLUSION

HOC has been adopted in the previous research as a method to measure OHS performance. In this paper the method has been extended to develop an OHS measurement tool that can be used by the construction industry. Being derived from the HOC framework, the HOC score can directly measure the quality of OHS risk control solutions and interventions aimed at improving OHS performance. The HOC score helps OHS professionals decide on solutions to achieve desired outcomes or avoid unwanted consequences. Thus, it can be used as a useful leading indicator of OHS performance. For proactive approaches like PtD, the benefit of using such a metric is that it provides a direct and valid measurement of the quality of OHS improvement interventions with no time lag. It can be used to compare different options during decision-making or to evaluate OHS outcomes after the fact. Being calculated at decision level, it is also sensitive enough to changes in the quality of OHS outcomes resulting from decisions made during the design stage of projects.

REFERENCES

Arezes, P M and Miguel, A S (2003) The role of safety culture in safety performance measurement. “Measuring Business Excellence”, 7(4), 20-28.

Cadieux, J, Roy, M and Desmarais, L (2006) A preliminary validation of a new measure of occupational health and safety. “Journal of Safety Research”, 37(4), 413-419.

Daniels, C and Marlow, P (2005) Literature review on the reporting of workplace injury trends. HSL/2005/36, Health and Safety Laboratory, HSE, London.

Dyreborg, J (2009) The causal relation between lead and lag indicators.“Safety Science”, 47(4), 474-75.

Gambatese, J A, Behm, M and Rajendran, S (2008) Design's role in construction accident causality and prevention: Perspectives from an expert panel. “Safety Science”, 46(4), 675-691.

Gibb, A, Lingard, H, Behm, M, & Cooke, T (2014) Construction accident causality: learning from different countries and differing consequences. “Construction Management and Economics”, 32(5), 446-459.

Grote, G (2009) Response to Andrew Hopkins. “Safety Science”, 47(4), 478.

Hale, A (2009) Why safety performance indicators? “Safety Science”, 47(4), 479-480.

Hallowell, M R, Hinze, J W, Baud, K C and Wehle, A (2013) Proactive Construction Safety Control: Measuring, Monitoring, and Responding to Safety Leading Indicators. “Journal of Construction Engineering and Management”, 139(10), 040130101-8.

Hinze, J, Thurman, S and Wehle, A (2013), Leading indicators of construction safety performance. “Safety Science”, 51(1), 23-28.

Hollnagel, E, (2008) Safety management – looking back or looking forward. In: Hollnagel, E, Nemeth, C P, Dekker, S (eds.), “Resilience Engineering Perspectives, vol. 1. Remaining Sensitive to the Possibility of Failure”. Ashgate, Aldershot.

Kjellén, U (2009) The safety measurement problem revisited. “Safety Science”, 47(4), 486-489.

Lingard, H, Pirzadeh, P, Blismas, N, Wakefield, R and Kleiner, B (2014) Exploring the link between early constructor involvement in project decision-making and the efficacy of health and safety risk control. “Construction Management and Economics”, 32(9), 918-931.

Lingard, H, Saunders, L, Pirzadeh, P, Blismas, N, Kleiner, B, Wakefield, R (2015) The relationship between pre-construction decision-making and the effectiveness of risk control: Testing the time-safety influence curve. “Engineering, Construction and Architectural Management”, 22(1), 108-124.

Lingard, H, Wakefield, R and Blismas, N (2013) “If you cannot measure it, you cannot improve it”: Measuring health and safety performance in the construction industry. In: Kajewski, S , Manley, K and Hampson, K (Eds.), “19th CIB World Building Congress: Construction and Society”, 5-9 May 2013 2013 Brisbane, Australia. Queensland University of Technology.

Lofquist, E A (2010) The art of measuring nothing: The paradox of measuring safety in a changing civil aviation industry using traditional safety metrics. “Safety Science”, 48(10), 1520-1529.

Manuele, F A (2006) Achieving Risk Reduction, Effectively. “Process Safety and Environmental Protection”, 84(B3), 184-190.

Mearns, K (2009) From reactive to proactive-Can LPIs deliver? “Safety Science”, 47(4), 491-492.

Rajendran, S and Gambatese, J (2009) Development and initial validation of sustainable construction safety and health rating system. “J. Constr. Eng. Manage.”, 135(10), 1067-1075.

Reason, J (1997) “Managing the Risks of Organizational Accidents”. Ashgate, Aldershot.

Reiman, T. and Pietikäinen, E (2012) Leading indicators of system safety - Monitoring and driving the organizational safety potential. “Safety Science”, 50(10), 1993-2000.

Sparer, E H and Dennerlein, J T (2013) Determining safety inspection thresholds for employee incentive programs on construction sites, “Safety Science”, 51(1), 77-84.

Stricoff, R S (2000) Safety Performance Measurement: Identifying Prospective Indicators With High Validity. “Professional Safety”, 45(1), 36-39.

REVISITING LORENT

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Much of the archival design related accident causality research in the construction industry points to a 1987 National Action Committee for Occupational Safety and Health in Construction (CNAC) report. This research analyses the CNAC report and follow other research documents that have referenced the report with a critical evaluation. The original 1987 report focuses on design's influence on falls from height rather than all of the hazards present on construction sites. Yet, in that report it is confusing as to the exact nature of the recommendations, and as a result, may have inadvertently affected the pursuit and direction of subsequent research. Our research examines the potential discrepancy and its impact on accident causality research in the construction sector. The importance of finding and reading primary source material in construction research is highlighted. A potential concern is that the unreasonable attribution of design in accident causality causes the industry to lessen the focus on safe design overall; thus, those areas where safe design could truly have a positive impact (i.e., falls from height) get overlooked and under-emphasized.

Keywords: construction, design, falls, prevention though design, safety.

INTRODUCTION

The concept of Prevention through Design (PtD) aims to integrate hazard analysis and risk assessment methods upstream from the construction site, during the conception and design phases of a project in order to take the necessary actions to reduce the risks of injuries and damages to an acceptable level (Manuele 2008). The need for this early consideration of safety hails from the hierarchy of controls. The hierarchy of controls is an orderly and systematic ranking of safety measures into broad

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categories. These categories according to Manuele (2009) are: 1) Elimination, 2) Substitution, 3) Engineering Controls, 4) Warning Systems, 5) Administrative Controls, and 6) Personal Protective Equipment. Controls that are higher in the ranking, such as Elimination, Substitution and Engineering Controls, have greater effectiveness and financial value compared to controls lower in rank, but require input from designers, as well as input during planning, in order to implement them on a construction project (Manuele 2009).

By the same token, inaction and inability during design and planning, are seen as influences for accident causation. One of the first authors to make this suggestion was Pierre Lorent in a report that he prepared for the Belgian National Action Committee for Safety and Health in Construction (Comité National d'Action pour la sécurité et l'hygiène dans la construction) the leading agency for construction safety and health in Belgium (Lorent 1987). The report, which was written in French, was instrumental and influential in generating interest in PtD in Europe. However, as discussed within this paper, the original report requires additional review and consideration.

BACKGROUND ON THE 1987 LORENT REPORT

Within his report, Lorent (1987) attempted to link quality management solutions to solutions for the improvement of construction safety. The forty page report dedicates only three pages to safety (Section 7), while at the same time several subsections of Section 7 include the statement "Etude en cours" (work in progress). At the time, "work in progress" was specified for the following subsections of the report:

- 7.2 Classification des accidents de travail dans la construction (Classification of work accidents in construction)
- 7.3 Categories d'accidents en hausse (Categories of accidents on the rise)
- 7.4 Types de travaux où se produisent des accidents graves (Types of work where serious accidents occur)
- 7.7 Relations entre les risques d'accidents de travail, conditions de travail et productivité (Relationships between the risks of work accidents, working conditions, and productivity)

Sections 7.4 and 7.5 of the report are shown in Figure 3 in French, and in English in Figure 4. Section 7.4 is titled "Analysis of the causes of accidents from falls from height" and discusses the "severity of the accidents", stating that 35% of fatal accidents are caused by falls from height. In addition, Section 7.4 indicates that for every 100 fall fatalities, 31% occur from scaffolding/formwork, 18% from roofs/glass canopies, and 12% during finishing work. The section continues with the categories of workers who are most often injured from falls from height. The percentages are as follows: 25% of the workers are form setters/ ironworkers/ concrete workers, 22% of the injured do finishing tasks, and 11% of them do civil engineering work. Finally, as mentioned previously, the section regarding the types of work where serious accidents occur was still a work in progress.

What is important to note for Section 7.4 is that all of the figures stated are not referenced to previous research or recorded data, and Lorent does not provide a source for these numbers. Furthermore, within Section 7, which is devoted to safety, he only discusses accidents involving falls from height.

7.4. Analyse des causes des accidents suite à une chute de hauteur

- Gravité des accidents : 35 % des accidents mortels

sur 100 accidents mortels par chutes

31 % échafaudage – coffrage (conception du matériel et organisation)

18 % toitures, verrières... (conception architecturale)

12 % travaux de second oeuvre

- catégories de travailleurs accidentés suite aux chutes de hauteur

25 % coffreurs, ferrailleurs, betonneurs (conception du matériel)

22 % second oeuvre (organisation des co-activités)

11 % génie civil

- types de travaux où se produisent des accidents graves (plus d'1 mois d'incapacité)

étude en cours

7.5. Impact de la conception et de l'organisation. en amont du chantier

. Objectif : diminution du nombre des chutes de hauteur 30%

: diminution de la gravité des accidents suite aux chutes de hauteur : 40 %

. Les actions positives se situent au niveau d'anticipation le plus élevé

. La diminution du taux de fréquence des chutes de hauteur est entravée par une augmentation de l'exposition aux risques (voir augmentation de la productivité des travailleurs page 3, tableau n° 2)

. une évolution technique dynamique qui ne tient pas assez compte de la sécurité au travail.

Figure 3-Extract from the Original Lorent Report (Lorent 1987)

In Section 7.5, Lorent proceeds to discuss the impact of design and organization upstream from the work site. He states the objective to be the reduction of the number of falls from heights by 30%, and the reduction of the severity of the accidents from falls from height by 40%. The impact is summarized by three bullet points that are shown in Figure 3 (French) and Figure 4 (English).

It is unclear how the data described above was collected and how causal attributions are made. The percentages are allocated against various aspects of work: scaffolding, roofs, glass, etc. It appears that these are attributed to design activities. For example roof glass is associated with architectural design while scaffolding is linked with design of material and organization. Similarly, categories of injured workers are linked with design activities. It is not clear that this linking is defensible as the full evidence for the relationships implied between design activity and the severity and categories of injured workers was not established in Lorent's report.

7.4. Analysis of the causes of accidents from falls from height

- Severity of accidents: 35% of fatal accidents

  For every 100 fatalities from falls

  31% scaffolding - formwork (material design and organization)
  18% roofs, glass canopies ... (architectural design)
  12% work on finishing work

- Categories of injured workers following falls from height

  25% form setters, iron workers, concrete workers (equipment design)
  22% finishing work (co-organization activities)
  11% civil engineering

- Types of work where serious accidents occur (over 1 month of incapacity)

  Work in progress

7.5. Impact of design and organization, upstream of the work site

- Objective : Reduce of the number of falls from height by 30%
  : Reduce the severity of accidents following falls from height: 40%

- Positive actions are at the highest level of anticipation
- The decrease in the frequency rate of falls from height is hindered by increased exposure to risk (see increase in worker productivity page 3, table No. 2)
- A dynamic technical development which does not take sufficient importance in work safety

Figure 4-Translation of extract from the Original Lorent Report, in English

BACKGROUND ON THE 1991 REPORT BY EUROFOUND

The European Foundation for the Improvement of Living and Working Conditions (Eurofound) is a European Union Agency that aims to disseminate information, advice, and expertise on matters relating to living and working conditions in Europe. It is based both in Dublin and Brussels, and has produced several publications on topics ranging from working conditions and labor relations, to social policies (Eurofound 2015).

In 1991, Eurofound tasked Lorent to assemble a booklet of six national studies carried out for Eurofound (Eurofound 1991), that included his own 1987 study “Comité National d'Action pour la Sécurité et l'Hygiène dans la Construction, P. Lorent, Les conditions de travail dans l'industrie de la construction Productivité”, and the following five studies:

- The Management College, Birchall, Working in the Construction Industry, Henley, March 1987.

- CERTES, Campagnac and Caro, Les conditions de travail dans l'industrie de la construction, Paris, March 1987.
- Stichting Bouwresearch, Diepeveen and Brouwers, Les conditions de travail dans l'industrie de la construction, Rotterdam, March 1987.
- RSO, Rollier, La sicurezza nel settore delle costruzioni come problema di organizzazione e di progettazione, Milan, February 1987.
- Projektgruppe Arbeitsbedingungen in der Bauwirtschaft (PAB), Spannhake, Les carences de la sécurité du travail dans l'industrie de la construction et les frais qui en découlent, Dortmund, March 1987 (Eurofound 1991).

Chapter 2 of the booklet addresses the hidden costs associated with construction, and among these costs, Lorent mentions the costs of occupational accidents (Section 2.2). In addition to costs, Lorent discusses the causes of accidents (Section 2.2.3), where in reference to his 1987 report, he states that *"… an analysis of fatal accidents on building sites tends to show that about two thirds of them are due to shortcomings in design (architectural choices, decisions on materials and equipment, and organizational problems. …"*, a statement that is never made in the 1987 report (Eurofound 1991).

In continuation, Lorent states that 35% of fatal work accidents are caused by falls, and assumes that all falls are caused by design, 25% (shown as 28% in the figure in the report) (Haslam et al. 2005)have organizational deficiencies, and 37% are caused by implementation issues. It is clear from these numbers that there seems to be some discrepancy. Falls can be caused by both organizational deficiencies and by implementation issues. In addition with the exception of the 35% for falls, the other two percentages are not shown in the original 1987 report. Thus the statement that *"… about two thirds of them (fatal accidents) are due to shortcomings in design decisions and organizational problems …"* does not seem to be justified. Furthermore, no source of the information presented is mentioned (Lorent 1987; Eurofound 1991).

Lorent concludes this section of the report with a table repeating the data from his 1987 report, under Section 7.4 "Severity of Accidents" shown in Figure 4. He concludes *"… that about 60% of fatal accidents on building sites arise from decisions made upstream of the site…"* Again there seems to be a discrepancy since the original report does not mention methods for prevention for these accidents, nor any discussion of how the conclusion was reached. In this case Lorent states that "Scaffolding/ shuttering" accidents are prevented by "Equipment design and organization", "Roofing, facades, glazing, maintenance" are prevented by "Architectural design", and "Finishing works" are prevented by "Organization" (Lorent 1987; Eurofound 1991).

The value of 60% seems to be very high since more recent research has revealed a range from 27% (Haslam et al. 2005) to 42% (Behm 2005). Another issue that needs to be addressed and it is not mentioned in the report, is how far upstream should safety be considered; planning/design of the construction process at the beginning of the construction work, or to the design of the structure prior to the start of construction.

The Eurofound report makes more explicit statements about causality than the original Lorent report. Though questions arise as to the way fatal accidents were analysed and causal attributions were made. The statement that two thirds are due to shortcomings in design and organisational problems is problematic. The authors would argue, however, that sub-optimal design decisions are often made due to organisational problems, i.e, not consulting the right people at the right times and not following robust OSH risk management processes.

Organisational problems are also cited as consequences arising from the combined activity by members of different trades. In fact upstream organisational issues giving rise to sub-optimal H&S outcomes might involve a much broader range of scenarios than this. The coordination of multiple trades is arguably a site-based operational issue associated with the coordination of work in the construction stage of a project. The question of whether this should, in fact, be classed as an upstream activity arises.

Again, providing the causal analysis and methods used for attribution would help to clarify how the EU Foundation figures were derived. Again, like Lorent, there seems to be a lack of conceptual clarity in the interpretation of causes.

IMPACT OF THE EUROFOUND REPORT

Since the Eurofound report was published, several other publications have referenced the statements made by Lorent. In one example in conference proceedings, Jeffrey and Douglas (1994) refer to the Eurofound report as research carried out by Eurofound, and cite Lorent's conclusions as follows:

- *"60% of site fatalities can be related to decisions made off-site*
- *35% of site fatalities were caused by falls which could have been reduced through design*
- *25% of site fatalities are due to the simultaneous performance of incompatible activities*
- *37% of site fatalities are due to the management of production"* (Jeffrey et al. 1994)

In another example by Churcher and Alwani-Starr (1996), in conference proceedings again, the authors reference the Eurofound report showing and erroneously referring to the percentages of accidents attributed to project stages as 36% for Design, 36% Construction, and 27% Planning. These numbers in the Eurofound report as mentioned before are 35% for Design, 37% for Implementation (Construction), and 28% for Planning (Organization).

As expected this secondary and tertiary referencing created a cascading effect where newer publications utilized references in other publications without checking the original source documents. Such an example is observed in the Australian CHAIR Safety in Design Tool (NSW Workcover 2001), which references the Churcher and Alwani-Starr (1996) proceedings and their reference of the Eurofound report as research performed by them.

Did the Lorent and Eurofound reports lead to legislation?

Furthermore, it is possible that the Lorent and Eurofound reports were motivating factors for the development of extensive legislation, at least in Europe. As observed within the language in the Council Directive 92/57/EEC (EEC 1992) on the implementation of minimum safety and health requirements at temporary or mobile constructions sites, although the preamble does not cite the reports, there are several statements in the preamble that seem to repeat statements made by Lorent. Such examples are the following:

"Whereas unsatisfactory architectural and/or organizational options or poor planning of the works at the project preparation stage have played a role in more than half of the occupational accidents occurring on construction sites in the Community"

"Whereas, when a project is being carried out, a large number of occupational accidents may be caused by inadequate coordination, particularly where various undertakings work simultaneously or in succession at the same temporary or mobile construction site"

The Council Directive 92/57/EEC instructed all the member countries in the EU to enact legislation to implement Prevention tough Design in Construction. Such examples are the Construction (Design and Management) Regulations in the UK (Government 2007), and the Royal Decree 1627/1997 in Spain (INSHT 1997).

EMPHASIS ON FALLS FROM HEIGHT AS A PtD CONCENTRATION

It is evident from the Lorent and the Eurofound reports that the author concentrated on just falls from heights. The concentration on falls from height is an obvious one to consider, since this type of accident is the accident that is the ‘big killer’ for construction workers. Falls from height is a type of accident for which it is also easy to see that there are some things that designers can do to reduce the risk of falling, and the immediate causes of the accident are often fairly transparent compared to other accident types.

In South Africa for example, falls from height contributed to 12.8% of all accidents, and 17.2% of fatalities. Therefore, they clearly are a problem and should be focused on but PtD efforts should not be limited to combating these types of accidents alone. Design impacts many other aspects of the construction work in addition to work at height. Research performed in the past 20 years suggests that design plays a role in many different types of hazards present on construction sites. These hazards can result in different types of accidents (falls from height, trips/slips, struck-by, etc.). Targeting other accident types in addition to falls from height should be included to obtain a comprehensive perspective of the potential impact of the design. In addition, the analysis should address the range of injury severities (e.g., low, medium, high severity).

SUGGESTIONS FOR THE FUTURE

The Lorent (1987) and the Eurofound (1991) reports were a starting point in attempting to establish a link between upstream factors and construction site accidents. However, the unquestioning reliance on the Eurofound statistics in making the case for safety in design in the construction industry is counter-productive. In Australia design professionals have argued against the validity of the Eurofound findings, correctly stating that the data does not link 60% of all fatalities to design. This argument about percentages and attribution has been a distraction in the debate and discussion about how best to improve OSH by integrating consideration of OSH into all stages of construction project decision-making.

What is also important to consider, is to use more recent and more reliable information when OSH professionals want to display a causality between design and construction fatalities or injuries. Such examples could be research by Behm (2005) and Haslam et al. (2005). To strengthen the reliability and plausibility of any OSH research, primary sources should be found, understood, and utilized rather than relying on others to cite those sources and then so on and so forth. In addition OSH authors and policy makers must ensure that cited research must also be rigorous and scientifically founded.

A more nuanced understanding of the potential for design to contribute to better OSH outcomes is perhaps needed. When considering design as a causal factor, it is important to understand what is being designed, e.g. is it the product, the process of construction, an item of plant or equipment, or a component/system to be installed? Hazards can also emerge at the interface of different design tasks and components. Understanding the socio-technical complexity of design work in construction, rather than attempting to attribute responsibility to a single professional role, e.g. the architect or engineer, is also important. Identifying and promoting the best ways to ensure that OSH is effectively integrated into all project decision making, during planning, design, procurement, construction, and commissioning, should be a research priority.

When it comes to the implementation of the legislation already in place, like in Europe, there seems to be less of possibility for change. Construction industry professionals will most likely have to ‘get on with’ applying the legislation – so, arguably there is a different driver, that of moral responsibility. Elsewhere though, it is less clear.

Without argument, more thought put earlier in the process will improve things for construction workers. However, that is very different from attributing causality or blame, and as a result, the concept of 'design' should extend beyond architects and structural engineers to also include planners, estimators and other people who 'design' the work place and work tasks rather than JUST the permanent work (the product).

Upstream decisions, e.g. the design of a building/structure, can have an impact on the construction methods chosen, which, in turn, impacts on site-based activities. Rather than identifying a single cause, it is more appropriate to understand accidents as arising as a result of a complex interaction of causes some of which relate to design and the organizational aspects of construction projects, e.g. procurement, client specifications, project management environment, etc.

Arguably, instead of trying to identify a percentage of accidents that are attributed to design, it is important to make all participants in the supply chain of constructing a project acknowledge that they sometimes have the potential to influence OSH through their decision-making. If this is acknowledged, then construction project participants can be encouraged to consider the OSH implications of their decisions and make decisions that are responsible and good for OSH.

Lastly, we contend that there has been enough research linking design to negative construction outcomes. Instead, future research should focus on how design enables safety to occur on construction sites.

REFERENCES

Behm, M (2005) Linking construction fatalities to the design for construction safety concept. "Safety Science", 43(8), 589-611.

Churcher, D W and Alwani-Starr, GM (1996) Incorporating construction health and safetyinto the design process. Implementation of Safety and Health on Construction Sites Lisbon, Portugal.

EEC (1992) Council Directive on the implimentation of minimum safety requirements at temporaty or mobile construction sites. 92/57/EEC. EEC. Brussels, Belgium, EEC.

Eurofound (1991) From Drawing Board to Building Site : Working Conditions, Quality, Economic Performance. Dublin, European Foundation for the Improvement of, Living and Working Conditions.

Eurofound (2015) About Eurofound. Retrieved April 1, 2015,from http://www.eurofound.europa.eu/.

Government, H M S (2007) The Construction (Design and Management) Regulations 2007. London, Her Majesty's Stationery Office.

Haslam, R A, Hide, S A, et al. (2005) Contributing factors in construction accidents. "Applied Ergonomics", 36(4), 401-415.

INSHT (1997) REAL DECRETO 1627/1997, de 24 de octubre, por el que se establecen disposiciones mínimas de seguridad y salud en las obras de construcción. I. N. d. S. e. H. e. e. Trabajo. Madrid, Spain, Ministerio de Presidencia - Departamentos implicados.

Jeffrey, J and Douglas, I (1994) Safety Performance of the UK Constuction Industry. Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control. Gainsville, FL, 233-253.

Lorent, P (1987) Les conditions de travail dans l'industrie de la construction - Productivité, conditions de travail, qualité concertée et totale. Brussels, Comité National d'Action pour la Sécurité et l'Hygiène dans la Construction.

Manuele, F (2009) Safety through Design. "Accident Prevention Manual for Business & Industry: Engineering & Technology" P. E. Haganet al. Itasca, IL, National Safety Council, 3-35.

Manuele, F A (2008) Prevention through Design (PtD): History and Future. "Journal of Safety Research", 39(2), 127-130.

NSW Workcover (2001) CHAIR, Safety Design Tool.

DESIGNING FOR SAFE DEMOLITION - THE HAZARD POTENTIAL OF NANOMATERIALS

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When specifying products, designers should consider the health and safety of those working with the materials, either during construction or during decommissioning and demolition of a building or facility at the end of its life. The use of nanomaterials (those with at least one dimension less than 100 nm) in construction is reported to be on the increase, but it is difficult to identify exactly which products contain them; and there are uncertainties regarding their hazard potential. This paper is based on an ongoing IOSH-sponsored study to catalogue nano-enabled construction products through review of the literature, and consideration of manufacturers' data; and interviews with construction professionals to assess how widely they are used. The study is also using material characterisation techniques to identify the nanomaterials involved and assess the potential for particle release from products at end of life. The study has found wide variation in the hazard profiles of the different materials and products currently available. Some specialist concretes for example, are enhanced with silica fume which has been widely used for around 40 years and is a relatively low-risk nanomaterial. Other forms of nanosilica are used in insulation materials and surface coatings. Carbon nanotubes (CNT) are a nanomaterial which are hazardous in some forms. CNTs are not yet used commercially in concrete but are forecast to appear in the marketplace in a limited capacity by 2016. They are also used in very specialised surface coatings. Further information is needed to assess whether they could pose a health risk at end-of life from the combined impacts of material degradation over time and the destructive techniques commonly applied in building demolition and recycling (e.g. crushing, cutting, drilling etc).

Keywords: nanotechnology, silica, CNT, health risk, demolition.

INTRODUCTION

Nanomaterials generally have either particles or internal structures (e.g. holes or pores) with dimensions between 1 and 100 nanometres (nm). They can have very different properties from the more common ‘bulk’ forms of materials which are chemically similar. They are not all new – for example, carbon black is a nanomaterial which has been used as a rubber reinforcer in tyres for around 100 years. However, there has been a proliferation in the use of nanotechnology in recent years with the discovery of completely new forms of materials alongside the gradual evolution of familiar substances. Some of these have the potential to provide significant societal benefits, for example the use of nanomaterials to remove chlorinated hydrocarbons from contaminated land (Mueller et al. 2012); or in healthcare to allow targeted treatments for diseases such as cancer and multiple sclerosis. Other applications are arguably more trivial such as the use of nanosilver in socks, hairdryers and washing machines to ‘sterilise and deodorise (Samsung website). Construction is also seeing an expansion in the use of nanomaterials, with some predicting that 50% of building products will be nano-enabled by 2025 (AECOM 2014).

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Concerns have been raised about the hazard potential of nanomaterials. In principle, the toxicity of small particles is generally higher than that of larger particles with the same physicochemical properties, as a consequence of their greater surface area and higher reactivity (Lim et al. 2012). However, many other characteristics of materials also affect their hazardousness: including their shape, how strongly the particles adhere together, and the presence of additional substances such as heavy metals. For example, there are particular concerns regarding substances with high aspect ratios – those which are long and thin and might therefore behave in ways similar to asbestos fibres (Donaldson et al. 2013); this could include some types of carbon nanotubes (CNTs).

There is a lack of clarity regarding the extent to which construction products currently contain nanomaterials, and which particular material(s) might be present. This paper is based on an ongoing research project funded by the Institution of Occupational Safety and Health (IOSH) to address these uncertainties. A particular area of concern is the potential for exposure to nanoparticles at demolition, given the destructive and sometimes explosive nature of methods used. The research involves:

- A desktop study of the literature and manufacturers' data to identify construction products which might contain nanomaterials. This is being supplemented with e mail exchanges and interviews with representatives of companies which make and sell these products; and interviews with construction industry professionals to assess the extent and scope of their use.
- Laboratory based testing of a selection of construction products to identify the particular nanomaterials which they contain; followed by destructive testing to mimic common demolition methods and assess the potential for particle release.

An early finding of the work has been the variation in the hazard profiles of different nanomaterials. This paper uses selected findings from the research to illustrate this by comparing two nanomaterials which are commonly identified in the literature as being relevant to construction – silica (silicon dioxide) and Carbon Nanotubes (CNTs). In each case, the nanomaterial and its likely construction uses will be described and then the hazard potential considered. By highlighting the similarities and differences between the two materials, the paper will illustrate the importance of gaining a deeper understanding of building materials, beyond simply whether or not they are 'nano'.

SILICA

Nano forms of silica are found in various products which are widely accessible for use in the built environment, being available to both industry professionals and home owners. They are industrially produced with a wide range of particle sizes and associated properties; some forms are a by-product of silicon production, and applications have developed to take advantage of this. The structure of nanosilica is predominantly amorphous (literally, without a clear shape or form), and differs from the more hazardous crystalline silica (e.g. quartz) which is commonly used in construction and is a key constituent of Portland cement. Typical uses for nanosilicas in construction include concrete, insulation and surface coatings.

Silica in concrete

Microsilica (also known as silica fume) has an average particle size of around 150 nm, but is classed as a nanomaterial because over 50% of its particles by number are smaller than 100 nm. The small spherical particles enable concrete to be produced which is strong, dense and durable, with improved plasticity and reduced porosity (Friede 2006). It can be easily pumped long distances, and can be self-levelling. Most of the major concrete producers include microsilica-enabled concretes in their portfolio, and these have been in use for around 40 years. They are most likely to be used in complex or prestigious buildings - interviews with industry professionals suggest that microsilica concretes account for a relatively small proportion of the concrete market in the UK, largely because there are other additives, which are cheaper or easier to use, which provide similar properties (Goodier et al. 2015).

A second silica additive which can be used in concrete is nanosilica (also known, confusingly, as fumed silica). This has a particle size about 10 times smaller than silica fume and can be used to make ultra-high performance concretes (UHPC) which are very dense and allow the production of thin, strong concrete slabs and elements (Schmidt et al. 2013).

Silica in insulation

Silica insulation materials use aerogels which have been described as "the most effective thermal insulation on earth" (Aspen Aerogel website). They are formed by replacing the liquid in a silica gel with air, leaving a material which is around 97% air in a silica framework. The excellent insulating properties of the materials arise from the poor conductivity of air, in addition to the improved resistance to heat flow which is associated with decreasing pore size i.e. the very small spaces within the silica structure (Hanus and Harris 2013). Aerogels are commonly described in manufacturers' and academic literature as being 'nanoporous' (van Broekhuizen and van Broekhuizen 2009) or 'nanostructured' and as not containing nanoparticles. Notwithstanding, a small number of nanoparticles were seen in insulation materials tested in the current research.

Aerogels are used in three main forms of insulation. The first are translucent granules which can be included within walls or ceiling materials designed to allow daylight entry. The second are blankets which include the aerogel in a fibre matrix to produce a durable and flexible material which has additional benefits of providing noise insulation and fire retardancy. These blankets can then be wrapped around pipes and other structures or applied to plasterboard to create thermal panels. The third insulation type is Vacuum Insulated Panels, which use impermeable laminates to enclose silica aerogel within a vacuum. All these materials are relatively expensive (perhaps 6-10 times the more commonly used equivalents (Cuce et al. 2014)) and are currently used predominantly in specialist applications such as oil rigs or arctic modules.

Silica in coatings

Nano-enabled coatings are widely available to the building trade or the home consumer, offering waterproofing or dirt resistance, as well as increased scratch resistance. Figure 1, taken with a scanning electron microscope as part of the current research, shows the structure of one such material. This product, which is marketed for use in shower enclosures, is reported to have water and oil-repellent properties and to be easy to keep clean and to reduce lime scale build-up. Nanosilica is one of a number of materials which contribute to these products (others include titanium, silver and aluminium) but identifying exactly which materials are contained and whether they are at the nanoscale is extremely difficult. The presence of nanomaterials is rarely identified in material safety data sheets, and some materials are marketed as nanotechnology but do not actually contain nanoparticles (see for example, Figure 2).

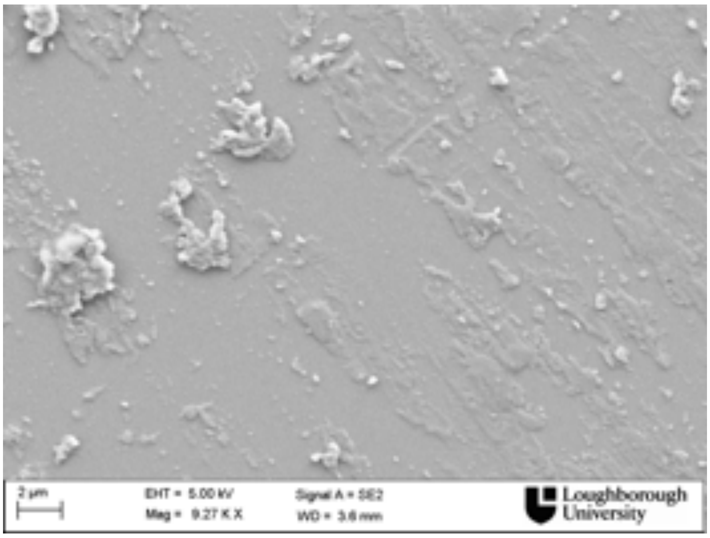

Figure 5 A sample of coated glass, showing a small number of nanosized particles

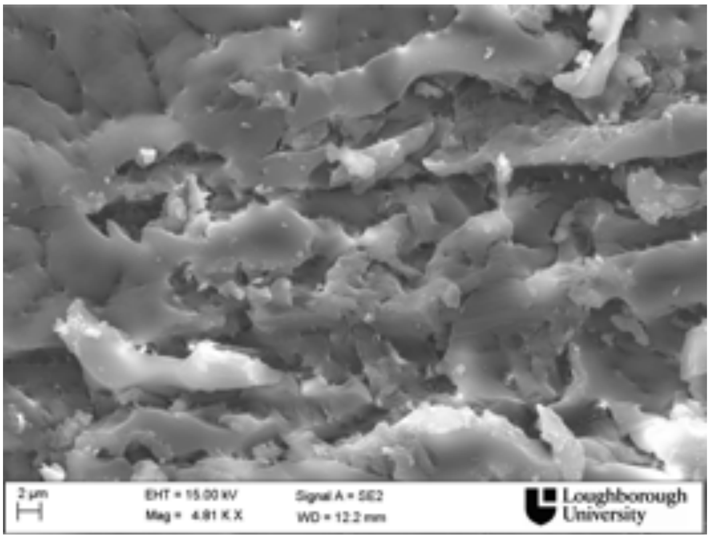

Figure 6 A 'nanotechnology coating', which does not actually contain nanoparticles

Hazard potential of nanosilica at demolition

Nanosilica (including silica fume) is generally identified as being at the safer end of the nanospectrum (Som et al 2014; Becker 2011). A detailed review by Napierska et al (2010) concludes that there is insufficient evidence to declare it 'safe', but also identifies that any effects on the lungs appear to be reversible (i.e. temporary). It is important to reiterate that the nanosilica used in building materials is generally amorphous in structure; this is a material which in its non-nano form is markedly less hazardous than the crystalline silica (quartz) found in Portland cement which contributes to silicosis and other long-term lung diseases.

Common demolition and recycling methods used for concrete include crushing, breaking or exploding structures (see Figure 3), these are processes which are recognised in the industry as having a high potential for dust release. Exposure to dust from insulation materials might occur if they are removed manually, in readiness for transfer to landfill. Exposure from coatings will depend on the substrate – wood removed from buildings is generally either chopped mechanically for fuel or transported to landfill; concrete structures will be treated by the usual demolition methods regardless of the presence of coatings. There is therefore some potential for dust exposure to occur with all materials.

(source:DSM demolition)

(source: Jones, Loughborough University)

Figure 7 Stages of concrete demolition and recycling with the potential to cause dust release

Testing in this research to quantify nanosilica content has found that relatively small numbers of nanoparticles are present in either insulation materials or surface coatings. This is also the case for cured concrete (Figure 4), although further testing is needed to confirm this with certainty.

In fact, nanoparticles are released during the demolition of concrete, regardless of whether these have been intentionally added. A high proportion of the particles released by the destruction of standard (non-nano) concrete are reported to be nano-sized (Kumar and Morawska 2014), known as Process Generated Nanoparticles. It is not yet known whether this significantly increases if nanomaterials are added during construction, although if the number of added nanoparticles is small this may not increase particle release substantially. Regardless of whether nanomaterials are believed to be present, good practice in demolition should always take into account the risk of dust exposure, with control measures including the use of water to reduce dust and the use of appropriate, properly fitted PPE. It is commonly recommended (e.g. by the HSE in the UK) that an FFP3 mask (N95 in the US) is used to protect against construction dust, such masks typically provide protection against both large particles and nanosized ones (Schaffer 2009).

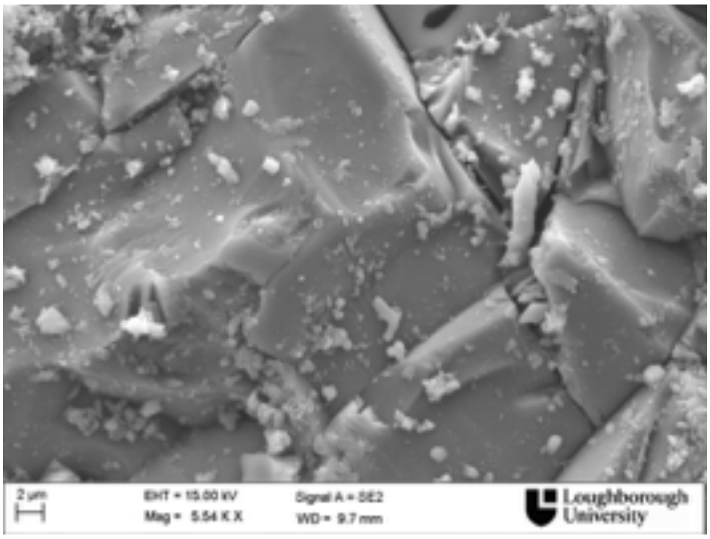

Figure 8 Silica fume concrete, showing a small number of nanoparticles (taken from Jones et al. 2015)

CARBON NANOTUBES

Carbon nanotubes (CNTs) are hollow structures with a diameter between 1 and 100 nm, and a length of several microns or longer. They essentially consist of a single atom layer of carbon (graphene) rolled into a tube, and may have a single wall (SWCNT), or may consist of several tubes inside each other, multi-walled carbon nano tubes (MWCNT). They are potentially useful in construction and in many other applications because of their extremely high strength and their electrical conductivity. They are currently, however, expensive to produce and difficult to work with. For example, they have a strong tendency to agglomerate and aggregate, requiring complex techniques to disperse them within materials to take advantage of their functionality. Interviewees for the current research considered the technology to be some way from commercial use in construction. Nevertheless, production capacity for CNT is rapidly increasing and prices falling, so that developments may occur quickly once suitable processes and opportunities are developed.

CNTs in Concrete

CNTs are widely discussed within the academic literature as a potential additive for concrete. In particular, they are reported to provide high strength, so that some concrete structures might eventually be built without steel reinforcement. They might also provide self-healing properties, or have the ability to resist crack propagation (although other materials can also provide these properties); and potentially can be 'self-sensing', enabling damage detection at an early stage.

Concretes containing CNTs are not commercially available currently but a recent report by Eden Energy (2014a) has announced "[a] preliminary trial in USA ……of Eden's CNT enriched concrete on a suitable roadway or similar area", is scheduled to take place in late 2014/2015.

CNTs in Coatings

At least one company is marketing a coating for steel based on CNTs which offers 'significant advantages' in corrosion protection (Tesla website). Others are marketing CNTs for inclusion in paints which offer resistance against fire or provide non-stick qualities for use in marine environments such as on boats or oil rigs. It is very difficult to identify how much such materials are being used or even whether they have moved beyond development and trial phases.

Hazard potential of CNTs at demolition

The main concerns regarding the health risks of CNTs arise from their similarity in structure to asbestos (i.e. needle shape, high aspect ratio); their length, diameter and bio persistence influence their toxicity. It is commonly accepted that fibres narrower than 1µm are respirable and are carried to the lower parts of the lungs - this will include all CNTs (which have diameters as low as 1 nm). Fibres longer than 5 µm are considered potentially harmful as they either become lodged in the pleural space; or are too long for cells to break down and discharge, and hence become embedded in the lung tissue. Shorter, tangled CNTs are less harmful as they are more easily expelled by the usual mechanisms (Donaldson et al. 2013). However, some studies have identified that shorter fibres (for example, less than 2 µm) can also have adverse effects, and there is also a lack of agreement on the diameter of CNTs which are the most problematic (Madani et al. 2013). Additional factors such as the presence of heavy metals or the extent to which CNTs are aggregated together are similarly reported to affect toxicity. There is, therefore, still a degree of uncertainty around the hazardousness of CNTs and wide variation depending on the characteristics of the specific material used.

Exposure potential at demolition will, as for nanosilica, be from crushing, breaking, and possibly explosive techniques. For coatings, exposure will depend on the substrate to which it is applied – metals, for example, are likely to be cut up using mechanical or heat based tools prior to smelting for reuse.

One way of reducing the hazard from CNTs is by encasing them within a carrier substance or matrix, so that they are less likely to become airborne, and potentially less likely to be toxic. For example, Eden Energy, who are developing CNT-enhanced concrete as mentioned above, report that they have addressed health and safety concerns through the inclusion of the CNTs in a liquid admixture, and the fact that it will be firmly bonded to the finished concrete (Eden Energy 2014b). The robustness of such protective matrices will clearly influence the health risk from nanomaterials at the end of life of the structure. There is some evidence that a combination of weathering over time (for example by UV light, which degrades some polymers) and mechanical stress (which is likely to occur at several stages of demolition and recycling) can result in CNTs being released (Hirth et al. 2013). Testing to assess the likelihood of this occurring needs to be done on real products as there is likely to be significant variation between different types of matrix (in addition to the variation in hazard related to different types of CNT). However, this is difficult to do in advance of products being commercially released unless developers choose to carry out or collaborate with such testing.

CONCLUSIONS

Nanotechnology can be of considerable benefit to the construction industry and the built environment– nanosilicas and CNTs both have much to offer, as do nanoforms of other materials such as titanium dioxide, silver and zinc. However, there are also possible health risks: these vary between different substances, and with different forms of each substance. There is a lack of transparency regarding the use of nanomaterials which makes it difficult to identify where they are used and in what forms. This is a universal issue, applying to the two materials discussed in this paper as well as to other nanomaterials

This paper has illustrated though that there are differences between silica and CNTs, particularly in their hazard profile – not all nanomaterials are the same. Silica is widely available in its nano form, and in some cases has been used for many years. Although it is not 'safe' it could be argued that it is unlikely to add significantly to the existing risks of demolition, particularly in relation to respirable silica (quartz) dust from concrete.

CNTs are at an early stage of commercialisation in the construction industry, and it is difficult to predict where, and how extensively, they will be used in the future. The academic literature is enthusiastic about their potential but scaling up production in a reliable and affordable way is proving challenging (NNI 2015). It is also unclear what types of CNTs might be used in construction and how robust and long-lasting the materials they are embedded in will turn out to be. This makes it impossible to judge the potential for harm to arise from their use, given that some forms are recognised as being hazardous. Ideally, developments of new products will focus on the use of CNT types which have been identified as less harmful (such as those which are short and tangled), but it is also possible that the drive for improved functionality will override this.

Building designers are unable to make informed decisions regarding risk without knowing what is being used and where. Currently, the most potentially problematic nanomaterials are not widely available in the marketplace but they are expected to appear in the near future; it is therefore essential that we learn more about them. Ideally, designers would have the relevant information regarding their hazard potential (as well as their potential to reduce risks) to aid decisions concerning product specification. In its absence, they can (hopefully) only err on the side of caution, taking precautionary measures during construction and keeping good records in the health and safety file passed on to the end-user. This will permit demolition engineers in the future to make sensible decisions when deconstructing buildings and facilities, in the light of the best available information available at that time.

REFERENCES

AECOM (2014) " The Blue Book: Property and Construction Handbook International Edition" [viewed 2014, November 26]. Available: http://www.aecom.com/deployedfiles/Internet/Geographies/Australia-New%20Zealand/Documents/Blue%20Book%202014.pdf

Aspen Aerogels [viewed 2014, November 26]. Available: http://www.aerogel.com/

Becker, H, Herzberg, F, Schulte, A and Kolossa-Gehring, M (2011) The carcinogenic potential of nanomaterials, their release from products and options for regulating them. "International journal of hygiene and environmental health", 214 (3), 231-238.

Cuce, E, Cuce, P M, Wood, C J and Riffat, S B (2014) Toward aerogel based thermal superinsulation in buildings: A comprehensive review. "Renewable and Sustainable Energy Reviews", 34, 273-299.

Donaldson, K, Poland, C A , Murphy, F A, MacFarlane, M, Chernova, T and Schinwald, A (2013) Pulmonary toxicity of carbon nanotubes and asbestos - similarities and differences. "Advanced Drug Delivery Reviews", 65(15), 2078-2086.

Eden Energy (2014a) "Annual Report for the Year Ended 30 June 2014 Eden Energy Ltd and Controlled Entities ABN 58 109 200 900" Available: http://www.edenenergy.com.au/pdfs/9655b8bc99f0f15e9fa9c3ac46d9ec92.pdf

Eden Energy (2014b) "Presentation to the Concrete Institute of Australia". [viewed 2015 May 15] Available: http://www.edenenergy.com.au/pdfs/6afaf9eddd984d978e3e7cd605545531.pdf

Friede, B (2006) Microsilica-characterization of an unique additive. In: "Proceedings of the 10th International Inorganic-Bonded Fiber Composites Conference (IIBCC 2006)" Sao Paulo, Brazil, Universidade de Sao Paulo and University of Idaho , October 15–18, pp. 135.

Goodier, C I, Dunne, D, and Christodoulou, C (2015) Resistivity and water absorption of concrete. In: "ICCRRR - International Conference on Concrete Repair, Rehabilitation and Retrofitting", Leipzig, 05 - 07 October 2015

Hanus, M J and Harris A T, (2013) Nanotechnology innovations for the construction industry. "Progress in Materials Science" 58 (7) 1056-1102.

Hirth, S, Cena, L, Cox, G, Tomović, Ž, Peters, T and Wohlleben, W (2013) Scenarios and methods that induce protruding or released CNTs after degradation of nanocomposite materials. "Journal of Nanoparticle Research" 15(4) 1-15.

Jones, W, Gibb, A, Goodier, C, Bust, P and Song, M (2015). Nanomaterials in construction and demolition-how can we assess the risk if we don't know where they are? In: " Journal of Physics: Conference Series", 617 (1), IOP Publishing.

Kumar, P and Morawska, L (2014) Recycling concrete: An undiscovered source of ultrafine particles. "Atmospheric Environment", 90, 51-58.

Lim, C, Kang, M, Han, J and Yang, J (2012). Effect of agglomeration on the toxicity of nano-sized carbon black in Sprague-Dawley rats. "Environmental health and toxicology" 27, e2012015.

Madani, S Y, Mandel, A and Seifalian, A M (2013) A concise review of carbon nanotube's toxicology. "Nano reviews", 4.

Mueller, N C, Braun, J, Bruns, J, Černík, M, Rissing, P, Rickerby, D and Nowack, B (2012) Application of nanoscale zero valent iron (NZVI) for groundwater remediation in Europe. "Environmental Science and Pollution Research", 19(2), 550-558.

Napierska, D, Thomassen, L, Lison, D, Martens, J A and Hoet, P H (2010) The nanosilica hazard: another variable entity. "Particle and Fibre Toxicology", 7 (1), 39.

NNI (2015) "Realizing the Promise of Carbon Nanotubes Challenges, Opportunities, and the Pathway to Commercialization Technical Interchange Proceedings September 15, 2014" [Homepage of National Technology Initiative], [viewed 2015, March 18]. Available: http://www.nano.gov/sites/default/files/pub_resource/2014_nni_cnt_tech_meeting_report.pdf.

Samsung [viewed 2015 May 15] Available: http://www.samsung.com/ph/consumer/learningresources/washingmachine/silver_nano/site.html

Schmidt, M, Amrhein, K, Braun, T, Glotzbach, C, Kamaruddin, S and Tänzer, R (2013) Nanotechnological improvement of structural materials – Impact on material performance and structural design. "Cement and Concrete Composites", 36 (0), 3-7.

Shaffer, R E and Rengasamy, S (2009) Respiratory protection against airborne nanoparticles: a review. "Journal of nanoparticle research" 11 (7), 1661-1672.

Som, C, Zondervan-van den Beuken, E, Van Harmelen, T, Güttinger, J, Bodmer, M, Brouwer, D, Buist, H E, Carroll, R, Coll, C, Fransman, W, Hartmanis, A, Hincapie, I, Hischier, R, Karachalios, T, Kouravelou, K, Kuijpers, E, Ligthart, T, Notter, D, Nowack, B, Seibold, U and Schneider, G (2014) "LICARA Guidelines for the sustainable competitiveness of nanoproducts" Dübendorf, St. Gallen, Zeist,.

Tesla Nanocoatings [viewed 2015 May 15] Available: http://www.teslanano.com/about/

van Broekhuizen, F and and van Broekhuizen, P (2009) "Nano-products in the European Construction Industry State of the Art". Amsterdam European Federation of Building and Wood Workers.

A REVISED FRAMEWORK FOR MANAGING CONSTRUCTION HEALTH AND SAFETY RISKS BASED ON ISO 31000

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There is an increasing demand being placed on those managing construction projects to complete their work efficiently; while also ensuring that the risks associated with financial, environmental protection, health, safety and quality are simultaneously managed effectively. The international risk management guideline ISO 31000, adopted in Australia as the joint Australia and New Zealand AS/NZS ISO 31000 (2009), has been suggested in order to represent one of the best integrated frameworks that can be used for managing all types of risks. However, apart from the guidance notes and supporting documentation, there is little published research that supports such claims. For this reason the utility of managing construction health and safety risks effectively, using the above standard on its own, remains questionable. The aims of this paper are threefold. Firstly, it gives a brief introduction to the new risk management guidelines and its adoption in Australia. Secondly, it critically reviews the published literature on the above risk management standard. Thirdly, it discusses three main differences between the risk management standard and health and safety management practice. The paper concludes with a proposed revised framework based on ISO 31000 that can be used to manage construction health and safety risks more effectively.

Keywords: risk management, ISO31000, construction health and safety management, hazard identification, risk treatment and control.

INTRODUCTION

Effective management of construction health and safety risks is an integral part of construction work. It is becoming evident that those charged with the responsibility of managing health and safety risks in many organisations are increasingly expected to either draw upon, or adopt, strategies and measures that can simultaneously achieve other risk management objectives, including that of environmental protection, finance and quality management. This, in part, is driven by the recognition that health and safety needs to be integrated into all decision making processes (Sunindijo & Zou, 2014), with the development of an international standard for risk management in the form of ISO 31000 being suggested to provide necessary mechanism for such integration (International Organization for Standardization, 2009).

The idea of integrating health and safety into the decision-making process is not only necessary, but also long overdue. However, apart from the guidance notes and supporting documentation, published research on this standard is limited, even though construction risk management itself continues to be the subject of significant research (Jefferies & McGeorge, 2008; Yaraghi and Langhe, 2011). Very little attention has been given to the framework needed to support the implementation of risk management process in the construction industry (Sousa, De-Almeida, & Dias, 2012). This is a significant gap in the literature, and begs the question of whether a blanket adoption of this risk

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standard on its own is enough for managing health and safety risks in the industry? This research attempts to fill this gap through an integrative review of the literature on construction health and safety management and risk management.

RESEARCH METHODS

The research method used in this research involves an integrative review of the literature, consistent with that used by Corina and Palaneeswaran (2010) and Vincent, Taylor-Adams, and Stanhope (1998). The efficacy of document reviews as research method has been previously established (Mogalakwe, 2006).

The remaining sections of this paper discusses the development and implementation of the above risk management standard, reviews research based on risk management; and goes on to examine three main differences between the risk management standard and health and safety management practices. The paper concludes by proposing a revised framework which integrates the key ideas derived from the review.

THE DEVELOPMENT OF ISO 31000

The new risk management standard was published by the International Organization for Standardization (ISO) in 2009. Titled *'Risk management- principles and guidelines'*, it represents the concerted efforts by a working group of international technical advisors from a range of industries and backgrounds (Gjedrum & Peter, 2011). This development is a very important achievement. While those working in, or associated with risk management have always sought to make decisions about risks, the acceptability of those risks, and the reliability of information required to make the necessary decisions about the (levels of) risk, their ability to do so mainly depended upon how risks were defined; the different aspects of the process involved and what these processes sought to achieve (Purdy, 2010). This meant decision-makers were left to resolve pieces of similar but fundamentally different information obtained from different processes, with different assumptions and; in some cases described using the same words but with different meanings. In this regard one of the main challenges for ISO was to reach consistency and reliability in risk management through a standard that could be applied to all forms of risk.

ISO 31000 has evolved over two decades when the need for a global and improved risk management approach was first realised in the 1990s. Initially, these were aimed at addressing societal concerns associated with safety standards and environmental impacts of new technologies and products (Mitchell, 1990). In seeking to be truly international in nature, a number of different approaches, guidelines and standards were considered, some examples of which are illustrated in Table 1. The development and adoption of ISO 31000 occurred over a period of four years, involved twenty-nine countries and underwent three major revisions before being adopted (Dali & Lajtha, 2012). As a result the new guideline has been suggested to be more relevant as it can used in a range of countries and organizations, irrespective of the complexity, size or type (International Organization for Standardization, 2009).

Table 1: Some approaches for managing risk prior to ISO 31000

Standard	Author	Year
BS IEC62198 (2001): Project risk management - application guidelines	British Standards	2001
IEEE 1540 (2001): IEEE standard for software life cycle processes - risk management	Institute of Electrical and Electronic Engineers	2001
JIS Q2001 (2001): Guidelines for development and implementation of risk management system	Japanese Standards Association	2001
CEI/IEC 62198 (2001): International standard, project risk management - application guidelines	International Electrotechnical Commission	2001
AIRMIC/ALARM/IRM (2002): A risk management standard	Institute of Risk Management/National Forum for Risk Management in the Public Sector/Association of Insurance and Risk Managers	2002
FERMA (2003): A risk management standard	Federation of European Risk Management Associations	2003
AS/NZS 4360 (2004): Risk management	Standards Australia International	2004

For countries such as the United States, this development represented an expansion of the practice of risk management; a field which evolved out of industrial safety and insurance (Gjedrum & Peter, 2011). The complexity of construction work, combined with the fact that construction work is undertaken by small, medium and large organisation suggests that ISO 31000 is relevant in advancing risk management practice in the industry.

The Joint Australian/New Zealand Standard for Risk Management

The first risk management standard adopted in Australia was the joint Australian and New Zealand Standard AS/NZS 4360Risk management, which has been suggested to represent the first standard on the subject (Flaus, 2013). Since its inception in 1995, this standard has been revised twice, first in 1999 and again in 2004 (Standards Australia, 2009). The latter addition took into account feedback of some ten years of user experience, before being proposed to the ISO. Hence the first draft of ISO 31000 replaced AS/NZS 4360 (Leitch, 2010). The current joint Australian and New Zealand risk management standard is based on ISO31000.

KEY ELEMENTS OF ISO 31000

ISO 3100 is based around five main chapters /clauses, viz:

1. Scope;
2. Terms and definitions;
3. Principles;
4. Framework; and
5. Process (International Organization for Standardization, 2009).

Of particular interest to construction safety academics, policy makers and practitioners are the last three chapters, and these are briefly considered next.

Principles

ISO 31000 lays out a set of eleven key principles that organisations need to follow. As worded, an effective framework for risk management is expected to

1. create and protect value;
2. be a central part of all organizational processes;

3. be part of all decision-making;
4. address uncertainty;
5. be systematic, structured and timely;
6. be based on the best information available;
7. be tailored to the needs of the individual organization;
8. take into account human and cultural factors;
9. be transparent and inclusive;
10. be dynamic, iterative and responsive to change; and
11. facilitate continuous improvement (International Organization for Standardization, 2009).

In effect, these have been suggested to represent the essential performance criteria against which risk management can be assessed, evaluated or measured (Purdy, 2010).

Framework

ISO 31000 stresses the use of a framework that fully integrates the management of all types of risks likely to be experienced by an organization. Authors such as Gjedrum and Peter (2011) have noted the framework can be used to provide an assurance that the organization-wide processes for managing risks are supported, iterative, continues to remain effective, and provides the necessary mechanism for integration, reporting and accountability; hence needs to include some ways of monitoring and reviewing. According to Luko (2013), it also includes core supporting organizational structure, mandates and overall management. In some respects this is tantamount to the Plan-Do-Check-Act (PDCA) cycle of continuous improvement suggested by Deming, although the jargon may be different. It is important to note that the *"framework is not intended to prescribe a management system, but rather to assist the organization to integrate risk management into its overall management system"* (International Organization for Standardization, 2009, p. 11). One way by which construction organizations which already have established management systems for environmental protection, health and safety, and quality assurance can achieve this is by integrating these management systems into the organisation's risk management approach.

Process

Effective risk management involves a series of integrated and coordinated activities aimed at directing and guiding an organisation in relation to risk (Flaus, 2013). ISO 31000 suggests these can be grouped into five steps:

1. communicate and consult;
2. establishing the context;
3. risk assessment;
4. risk treatment; and
5. monitoring and review (International Organization for Standardization, 2009).

Steps 1 (communicate and consult) and 5 (monitoring and review) have been suggested to be included in the main steps of establishing the context, risk assessment and risk treatment.

CONSTRUCTION RISK MANAGEMENT

Risk management of construction health and safety has been the subject of much research, resulting in an ongoing body of reviews on the subject. Examples of these include Walters (2010), for example, examined the effectiveness of consultation; Bhattacharjee, Ghosh, and Young-Corbett (2011) who reviewed commonly used techniques used for improving construction safety; Swuste, Fritjers, and Guldenmund (2012) who examined structures, processes, safety management systems and responsible for safety; and a Cochrane review of the effectiveness of technical, human factors, organisational interventions and regulations (van der Molen et al., 2012). None of these reviews used ISO 3100 as a framework or point of reference.

There has been some published research around this standard. Ciocoiu and Dobrea (2010) examined standardizations in improving the effectiveness of an integrated risk management strategy and concluded the development of an ISO standard on risk management meant an appropriate tool was available internationally for formalize the process and harmonizing the best practice approach. Oehmen, Ben-Daya, Seering, and Al-Salamah (2010) examined the adoption and application of ISO 31000 in product design and concluded that; while the suggested five step process was relevant, the published literature addressed different aspects of them to varying degrees, and there was generally a lack of integration between the suggested standards and processes. Gjedrum and Peter (2011) compared ISO 31000 with the Enterprise risk management framework developed by the Committee of Sponsoring Organizations of the Technology Commission (COSO) and found that a major difference between the traditional processes of managing risks and the new guideline was the inclusion of 'establishing the context' and continuous 'communication and consultation'; and that the main strengths of ISO 31000 lay in the identification of risk owners. Luko (2013) reviewed the terminology and language used the new guidelines as adopted in the United States as ANSI/ASSE Z690.2 -2011, and concluded that ISO 31000 did provide a good framework upon which applications for managing quality and risks could be expanded upon.

At the time of preparing this paper, ISO 3100 has been the subject of two construction risk management papers. The first, by Liu, Low, and He (2011), examined the practices and challenges of implementing Enterprise Risk Management (ERM) modelled on ISO 31000. This research revealed that the construction organisations generally had a basic understanding of risk management and a relatively clear focus on market and financial risks, most had an established risk management system, and the main means of managing risks involved behavioural control. The second, by Sousa et al. (2012), proposed a framework for managing construction risks by integrating a model of Organizational management (OM), the PDCA cycle, the five step risk management process, the key functional areas, management processes and the different stakeholders involved in construction projects.

Based on a review of the above literature, the following points can be made. First, there is generally a level of acceptance that ISO 3100 is about harmonization of existing process, although there is very little published on (i) the principles and their adoption and/or utility in measuring performance, and (ii) the efficacy (or otherwise) of suggested five step process. Second, ISO 31000 enables some level of integration into the different business and other risk management processes, although it is unclear how this can be achieved in actual practice. Two possible alternatives suggested include ERM and OM, however, both these approaches are likely to be more relevant to large organisations, but the extensive frameworks suggested can prove difficult (if not costly) for medium and small sized constructions which comprise the bulk of the construction sector. Some authors, including Leitch (2010) have commented that overall, the standard itself is disappointing, and attributing this to the difficulties with language and country of origin of the representatives involved in developing and finalising

ISO 31000. However this is normal, and expected, in the development of any standard aimed at an international level of adoption.

On a more pragmatic level those of us who practise in health and safety, occupational hygiene or ergonomics can point out a number of differences between what is included in ISO 31000 and health and safety management in practice. The next section discusses these differences.

KEY DIFFERENCES BETWEEN THE RISK MANAGEMENT STANDARD AND HEALTH AND SAFETY MANAGEMENT

There are at least three main differences between ISO 31000 and health and safety management practice which can impact on the effective management of health and safety risks in construction. These differences largely involve the process of risk management.

The first is the inclusion of 'establishing the context;' a concept which is not featured in health and safety management practice. According to Sousa et al. (2012), this step involves evaluating and understanding the internal and external contexts, the challenges faced by the organisation, factors which can impact on the achievement of goals, the broader risk management strategy. The authors contend that asking six key questions around who (stakeholders/parties), what (design), which way (activities), why (motives), wherewithal (resources), and when (timing) can assist in identifying the key parameters. Flaus (2013), suggests it is a "stage in formalizing the definition of the framework…it allows us to define the object…interactions with the environment, the nature of risks being studied … consequences…scales of probability and severity, the risk matrix and thresholds of acceptability"(Flaus, 2013, p. 64). This stage of the process can be distilled into four (4) key inputs:

1. External environment;
2. Internal environment;
3. Risk management framework; and
4. Risk criteria.

External environment includes those forces and institutional factors outside an organisation that can potentially affect its performance (Robbins, Bergman, Stagg, & Coulter, 2006)., and can include factors such as economics, political/legal, socio-cultural, demographics, technological, global, industrial, clients/customers, competitors, suppliers, stakeholders (International Organization for Standardization, 2009; Standards Australia, 2009). Internal environment includes factors such as culture, goods and services provided, technology, pressure groups, policies /procedures/rules, internal politics, work practices, management and supervisory styles, and degree of change experienced (International Organization for Standardization, 2009; Standards Australia, 2009). The most common frameworks used in health and safety management practice include AS/NZS ISO 4801/4804, 9001, 14000 and OHSAS 1800, or its equivalent in the United States. Consequences, probability, severity, risk matrices and acceptability are terms that are associated with the risk assessment process itself (Flaus, 2013).

The second key difference is the notion of 'risk identification', which ISO 31000 suggests is the first part of the risk assessment process. This term itself is confusing, and represents a significant point of departure from health and safety research and practice. Risk itself is a controversial issue in many fields of practice; in the context of health and safety risk management it is associated with a degree of harm, injury or illness (Boyle, 2012) and is only possible if someone is exposed to a hazard (Flaus, 2013; Jensen, 2012). Being able to determine the degree involves making some level of determination based on a number of aspects, including exposure, consequence and severity; hence is the subject of some level of calculation or manipulation, either quantitatively or qualitatively! This, in effect, sees risk as the outcome of a manipulated process. Health and safety standard and guidance, and adopted universally in practice, relate more to the notion of identifying hazards, which, in its broadest sense, refers to anything that has the potential to cause harm (Boyle, 2012; Jensen, 2012). For that reason it is more appropriate to use the term hazard identification instead of risk identification, for risks cannot be identified, but hazards can.

Related to the notion of risks in the standard are the terms risk analysis and risk evaluation; each of which have a different meaning. According to ISO 31000, analysis involves a “comprehending the nature of risk to determine the level of risk” (Standards Australia, 2009, p. 5); while evaluation involves “comparing the results of risk analysis with risk criteria to determine whether the level of risk is acceptable or not” (Standards Australia, 2009, p. 6). In this respect there are two different outcomes of analysis and evaluation of risks:

- from risk analysis - an understanding of the nature and level of risk, and
- from evaluation - decision about whether level of risk is acceptable or not!

Health and safety standards and guidance, and universally adopted in practice, refer to the simpler process of 'risk assessment' which takes into account both analysis and evaluation. This is best summarised by Rausand (2011) who defines risk assessment as 'the overall process of risk analysis and risk evaluation' (p.9). Summarising these two ideas gives us the main difference into the notion of risk between ISO 31000 and health and safety risk management practice. In the latter, risk includes determining the level of risk (hence the process of risk analysis) and a decision about whether this level of risk is acceptable or not (risk evaluation); but this is based on the hazard, not risk, as suggested in the former. So the two sets of coordinated activities to support communication, consultation and establishing include:

1. hazard identification (instead of risk identification); and
2. risk assessment (which includes risk analysis and evaluation, but not risk identification).

The third difference is the notion of 'risk treatment', which the standard suggests can be achieved in the seven key ways; which Flaus (2013) summarises into four:

1. transfer;
2. terminate;
3. treat; and
4. tolerate

The use of the term treatment seeks to suggest that an adverse outcome is a normal expectation of risk management. This represents one of the key philosophical problems with this line of thinking when applied to health and safety, which has at its core the main objective of preventing harm, illness, injury or diseases; not treatment! For these reasons health and safety standards and guidance, as adopted universally in practice, refer more to risk control rather than risk treatment.

A REVISED FRAMEWORK FOR HEALTH AND SAFETY RISK MANAGEMENT

While there are other subtle and minor differences in terms of language, definitions and terminology, the ones discussed above are those will cause confusion and apprehension among those seeking to use ISO 31000 for advancing the practice of health and safety risk management. For this reason a revised framework is proposed, illustrated in Figure 1, which integrates the processes suggested in ISO 31000 and universally adopted health and safety management practice.

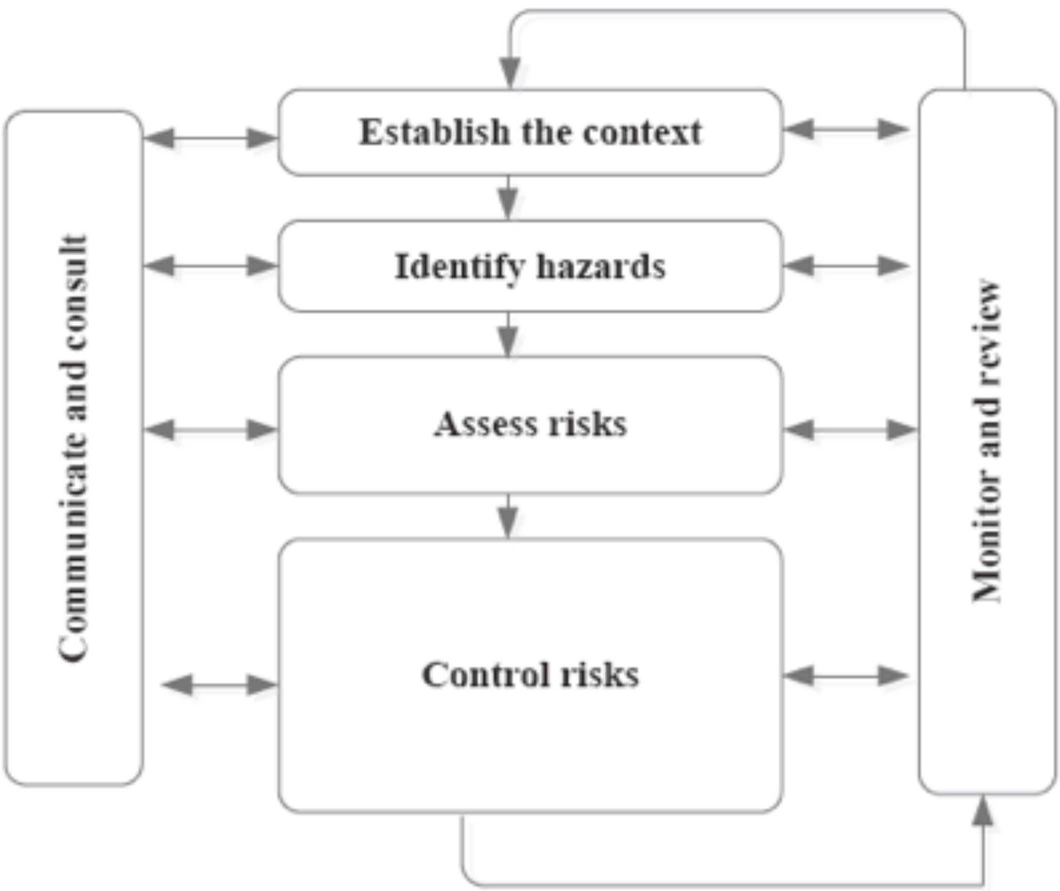

Figure 1: Proposed framework for managing construction health and safety risks

The revised framework incorporates the six key steps:

1. Communication and consultation;
2. Establishing the context
3. Identifying hazards

4. Assessing risks
5. Controlling risks; and
6. Monitoring and reviewing risks.

In suggesting the above, users can replace the process shown in Clause 5 of ISO 31000 with Figure 1 above. This will ensure some level of consistency and harmonization of the commonly used practices for managing health and safety risks, while allowing for the integration of key principles and framework proposed by ISO 31000.

CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH

ISO 31000 provides a set of eleven principles which constitute the key performance criteria against which risk management can be managed and supported with a series of integrated and coordinated activities arranged as a five step process. A review of the literature suggests little empirical research has been conducted on the actual application of ISO 31000. There are at least three fundamental differences in (1) the conceptualization and understanding of risks; (2) the actual processes management of these risks from the different domains of quality, environment and health and safety; and (3) control of risk instead of treatment. A revised framework is proposed which integrates the process of risk management suggested in ISO 31000 and the actual practice of health and safety management. In presenting the revised framework it is not suggested that the process suggested in ISO 31000 is irrelevant, in fact it is more so, because it enables users to integrate health and safety into an organisation's broader risk management strategy. What the revised framework allows for is for users to adopt and /or modify based on their needs.

It is recognised the proposed framework is theoretical in nature and is yet to be tested empirically. In this regard it serves as an invitation to researchers, academics and practitioners to explore the opportunities afforded by the revised framework to progress the vision zero agenda in construction. Future research questions which can be explored include the utility of the eleven principles of risk management for assessing health and safety performance, experiences and pitfalls in the application of the different processes for managing health and safety risks, comparative analysis of the proposed framework as applied in small and medium-sized companies, and developments in risk control and /or treatment.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of editors and the two anonymous reviewers whose comments helped refine this paper.

REFERENCES

Bhattacharjee, S., Ghosh, S., & Young-Corbett, D. (2011). Safety Improvement Approaches in Construction Industry: a Review and Future Directions. Paper presented at the 47th ASC International Conference.

Boyle, T. (2012). Health and safety: risk management (3 Ed.). Leicestershire: IOSH Services Limited

Ciocoiu, C. N., & Dobrea, R. C. (2010). The role of standardization in improving the effectiveness of integrated risk management. In G. Nota (Ed.), Advances in Risk Management (pp. 1-18): INTECH Open Access Publisher

Corina, G. & Palaneeswaran, E. (2010). Towards effective management of major hazard facilities. Paper presented at the Chemeca 2010, Adelaide, South Australia

Dali, A. & Lajtha, C. (2012). ISO 31000 Risk management - "The Gold Standard". EDPACS: The EDP Audit, Control, and Security Newsletter, 45(5), 1-8.

Flaus, J.-M. (2013). Risk analysis: socio-technical and industrial systems. London: John Wiley & Sons, Inc.

Gjedrum, D., & Peter, M. (2011). The new international standard on the practice of risk management: a comparison of ISO 31000:2009 and the COSO framework. Risk Management, March (21), 8-12

International Organization for Standardization. (2009). ISO 31000-2009. Risk management - principles and guidelines. Geneva, Switzerland: International Organization for Standardization

Jefferies, M. & McGeorge, D. (2008) Public-Private Partnerships: A Critical Review of Risk Management in Australian Social Infrastructure Projects. Journal of Construction Procurement, Special Edition: Building Across Borders, 14, (1), 66-80

Jensen, R. C. (2012). Risk-reduction methods for occupational safety and health. New Jersey: John Wiley & Sons

Leitch, M. (2010). ISO 31000: 2009-The new international standard on risk management. Risk Analysis, 30(6), 887-892

Liu, J. Y., Low, S. P., & He, X. (2011). Current practices and challenges of implementing enterprise risk management (ERM) in Chinese construction enterprises. International Journal of Construction Management, 11(4), 49-63

Luko, S. N. (2013). Risk management principles and guidelines. Quality Engineering, 25(4), 451-454

Mitchell, J. K. (1990). Human dimensions of environmental hazards: Complexity, disparity and the search for guidance. In A. Kirby (Ed.), Nothing to fear: risks and hazards in the American Society (pp. 131-175). Tucson, Arizona: University of Arizona Press

Mogalakwe, M. (2006). The use of documentary research methods in social research. African Sociological Review, 10(1), 221-230

Oehmen, J., Ben-Daya, M., Seering, W., & Al-Salamah, M. (2010). Risk management in product design: current state, conceptual model and future research. Paper presented at the ASME International Design Engineering Conference & Computers

Purdy, G. (2009). ISO 31000:2009 - Setting a new standard for risk management. Risk Analysis, 30(6), 881-886

Rausand, M. (2011). Risk assessment: theory, methods, and applications. Hoboken: John Wiley & Sons, Inc.,.

Robbins, S. P., Bergman, R., Stagg, I., & Coulter, M. (2006). Foundations of management (2nd Ed.). Frenchs Forest: Prentice Hall

Sousa, V., De-Almeida, N. M., & Dias, L. A. (2012). Risk management framework for the construction industry according to the ISO31000: 2009 standard. Journal of Risk Analysis and Crisis Response, 2(4), 261-274

Standards Australia. (2009). AS/NZS ISO 31000: 2009. Risk management: Standards Australia International

Swuste, P., Fritjers, A., & Guldenmund, F. (2012). Is it possible to influence safety in the building sector? A literature review extending from 1980 until the present. Safety Science, 50, 1333-1343

Sunindijo, R. Y., & Zou, P. X. W. (2014). An integrated framework for strategic safety management in construction and engineering. In Aulin, R and Ek, A (Eds.) Proceedings of CIB WO99 international health and safety conference, Lund, Sweden

van der Molen, et al. (2012). Interventions for Preventing Injuries in the Construction Industry (Review). Cochrane Database of Systematic Reviews

Vincent, C., Taylor-Adams, S., & Stanhope, N. (1998). Framework for analysing risk and safety in clinical medicine. British Medical Journal, 3161(7138), 1154-1157

Walters, D. (2010). The role of worker representation and consultation in managing health and safety in the construction industry: International Labour Organization.

Yaraghi, N., and Langhe, R.G. (2011) Critical Success Factors for Risk Management Systems, Journal of Risk Research, Vol.14(5), pp.551-581

A FRAMEWORK FOR ANALYSING THE DETERMINANTS OF HEALTH AND SAFETY SELF-REGULATION IN THE CONSTRUCTION INDUSTRY

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While regulating health and safety (H&S) is one of the preconditions for improving and sustaining H&S, there is substantial evidence that the Nigerian construction industry continues to suffer neglect in that regard. Nonetheless, some construction contractors self-regulate in the absence of external influences including regulation. The decision to self-regulate is determined by a number of key factors. It is, therefore, important to understand their decisions to self-regulate for effective policy making with the aim that more construction contractors will start adopting self-regulatory programs for H&S. Based on current evidence and theories from existing literature, this paper presents a proposed framework for analysing the determinants of H&S self-regulation in the Nigerian construction industry. Some elements of the framework are centred on: regulatory issues, the ability to self-regulate, normative factors, industry issues, social pressure and economic climate. It is established in this study that while there is significant hypothetical relationships among the elements of the framework, the evidence in practice may annul the hypothetical relationships.

Keywords: construction industry, factors, health and safety, Nigeria, self-regulation.

INTRODUCTION

While the significant contribution of the Nigerian construction industry to the Nigerian economy is acknowledged in various studies (Diugwu et al. 2013; Umeokafor et al 2014; Windapo & Jegede 2013), the deplorable state of the industry in terms of health and safety (H&S) is however also noted (Ajayi & Thwala 2014; Diugwu et al. 2012; Dodo 2014; Idoro 2007, 2011; Windapo & Jegede 2013). In particular, Idoro (2007) found the injury per accident rate of multinational contractors to be relatively high at 0.13 – 4.0, with a recorded mean of 0.94. Idoro (2007) also reports an injury per accident rate of 0.19 – 3.0 and a mean of 0.77 for the indigenous contractors. Additionally, Ajayi and Thwala (2014) in a study of 48 construction contractors in South-West Nigeria found the mean scores of 3.67 for management concern for safety procedures and 4.04 for feedback from site employees. These values fall within the ranges of >3.40 and ≤ 4.20 thus showing a near major/major extent of impact (Ajayi & Thwala 2014). There is dearth of H&S statistics in Nigeria (Idoro 2008), so it can be argued that this is a 'tip of the iceberg'.

There are many ways to improve the state of H&S in the construction industry. For instance, adopting advanced technology (Marks & Teizer 2013), designing to prevent hazards (Lingard et al. 2012), regulation of H&S (Umeokafor et al. 2014) to name but few. Nonetheless, the regulation of H&S is the main approach that is adopted in Nigeria (Diugwu et al. 2013). But, the current evidence indicates that the regulation of H&S in Nigeria is poor resulting in unsatisfactory standards of H&S (for example: Idoro 2008, Diugwu et al. 2012, Umeokafor et al. 2014). Diugwu et al. (2012) emphasise

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that the poor state of H&S in Nigeria is due to the dysfunctional regulatory state of H&S. The Nigerian construction industry is arguably unregulated because it is not covered by the existing Factories Act LFN 2004 (Diugwu et al. 2012; Idoro 2008), yet some construction firms especially multinationals adopt international legislation (Idoro 2011) such as Construction (Design and Management) Regulations (CDM) 2007 or 2015.

Koehn et al. (1995) note that safety should be a major concern for employers, but in Nigeria, it is believed that only a particular sector of the construction industry has employees' safety as a major concern. Typically, Windapo and Jegede (2013) note that multinational construction firms have very good systems in place for managing H&S thus have better H&S records. Some of these firms develop policies and safety programs so as to protect their reputation in these developing countries (Koehn et al. 1995) and to reap the benefits of improved H&S such as higher productivity. However, the implementation of the standards and/or legislation is at the discretion of the adopters (Idoro 2008). The premise established so far explains why scholars call for attention on H&S enforcement and H&S audit both in research and in practice (Dodo 2014).

Regulation is the process of developing or adopting and administering policies and/or standards. This includes: enforcement of policies, inspection, monitoring of the regulatory process *inter alia*. Havinga (2006) notes that regulation can be at state/public and/or private level. When at a private level it is called self-regulation. Self-regulation of H&S is the process by which organisations develop or adopt and administer policies and/or standards without external intervention or with little external intervention as a mechanism to reduce risks in the workplace. If this is the case, then many construction contractors in Nigeria probably self-regulate.

The regulatory environment of the Nigerian construction industry is unique in that H&S regulation falls into four categories of self-regulation (see the section below). Hence, compliance with legislation theories are also considered in this study.

Studies demonstrate various ways to understand self-regulation such as the social legitimacy of the law and social pressure (Giuliano & Linder 2013). This is in addition to economic or business cases made in Giuliano and Linder (2013). Winter and May (2001) also note the same for compliance with legislation adding others such as the ability to comply with the law. *Ibid* go on to explain compliance with theories such as normative motivation, calculated motivation, and social motivation. Little or no literature can be found on H&S self- regulation in developing countries.

Against the background established so far, it is vital to understand the determinants of H&S self-regulation so as to design strategies that will encourage other firms to start self-regulating. This paper presents a framework for analysing the determinants of H&S self-regulation. The framework is based on theories and evidence from literature. It is part of a research project that is aimed at understanding the determinants of self-regulation with regard to H&S in the Nigerian construction industry. In this paper, there is a review of literature that relates to the legal context of H&S in the Nigerian construction industry. This is followed by a brief discussion of the types of H&S self-regulation that arguably exist in the Nigerian construction industry. The research method is then presented followed by the framework and critical discussion.

Granted that this study is contextualised to Nigeria, other developing countries will likely find it applicable. As Kheni et al. (2010) demonstrate (by citing Ofori 1999; Hillebrandt 1999; Thomas 2002), developing countries have similar characteristics with regard to cultural environment, construction methods, regulatory approach and technology.

OVERVIEW OF REGULATION OF HEALTH AND SAFETY IN THE NIGERIAN CONSTRUCTION INDUSTRY

The Factories Act F1 LFN 2004 is the H&S legislation designed to cover workplaces in Nigeria, stipulating the minimum H&S requirements for factories. Nonetheless, the Factories Act is inadequate as several studies demonstrate (for example Diugwu et al. 2012; Idoro 2008; Umeokafor et al. 2014).

Among the significant flaws of the Factories Act is the exclusion of construction sites and activities in the definition of its premises (Diugwu et al. 2012; Idoro 2008). As a result, it is argued that the construction industry is not covered by any local legislation thus unregulated by the H&S custodian in Nigeria (Idoro 2008).

However, the views below demonstrate that H&S laws or standards or instruments through one way or the other arguably cover the Nigerian construction industry. For instance, paragraph 1 article 16 of the ILO standard (Occupational Safety and Health Convention, 1981 NO 155) which Nigeria has ratified states that all employers should make sure that the workplaces, equipment, machinery and work processes that they control are safe, with no risk to health. This is as far as it is reasonably practicable (Occupational Safety and Health Convention, 1981 NO 155). Similarly, paragraph 3 article 16 of the aforesaid ILO convention also requires employers to take proactive steps to protect their employees. Therefore, this ILO standard is binding on Nigeria, as it has ratified it. However, due to the dualist legal system of Nigeria, '…*International instruments do not have the force of law in Nigeria until such instruments are specifically incorporated into Nigerian law* (through legislative process)' (Okene 2009 p 30).

Nonetheless, authors such as Okene (2009) demonstrate that irrespective of the fact that the legal system of Nigeria is dualist, the courts in Nigeria can indirectly apply international instruments such as the Occupational Safety and Health Convention, 1981 NO 155). This can be on the grounds that it can aid the interpretation of the local laws or used for reference purposes by the courts (Okene 2009). It may also be on the grounds that it can make up for the anomalies of the local laws (ILO 2009) such as the Factories Act 2004, which excludes the construction industry in the definition of its premises. Okene (2009) offers a treatise on applying international legal instruments in Nigerian local law system.

On the grounds established above, it can be argued that the Nigerian construction industry is indirectly covered by Occupational Safety and Health Convention, 1981 NO 155. However, the extent to which the ILO standard is recognised and implemented may be low. After all, the local legislation, the Factories Act is yet to be adequately implemented and enforced.

Another way that H&S laws arguably cover the Nigerian construction industry is through adopted laws or corporate policies. For instance, some of the H&S policies and pieces of legislation that are adopted from the other countries by construction contractors and H&S corporate policies from the parent companies of multinational companies also cover the firms.

Nonetheless, both sides of the arguments above form the basis of this study. This is on the grounds that in Nigeria, H&S self-regulation can be argued to exist in the main variations thus:

> Industry self-regulation: this is a process whereby members of the industry or trade association and/or professional organisations design or develop standards and administer them so as to control the activities of its members (Hutter 2006; King & Lenox 2000). This obtains in some parts of Nigeria like the oil producing states where members of the industry set the H&S requirements. It is also possible to describe this as client led self-regulation, as clients can specify the H&S standards for its contractors in the industry. This alternatively can be viewed as a form of self-regulation.
>
> Pure self-regulation: this is where organisations will voluntarily develop or adopt standards and administer them (Gunningham 2011). If this is the case, then based on the comments of scholars such as Diugwu et al. (2012) and Idoro (2008), it can be argued that pure self-regulation may also obtain in Nigeria. Diugwu et al. (2012) and Idoro (2008) note that the Factories Act 2004 does not cover the construction industry. As a result, some construction organisations voluntarily adopt H&S standards and/or laws from developed countries and implement them (Idoro 2008).

However, there are construction companies that it is part of their company policy to self-regulate or that are bound by H&S legislation from outside Nigeria to self-regulate. These can be viewed as enforced self-regulation (Ayers & Braithwaite; Hutter 2001). Similarly, it is possible that some firms may comply with the requirements of the ILO convention afore-discussed because of their international reputation or standards, thus they are forced to self-regulate by the law. These are compliance with H&S laws, therefore, enforced H&S self-regulation. Enforced self-regulation can come at industry or state levels.

In view of the above, this study adopts a broad depiction for self-regulation covering the four categories above.

RESEARCH APPROACH

As enforced self-regulation is compliance with legislation, the literature on compliance with legislation was reviewed. Thus, the theories (such as calculated motivation theory) that explain compliance with legislation were therefore partly used in developing the framework. Also, as the subject broadly covers self-regulation at both industry and voluntary levels, the literature germane to determinants of self-regulation was reviewed and theories explaining the determinants were also included in developing the framework. Then evidence from literature that supports the theories was also used in developing the framework. It is important to note that some compliance theories are consistent with some self-regulation theories. Having done the above, it was observed that based on the researcher's opinion and further literature review, some elements of the framework that explain self-regulation in the Nigerian context such as power relationship case had emerged. Again, these were supported by evidence from literature.

Developing frameworks based on theories and evidence is consistent with studies not limited to Giuliano and Linder (2013), Nielsen (2003) and Lynes and Andrachuk (2008). The frameworks that these studies present with regard to self-regulation, and compliance with legislation alongside Peterson and Diss-Torrance (2012) and Winter and May (2001) have informed the development of the framework that this paper presents.

As developing the framework was based on a qualitative paradigm (i.e. literature review and researcher's opinions), its reliability and validity may be questioned. Consequently, it was sent to two H&S experts and one construction expert for validation. On receipt of their comments, the framework was revised. It is also thought that as Manu (2012) demonstrates, the peer-review process that this paper has gone through provides an acceptable level of academic validation for the framework. It is possible that non-professional views from the Nigerian construction industry will provide further insight to the discourse. Nevertheless, the experiences of the experts consulted have developed over the years thus can be supportive (cf. Manu 2012).

DEVELOPMENT OF THE ANALYTICAL FRAMEWORK

The analytical design

Fig. 1 shows that the determinants of self-regulation are interrelated (Giuliano & Linder 2013; Winter & May 2001) or not independent (Gonzalez-Benito & Gonzalez-Benito 2005). The arguments of the hypothetical relationship among factors of compliance by Nielsen (2003) can be repeated here. However, the evidence in practice that is presented in this paper may annul the hypothetical positions. In particular, it is possible that the market that construction contractors operate in will determine transaction cost (see industry case), providing more funds or reducing the funds available for H&S. This will in turn determine construction contractors' ability to self-regulate (see Fig. 1). Going by the argument of reducing the cost allocated to H&S, the evidence that construction contractors self-regulate because they understand the economic benefits of H&S self-regulation may annul the hypothetical relationship. Analogously, if the regulatory environment or legislation is complex (regulatory case), the ability of the construction contractors to self-regulate can be affected. Again, this can be annulled by the premise that under the H&S regulatory environment of Nigeria, construction contractors can adopt clear standards from other countries. Other hypothetical relationships or interrelationships are in Fig. 1.

Contextual influence

Construction contractors in Nigeria are susceptible to the contextual environment of Nigeria just like other countries (cf. Kheni et al. 2010). Therefore, contextual factors such as religion, culture, and political influence due to the contextual environment (Fig. 1) influence them. These factors also influence the elements of the framework (Fig. 1). For instance, the Nigerian construction industry is not covered my any local H&S law (Diugwu et al. 2012, Idoro 2008), so the likelihood that construction contractors in Nigeria will not be prosecuted is high, and this is well known to them. This impacts on the economic case (see economic case below). It also impacts on regulatory case in that there will be no regulatory activities to drive and/or encourage self-regulation in terms of H&S (see regulatory case below). In terms of the ability to self-regulate, the H&S legislation of Nigeria is inadequate and the adopted ones may not be practicable (Aniekwu 2007). This may hinder the ability of the regulated to self-regulate.

Economic case

The argument that construction contractors in Nigeria will self-regulate in terms of H&S stems from deterrence theory (Ayres & Braithwaite 1992) or calculated motivation theory (Peterson & Diss-Torrance 2012;Winter & May 2001) (also see Giuliano and Linder 2013). Construction contractors weigh the benefit of self-regulation, the cost of self-regulation and the likelihood that they will be apprehended in Nigeria and decide if they will self-regulate. This means that they will self-regulate so as to save cost or to get more clients (Giuliano & Linder 2013). Giuliano and Linder (2013) also present this as business case in their framework for explaining self-regulation. Giuliano and Linder (2013) is indicative of pure-self-regulation, but can also be viewed as industry self-regulation, as it shows little elements of state involvement.

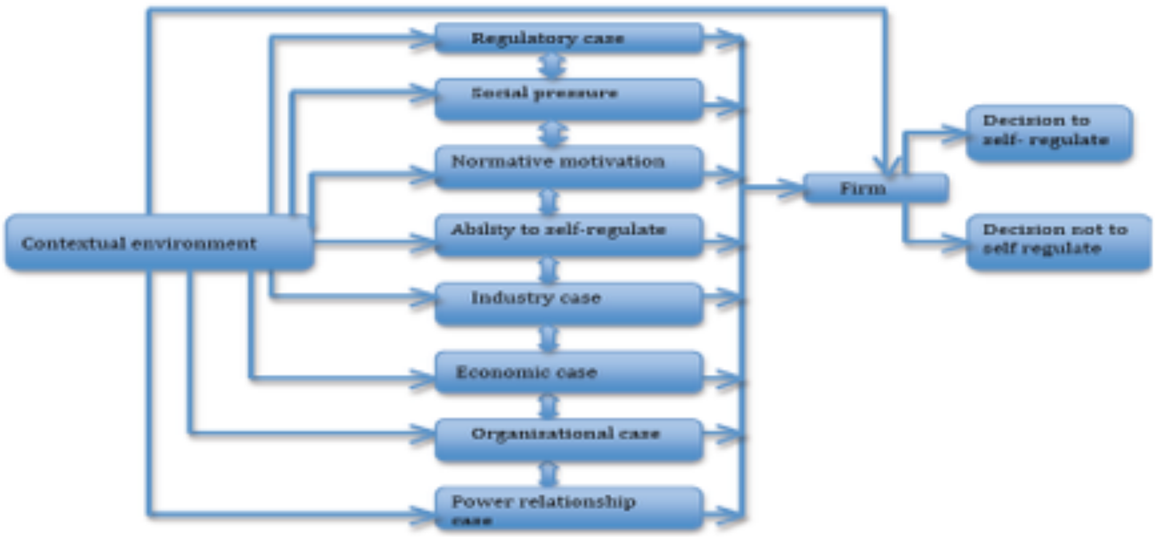

Fig. 1: A proposed framework for analysing the determinants H&S self-regulation.

Levinson (1987) also makes economic arguments for H&S self-regulation. Under this theory, factors such as self-regulation because of fear of punitive measures, self-regulation because of increased profit or productivity fall into this element of the framework. The argument by Nielsen and Mathiesen (2003) supports the discourse in that these economic factors determine compliance with legislation.

However, it is possible that the economic case may not hold in all cases. Cashore et al. (2005) found that economic or market factors do not determine the self-regulatory programs that some firms will adopt. This may be because of the environmental benefits of the programs thus suggesting moral values.

Normative motivation

This stems from Peterson and Diss-Torrance (2012) and Winter and May (2001). It is similar to altruism (Giuliano & Linder 2013) and the sense-making theory (Ancona 2012) of compliance with legislation. The regulated will consider how appropriate the legislation is and its moral standard and then decide whether to comply or not (Winter & May 2001). This also means that construction contractors will self-regulate if they believe that it is the right thing to do (cf. Giuliano & Linder 2013) or because they perceive the legislation as legitimate. This premise is consistent with Cashore et al. (2005), King and Lenox (2003), Nielsen (2003), and Nielsen and Mathiesen (2003).

With regard to the Nigerian construction contractors, if the argument that enforced self-regulation obtains holds, the regulated may perceive the adopted legislation as legitimate thus will self-regulate. This suggests that management perception is core in this regard. Levinson (1987) demonstrates the role of management commitment in H&S self-regulation. Also, if the argument that pure self-regulation obtains in Nigeria holds, the regulated knowing the benefits of self-regulation such as low accident rate may consider it moral to self-regulate. This highlights the role of the moral position of the organisations in determining H&S self-regulation. This may in turn become a norm in the organisation. Christmann and Taylor (2001) discuss the role of norm in self-regulation in detail.

Social pressure

The impact of accidents on the society can prompt the following: pressure from public interest groups, legal actions, and negative publicity. These actions from external bodies will determine if organisations will self-regulate (Giuliano & Linder 2013). Just as this can make organisations comply with legislation, it can also encourage them to self-regulate (Cashore et al. 2005). According to Peterson and Diss-Torrance (2012) and Winter and May (2001), organisations will comply with legislation to gain recognition with society or other stakeholders they interact with. The same can be said of pure self-regulation or self-regulation with little industry involvement (Giuliano & Linder 2013). Winter and May (2001) and Nielsen (2003) depict this as social motivation. King and Lenox (2000) discuss this from an industry self-regulatory perspective noting that the image of organisations with poor safety records can be the target. Social pressure can also come from competing firms (suggesting industry case), and the media. Levinson (1987) also demonstrates the impact of unionisation on self-regulation in terms of H&S.

Ability to self-regulate

In the context of this study, this can occur when the construction contractors wish to self-regulate in terms of H&S but are unable to. This can be due to lack of finance, inadequate legislation, complex legislation, and lack of proper knowledge of the legislation (Winter & May 2001). In particular, the uncontextualised H&S legislation in Nigeria is impracticable (Aniekwu 2007); this may discourage construction contractors or limit the extent they self-regulate. Correspondingly, Nielsen (2003) and Winter and May (2001) demonstrate this element in the context of compliance with legislation. Typically, Nielsen (2003) suggests that management and transaction cost can determine the ability to self-regulate in terms of H&S. Laeeque et al. (2006) also support this premise in that the ability to comply is a major motivator for large firms because they mostly have the resources. The ability of construction contractors in Nigeria to self-regulate in terms of H&S can also be determined by level of innovation and level of education as Christmann and Taylor (2001) suggest.

Regulatory case

The nature of legislation, the level of involvement of construction contractors in the regulatory process (which is determined by the category of regulation), the level of external involvement can determine if an organisation will self-regulate. Therefore, the higher the level of external involvement, the more likely it is that the regulated will not self-regulate. When organisations feel that they are involved in the regulatory process, they may feel that their interests are covered. In industry self-regulation, the firms can also develop the regulatory systems knowing how to get other firms to self-regulate.

Giuliano and Linder (2013) present the threat of regulation case covering the efforts of the regulator, the legislative proposals and political discourse. As per regulatory efforts, scholars argue that regulatory activities can make organisations self-regulate (Giuliano & Linder 2013) or comply with legislation (Nielsen 2003), but Wu (2009) finds little evidence that regulatory pressure can contribute to over-compliance under certain conditions. It is therefore suggested that the impact of regulatory efforts on H&S self-regulation on Nigerian construction contractors may be limited.

The main arguments on the impact of international regulatory environments on firms in developing countries are made by Christmann and Taylor (2001). They note that firms in developing countries may self-regulate, as they may fear that selling their products in the international market may be challenging. This is because the international market may have standards that will require them to self-regulate. Therefore, in the context of this study, the national market and even the international market should be attractive enough to indigenous construction contractors so as to get them to self-regulate. This also indicates the positive impact of globalisation on self-regulation (Christmann & Taylor 2001).

Industry case

This is another significant explanation for H&S self-regulation in Nigeria. It is noted in studies that construction contractors in the oil and gas sector of Nigeria have good H&S records (Windapo & Jegede 2013) (also see Okojie 2010). The standards that these oil and gas companies (who mostly have foreign corporate policies) set regulate the industry. They have stringent requirements for all contractors.

On a different point, this element of the framework also covers the activities in the market or industry that the construction contractors operate in. Typically, there can also be competitive pressure in the market, and pressure from larger firms, making construction contractors to self-regulate. Also, high level of risks in the operations of industries, as can be seen in the oil and gas sector of Nigeria, may make them to self-regulate. It is also possible that some contractors will self-regulate because others are self-regulating. Gonzalez-Benito and Gonzalez-Benito (2005) pen the influence of industrial sector on environmental proactivity, which can be pure self-regulation.

Additionally, it is also possible that the influence of construction supply chain can contribute to H&S self-regulation as clients or designers can influence self-regulatory decisions. Clients can make H&S mandatory. Also, the perceptions in the industry accounts for the decision to self-regulate. For instance, in the Nigerian construction industry, H&S is viewed as exclusively for large firms or for contractors in the oil and gas sector.

Organisational case

This relates to the internal factors in the organisation in terms of decision-making. This can be where construction contractors self-regulate because of their corporate culture. Corporate culture can be determined by the structure of ownership. For multinationals, this is a combination of Nigerians and foreigners thus a mixture of cultures. For indigenous firms, this is fully of Nigerian culture. In this cases, the organisation will consider its corporate culture, the contextual environment of Nigeria and decide to self-regulate or the extent of self-regulation. This may explain why evidence from the literature suggests that multinationals self-regulate in terms of H&S (Okojie 2010; Windapo & Jegede 2013).

Power relationship case

This relates to the ability of a group in the society to influence or control others. Firstly, those that are regulated in Nigeria will consider the level of their power relationship in the society and decide whether to self-regulate or not. Specifically, powerful people in the higher echelon of the society, politicians or their friends own most of these construction firms (Okojie 2010). Thus, they are able to largely resist any opposition in the country. They are also able to influence regulatory authorities as

Okojie (2010) reports. Worse still, evidence suggests that their ability to secure contracts may not necessarily be affected by their H&S record. Conversely, although rare, it is possible that they will self-regulate to protect their status in the society.

Secondly, the power of influence can also come in the form of financial power. If the level of the power relationship of the regulated is low, they may resort to financial power. It is possible that some construction contractors engage in corrupt practices such as bribery, to influence or resist oppositions. Umeokafor et al. (2014) discuss bribery and corruption in the Nigerian construction industry.

CONCLUDING REMARKS AND THOUGHTS

A proposed framework for analysing the determinants of H&S self-regulation in the Nigerian construction industry is presented in this paper. Some elements of the proposed framework include: regulatory case, power relationship, organisational case, normative case, and the ability to self-regulate. Also, it is demonstrated that contextual influence may impact on the entire framework. The insight that this study provides has implications not limited to understanding the decision-making processes of firms to self-regulate in terms of H&S. It also provides insight into analysing and understanding the H&S regulatory environment of Nigeria and policymaking. While this proposed framework may be designed for the Nigerian construction industry, it can also be helpful to other developing countries because they have similar characteristics. Also, the framework is not restricted to the construction industry or H&S, as self-regulation extends to other industries and other socio-legal areas. While the research approach of this study may be argued to present subjective views, with potential bias, the framework validation process offers some level of confidence. However, further studies can validate the framework through focus group discussions or surveys.

REFERENCES

Ajayi, O and Thwala, W D (2014) Assessment of the impact of musculoskeletal disorders on Nigerian construction workers. In: Kum, R K, Nani G, Atepor, L. Oppong, R A, Awere E and Bamfo-Agyei E (Eds) ‘Procs 3rd Applied Research Conference in Africa. (ARCA) Conference’ 7- 9 August 2014, Accra, Ghana.

Ancona, D (2012) Sensemaking: Framing and acting in the unknown. In Snook. S, Noriah, N and Khurana, R (eds) ‘The Handbook for teaching leadership: Knowing, Doing and Being’. London: Sage Publication.

Aniekwu, N (2007) Accidents and safety violations in the Nigerian construction industry, ‘Journal of Science and Technology’, 27 (1) 81 – 89

Ayres, I and Braithwaite, J (1992) ‘Responsive regulation: Transcending the deregulation debate’. New York: Oxford University Press.

Cashore, B, van Kooten, G C, Vertinsky, I, Auld, G and Affolderbach, J (2005) Private or self-regulation? A comparative study of forest certification choices in Canada, the United States and Germany. ‘Forest Policy and Economics’, 7, 53-69.

Christmann, P and Taylor, G (2001) Globalization and the environment: determinants of firm self-regulation in China. ‘Journal Of International Business Studies’, 32(3), 439 - 458.

Diugwu, I A, Baba, D L, and Bima, A M, (2013) Research and legal underpinnings of the quantity surveyor as a health and safety manager’, in Ibrahim, A. D., Adogbo, K J, and Ibrahim, Y M (eds), ‘1st Annual Research Conference (AnReCon)’, 3 - 5 September, Abuja, Nigeria. The Nigerian Institute of Quantity Surveyors, 243 - 252.

Diugwu, I A, Baba, D L, and Egila, A E (2012) Effective regulation and level of awareness: An expose of the Nigeria’s construction industry. ‘Open Journal of Safety Science and Technology’, 2,140-146.

Dodo, M (2014) The application of health and safety plan in Nigeria construction firms, 'Jordan Journal of Civil Engineering, 8(1) 81 – 87.

Giuliano, G and Linder, A (2013) Motivations for self-regulation: The clean air action plan, 'Energy Policy' 59, 513 – 522.

Gonzalez-Benito, J and Gonzalez-Benito, O (2005) A review of factors of environmental proactivity. 'Business Strategy and the Environment', 15, 87- 102.

Gunningham, N (2011) Investigation of industry self-regulation in workplace health and safety in New Zealand. Gunningham & Associates Pty Ltd. Retrieved on 12-09-14 from http://www.dol.govt.nz/whss/resources/investigation-industry-self-regulation-whss-nz.pdf

Havinga, T (2006) Private regulation of food and safety by supermarkets. 'Law and Policy', 28 (4), 516- 533.

Hutter, B (2001) Is enforced self-regulation a form of risk taking?: The case of railway health and safety '*International Journal of the Sociology of Law*', 29 (4), 379 - 400.

Hutter, B (2006) 'The role of non-state actors in regulation'. Centre for analysis of risks and regulation, London school of Economics and political science, London, UK.

Idoro, G I (2007) A comparative evaluation of health and safety performance of indigenous and multinational construction firms in Nigeria. 'Construction Research Journal', 1(1), 65-75.

Idoro, G I (2008) Health and safety management efforts as correlates of performance in the Nigerian construction industry. 'Journal of Civil Engineering and Management', 14(4) 277 - 285.

Idoro G I (2011) Comparing occupational heath and safety (OHS) management efforts and performance of Nigerian construction contractors. 'Journal of Construction in Developing Countries', 16 (2), 151 – 173.

International Labour Organisation (ILO) C155 - Occupational Safety and Health Convention, 1981 (No. 155). Retrieved from http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C155

International Labour Standard (ILO) (2009) Rules of the Game: An introduction to internal labour standards. Retrieved from http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---normes/documents/publication/wcms_108393.pdf

Kheni, N A, Gibb, A G F and Dainty, A R J (2010) The health and safety management within small- and medium-sized enterprise (SMEs) in developing countries: Study of contextual influence. 'Journal of Construction Engineering and Management', 136(10), 1104 – 1115.

King, A A, and Lenox, M J, (2000). Industry self-regulation without sanctions: The chemical industry's responsible care program. 'Academic of Management Journal', 43(4), 698 -716.

Koehn, E, Kothari, R K, and Pan, C (1995) Safety in developing countries: professional and bureaucratic problems, 'Journal of Construction Engineering and Management', 121 (3), 261 – 265.

Laeeque, H, Boon, H, Kachan, N, Cohen, J. C, and D'Cruz, J (2006) The Canadian natural health products (NHP) regulations: Industry compliance motivations. 'Advances Access Publication', 4 (2), 257- 262.

Levinson (1987) Self-regulation and health and safety.'Employee Relations', 9(4), 3-8

Lingard, H C, Cooke, T, and Blismas, N (2012) Designing for construction worker's occupational health and safety: A case study of social-material complexity. 'Construction Management and Economics', 30(5), 367- 382.

Lynes, J K and Andrachuk, M (2008) Motivations for corporate social and environmental responsibility: A case study of Scandinavian airlines 'Journal of International Management' 14 (4), 377-390.

Marks, E D and Teizer, J (2013) Method for testing proximity detection and alert technology for safe construction equipment operation, 'Construction Management and Economics', 31(6), 636 – 646.

Manu, P (2012) 'An investigation into the accident causal influence of construction project features', A Doctoral thesis University of Wolverhampton. Retrieved from http://wlv.openrepository.com/wlv/bitstream/2436/265178/1/Ackon%20Manu%20PhD%20thesis.pdf

Nielsen, J R (2003) An analytical framework for studying: compliance and legitimacy in fisheries management. 'Marine Policy' 27(5), 425- 435.

Nielsen, J R and Mathiesen, C (2003) Important factors influencing rule compliance in fisheries lessons from Denmark. 'Marine Policy', 27, 409-416.

Okene, O V C (2009) Brining rights home: The status of internal legal instruments in Nigerian domestic law. Journal of Law, Practice and Procedure, 1(4,) 12 -31

Okojie, O (2010) System for reporting occupational diseases in Nigeria. African Newsletter on Occupational Health and Safety, 20(3), 51-53.

Peterson, K and Diss-Torrance, A (2012) Motivation for compliance with environmental regulations related to forest health. 'Journal of Environmental Management',112, 104-119.

Umeokafor, N, Umeadi, B, and Isaac, D (2014) Determinants of compliance with health and safety regulations in Nigeria's construction industry. 'Journal of Construction Project Management and Innovation', 4(S1) 882- 899.

Windapo, A O and Jegede, O P (2013) A study of heath, safety and environment (HSE) practices of Nigerian construction companies. 'The Professional Builder', 4 (1), 92- 103.

Wu, J (2009) Environmental Compliance: The good, the bad, and the super green. 'Journal of Environmental Management' 90, 3363 - 3381.

UNDERSTANDING THE REGULATORY ACTIVITIES OF THE HEALTH AND SAFETY REGULATOR IN NIGERIA

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The lack of health and safety (H&S) regulation in Nigeria is one of the main factors blamed for the challenging state of H&S in Nigeria. This highlights the activities of the custodian of H&S, the Nigerian Federal Ministry of Labour and Productivity Inspectorate Division (LPID). This study examined the regulatory activities of LPID and developed a content framework of recommendations for improving the regulation of H&S in Nigeria. The work includes a review of literature and analysis of documents collected from the LPID in addition to interviewing 14 members of staff of LPID. The results reveal that the regulatory activities of LPID are based on deterrence theory. These activities such as the accident reporting and post-accident investigation procedures, proactive measures are evidenced as poor, adducing the position of the critics of LPID. Albeit, factors such as logistics, political influence, and inadequate legislation may hinder the regulatory activities of LPID, LPID can do more to improve the regulatory activities. It is thus recommended that while LPID sparingly engages in negative publicity as a means of reputation management, positive publicity strategies are worth adopting.

Keywords: health and safety, Nigeria, regulatory activities.

INTRODUCTION

Although it is axiomatic that health and safety (H&S) in Nigeria is poor, evidence from the literature shows that conditions are not improving (for example see: Ezenwa 2001; Okokon et al. 2014; Umeokafor et al. 2014a). Typically, Umeokafor et al. (2014a) report that 49.5% of the 93 reported injuries during 2002 – 2012 (11 years) were fatal. This shows an increase over time, as an earlier study (Ezenwa 2001) reports that 2.2% of the 3189 injuries reported from 1987 to 1996 were fatal. Analogously, in a case study that covers a period of 12 months, Okokon et al. (2014) also report a Crude Incident Rate (CIR) of 163.4 injuries per 1000 workers with regard to work-related traumatic injuries.

Adequate regulation is pertinent in improving H&S. Sadly, the dilapidating state of H&S in the country is blamed on inadequate regulation (Idubor & Oisamoje 2013), throwing the spotlight on the activities of the Federal Ministry of Labour and Productivity Inspectorate Division (LPID) the custodian of H&S in Nigeria and perhaps its regulatory approach. In particular, much of the regulation of H&S in Nigeria as suggested by literature is based on the deterrence approach, specifically command and control (Factories Act 2004; Umeokafor et al. 2014a), but enforcement, which is a core aspect of command and control, is demonstrated as poor in studies (Umeokafor et al. 2014a).

In response, evidence from the literature suggests that LPID acknowledges its inability to perform as expected (Akpan 2013). However, LPID blames inadequate legislation, political influence, restricted number of employees and the existing H&S regulatory approach in Nigeria as defining factors

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responsible for the poor performance of H&S and LPID in Nigeria (Akpan 2013; Umeokafor et al. 2014b). It is vital to note that the deterrence regulatory strategy (which LPID adopts) is criticised in studies (Ayres & Braithwaite 1992; Aalders &Willthagen 1997) for its downsides, which has prompted a move to other regulatory approaches (Hutter & Amodu 2008). It is asked at this point if the regulatory activities of the LPID, the regulatory approach or the contextual factors account(s) for the dilapidating state of H&S in Nigeria. It is, however, possible that all above or two account for the dilapidating state of H&S in Nigeria.

To advance this study, it is thought that as the problems relating to improving H&S in Nigeria are arguably complex, it is therefore naive to solely blame the regulator. Therefore, investigating the activities of LPID is coherent and can be a starting point. After all, views hold that efforts towards improving H&S in Nigeria are mainly based on regulation (Diugwu et al. 2013), and this is evidenced as poor. It is also thought that understanding the regulatory process of LPID will also involve examining its regulatory approach, and this may also highlight the contextual influences. This will then inform the development of a framework of recommendations for improving the regulation of H&S at the public entity level, which this study also seeks to do.

THEORETICAL FOUNDATION

The regulation of H&S is the process of developing or adopting and administering policies and/or standards that are based on ensuring the safety, health and welfare of people at work or those that will be directly or indirectly affected by workplace activities. Regulation can be at the state/public or private level. This paper focuses on state/public regulation.

Regulatory activities

Literature shows that regulation can be based on activities not limited to: setting and/or developing policies or standards, monitoring of regulatory process (Garcia Martinez et al. 2007), and enforcement of regulatory policies and/or standards (Winter & May 2001). There can also be reputation management, which involves the naming and shaming of organisations with poor H&S records (Fairman & Yapp 2005; Garcia Martinez et al. 2007) or promoting the image of organisations with good H&S records (Diugwu 2008). These can be done via social media such as Facebook. Regulation can also involve: providing information and educating the regulated (Fairman & Yapp 2005; Hutter & Amodu 2008). Again, the use of social media can be adopted at this stage. Inspections to ensure compliance (Fairman & Yapp 2005), targeted enforcement where resources are focused on repeated offenders (Hutter & Amodu 2008) and negotiation (Fairman & Yapp 2005) are also regulatory activities.

Deterrence theory

Regulation can be centred on theories such as deterrence theory, specifically command and control. According to Akers (1990) deterrence theory '… assumes that human actions are based on "rational" decisions - that is, they are informed by the probable consequences of that action' (p 654). Therefore, under this theory, crimes can be prevented if the zeal to commit a crime is counterbalanced by the consequences such as punishment (Akers 1990). This is of course given that offenders are rational actors (Akers 1990). Hence, this depends on: people making logical decisions prior to committing a crime; the severity of the punishment; people knowing the likelihood that they will be caught.

However, the perceived reward for committing a crime may exceed the assumed punishment thus the zeal to commit a crime may be sustained. So it is possible to argue that deterrence theory is about risk versus reward.

Basically, deterrence theory is based on preventing people from committing crimes with the use of punitive measures or threats.

Given the above premise, deterrence theory is advanced in the context of this study. Deterrence theory assumes that firms comply with legislation if the probability of being apprehended (p) and the cost of being caught (*D*) exceed the benefits of non-compliance (*U*): $U < PD$ (Fairman & Yapp 2005; Tombs & Whyte 2013). This usually entails adopting measures such as command and control (Tombs & Whyte 2013), involving fines and sanctions.

Consequently, deterrence theory implies that the regulated will comply with H&S laws for fear of sanctions or threats. Also, it assumes that sanctions will make offenders less likely to reoffend. Thus, the punitive damage for violating H&S law should be severe enough to dissuade the regulated from violating the law or from reoffending. Further, deterrence theory also implies that to achieve compliance, the likelihood of the regulated being caught should be high; thus, the regulated does not have a perfect knowledge of being caught or not (Tom & Whyte 2013). But, this puts both financial and resources burden on the regulator. Deterrence theory also assumes that compliance is a rational behaviour (Fairman & Yapp 2005); thus, the regulated is a rational actor. However, in reality the above may not always the case.

For example, in Nigeria, fines for breaching H&S legislation are as low as 1000 Naira (equivalent to US $5) (Factories Act 2004). Also, the likelihood of offenders being caught is low because the regulation of H&S is inadequate. Even if the regulated is caught, the likelihood of being prosecuted by LPID is low because of corruption and a dysfunctional legal system. Therefore, the regulated have a perfect image of the risk, believing that the reward for non-compliance outweighs the risk. As a consequence, under deterrence theory, the regulated in Nigeria will not comply with the law.

The debate on deterrence-based regulatory strategies

Regulatory strategies based solely on the deterrence theory have been criticised for reasons not limited to the following. First, deterrence strategy (command and control) sees the regulatory business as a two-party affair in that the regulatory agency and the firm are the only determinants to compliance (see Ayres & Braithwaite 1992). However, Ayres & Braithwaite (1992) argue that there are prosecutors and committee of legislators in the camp of the regulatory authority; and the industry, employees and trade unions on the side of the firm. Thus, it is an over- simplification to consider only the firm and the regulatory agency (Ayres & Braithwaite 1992). Second, deterrence-based strategies can be costly (Ayres and Braithwaite 1992). Third, it is also not consistent with current practices, and it is a barrier to innovation (Aalders & Willthagen 1997). Consequently, there has been a move away from command and control to more flexible and tolerant regulatory approaches (Aalders & Willthagen 1997; Hutter & Amodu 2008).

In contrast, studies such as Tombs and Whyte (2013) and Baldwin and Black (2007) contend the above points against deterrence-based strategies. In particular, Tombs and Whyte (2013) believe that the move away is underpinned by political motives. They maintain that the move away is pseudo as scholars still appreciate deterrence-based strategies (Tombs & Whyte 2013).

Regulation of health and safety in Nigeria

LPID is empowered by the Factories Act F1 LFN 2004 (the H&S legislation in Nigeria) to oversee H&S in Nigeria. A review of the Factories Act 2004 shows that the regulation of H&S in Nigeria is based on state regulation, which is centred on deterrence theory.

The background established so far may justify or evidence why authors (Idubor & Osiamoje, 2013; Umeokafor et al. 2014a) blame LPID for the poor regulation of H&S in Nigeria. However, views from authors arguably contend the aforesaid, thus tending to exonerate the LPID from criticisms and putting the blame on contextual factors or the H&S regulatory strategy in Nigeria. To explain, whereas the regulatory approach of LPID (which is deterrence-based) is usually costly, resource intensive and needs punitive laws to achieve compliance, studies note that the LPID is hindered by factors such as lack of funds, low person power (Akpan 2013; Idubor & Osiamoje 2013), dysfunctional legal system, and inadequate legislation. It is then asked at this point: is it the LPID or its regulatory system, which is determined by the Factories Act (thus beyond the powers of LPID) or contextual factors that is to be blamed for the poor regulation of H&S in Nigeria?

METHODS

Documentary information obtained from LPID (e.g., accident reports and enforcement reports from 2002 to 2012, intervention policies) was reviewed. This was followed by face-to-face semi-structured interviews of fourteen staff of LPID through purposeful sampling. The sampling covered employees with over two years experience, as it is believed that they will provide substantial information. As at early 2014, only forty-nine employees of LPID had the required number of years of experience (cf. Akpan 2013; Okojie 2010). The saturation point was attained prior to interviewing the eleventh interviewee. This is consistent with Guest et al. (2006) who found that the saturation point could be reached on interviewing the first twelve respondents. The interviewees represent the three levels in the ministry thus: top management, factory inspectors, and controller/administrators. The themes for the interviews emerged from the literature and document review and were piloted on three H&S inspectors. The themes formed the interview guide and are presented below. The interview guide of this study was in two parts thus: part one covered the personal information of the respondents; part two examined the regulatory activities of LPID. The result of the document analysis and interviews are presented in narratives and quotations below.

RESULTS

Regulatory foundation

The document review showed that the regulation of H&S in Nigeria is mostly based on command and control approach (inspection to be precise). Document review also showed that the LPID relies mostly on accident reporting as a driver for inspection in this regulatory approach, thus reactive intervention. However, while evidence from the interviews supports the aforesaid, there is also contradicting evidence. For instance, one of the respondents stated:

> '*The regulatory framework deals with the formulation of a national policy of H&S … the legislative acts (the Factory Act), which is incurred through a legislative process for acceptability hence popular compliance is expected. Thereafter, we have regulations* (i.e. product of an Act) *and codes of practice. Regulations* (i.e. product of an Act) *will explain the intent of the act. And then by ILO advice or standard or expectation, the factory inspector is supposed to be a consultant that is why we in the Ministry of Labour talk about administration of the law essentially rather than enforcement. Administration goes beyond enforcement'*. Also, '*The minister is given the power to make regulations* (i.e. product of an Act) *and they are supposed to assist in making the intents of the acts to be easily implementable'*.

Accident reporting, investigation and post-investigation actions

Accident reporting

From the documents reviewed, it is evident that the LPID has offices in all the 36 states of Nigeria and all accidents are reported to the Director of LPID who then decides on the next course of action. Furthermore, from the documents reviewed, it is revealed that the LPID has procedures in place for accident reporting, but these may not be robust. However, some external bodies that work with the LPID can hinder their services. For instance, there is a record of a case where the police produced the autopsy report of a victim six months after the accident. This does not help LPID in its activities.

Accident investigation

The documents reviewed also showed that while some of the accidents reported to the LPID were investigated within 24 hours, some were investigated up to five months after reporting. In a particular case, the investigation was conducted after the case was published in the newspaper, which was three months after the incident. Of course, the investigation will be based on the little evidence left (that is if any is left).

Further, the process of investigation is mostly based on interviewing which appears to be robust. However, there were cases where forensic examination may have been adequate, but no records have been found.

Post-accident investigation actions

In terms of post-accident investigation actions, having noted that all accidents in Nigeria are reported to the Director of LPID who decides on what next to do, it vital to note that only the Director can authorise the issuance of prohibition notices - closing down premises. The interviews even elaborate that closing down premises takes longer, starting from sending cautionary letters until it gets to the last stage of closing down. In particular, one of the respondents stated that:

> '*Enforcement is done after education of stakeholders, assisting and supporting them to comply with the laws'.*

Also, while the LPID is found to issue warning letters and has prosecuted some violators, the numbers of punitive measures were small compared to the number of violations. However, LPID also complements the punitive measures with reputation management, which is negative publicity. Again, evidence shows that negative publicity is done once in a while; this is induced by accidents, not poor H&S practices.

Proactive regulatory measures

Majority of the respondents stated that they conduct proactive inspections of workplaces once or twice a year and this depends on the level of risk in the workplace. Although there was documentary evidence of impromptu inspections, they were not carried out frequently. Also, the extent to which LPID achieves the 'one or two inspections' for each company is questionable, as some respondents said that they do not achieve that because of lack of person power. Worse still, the available person power may be under utilised in that one respondent stated:

> *'Honestly, since I have been here, I have not covered any accident, inspection or anything similar'.*

Nonetheless, the document review also suggested that the LPID acknowledges the inability of their enforcement procedures to create the expected impact in terms of improving H&S.

Another significant aspect of the interviews is that, while the respondents at management level claimed to have procedures in place for educating stakeholders, the respondents at the non-managerial levels claimed otherwise. For example, one of the respondents at non-managerial level stated:

> '*How can they* (that is LPID) *educate stakeholders while we* (the employees*) do not get training?'*

The contrary claim of the respondents at the non-managerial level is arguably supported by the fact that no evidence of educating stakeholders was found during documentation review.

Proactive regulation through cooperating with the management of organisations

Employee participation: it is also evident from the interviews that LPID understands the importance of employees' involvement; thus, they encourage the formation of safety committees. This is despite the fact that it is not obligatory in the H&S legislation. A respondent stated:

> *'There are things that we make compulsory such as safety committee and safety management control system, but we do not make risk assessment compulsory. The safety committee helps in ensuring employee involvement in safety matters. It gives employees a sense of belonging'.*

The respondents were then asked why risk assessment is not compulsory. Answers from the respondents suggest that they believe that organisations may duplicate risk assessments from other organisations just to fulfil the requirement.

Barriers to effective regulation of health and safety

When the respondents were asked of the challenges that they encounter while performing their duties, most of their answers were based on logistics such as limited internet access, inadequate transportation. Indeed, the respondents stated as follows:

> '*We just have one inspection vehicle in this state office, and we are about 41. To crown it all, most times there is no petrol for the vehicle'.*
>
> *'We do not have any vehicle here. Most time, we use public transport or we use our own vehicles'.*
>
> *'There is not enough tools for working. Can you imagine that some employees here have never seen a sound meter because we do not have it?'*
>
> *'We are not provided with adequate funds, up to the extent that we cannot post letters that we type with our old typewriters because of no money'.*

Other barriers highlighted by the respondents include: lack of training, ineffective means of communication, low level of knowledge, inadequate means of reporting accidents, political influence, inadequate legal system and lack of manpower. One respondent stated:

> '*Some of our colleagues at branch level have not received any training since they joined this organisation. Only those at the headquarters enjoy the benefits of working for this ministry'*.

Another significant barrier is inadequate legislation. The respondents stated that the penalties for violating the H&S legislation were not punitive enough. They also want to see more prescriptive legislation so as to improve the level of compliance, as prescriptive legislation is easily understood. Truly, some respondents stated:

> *'The law is vague; we now make regulations (*i.e. product of an act*) that prescribe the standards so that they can be easily enforced. When the law is vague, the regulated can easily argue it out'*.
>
> '*Prescriptive regulations* (i.e. product of an act*) are better understood because they are broken down to the level that the users can easily interpret them'*.

This barrier of inadequate legislation is also supported by evidence from the document review. The inspectors also claim that as a result of inadequate legislation, they have developed an alternative measure. One respondent stated:

> *We tell the companies to have something like safety handbooks for their workers, which contain safety rules and regulations* (i.e. requirements). *These handbooks are designed based on the duties of employees. If the employees fail to comply with these rules and regulations* (i.e. requirements)*, their jobs are at risk. These handbooks are supported and signed into force by the managements of organisations and/or unions. The aim is to scare the employees.'*

The validity of the above claim remains questioned, as no documented evidence was found in that regard.

DISCUSSION

Regulatory foundation

Although LPID claims to focus on administration of the law, no evidence was found to support this. Rather sufficient evidence points to LPID focusing on (command and control) enforcement of the law. Considering the arguments against command and control in this paper, the position of Nigeria in terms of regulation of H&S is not surprising. The underpinning philosophy of deterrence theory that command and control is based on and its challenges may explain why compliance with the H&S law is poor in Nigeria. The equation above (*U< PD)* means that for organisations to comply, they will calculate the cost of being caught. And as Fairman and Yapp note, it is hard to calculate (2005). This is especially true in H&S where the direct and indirect costs are hard, if not impossible to measure (Manu 2012). Thus, the regulated may assume that it is rewarding not to comply. Also, as it is more unlikely that LPID will enforce the law, the likelihood that offenders will be caught is low. Therefore, the regulated may have complete knowledge of the possibility of being caught or not (Fairman & Yapp 2005; Tomb & Whyte 2013) thus may not comply with the law.

Additionally, considering the points against deterrence theory and the challenges that LPID faces, it is not prudent that regulation is solely based on command and control. Besides, the state of H&S in Nigeria demonstrates the inefficiency of this approach. The state of H&S intervention in Nigeria is presented in Umeokafor et al. (2014a) who note the low level of punitive enforcement activities in Nigeria covering an eleven-year period. Specifically, they note that over an eleven-year period, ten precautions and one recorded criminal prosecution were carried out (Umeokafor et al. 2014a). Umeokafor et al. (2014a) also go on to evidence the lower number of interventions that are adopted in Nigeria; this is consistent with the responses of the interviewees. This is also consistent with Okojie (2010) who notes that prohibition notices are hardly issued in Nigeria. Nigeria should move from command and control approach to other forms of self-regulation and/or partnering strategy.

Accident reporting, investigation and post-investigation actions

Having only the Director of LPID authorise the issuance of prohibition notices has been reported and criticised by Umeokafor et al. (2014b), and the long process that it takes does not help H&S in Nigeria.

Additionally, accident reporting and investigation are among the critical aspects of H&S management and regulation, but the evidence in this study does not speak well of LPID. The fact that it can take LPID up to five months to investigate incidents leaves the quality or outcome of the investigation questionable. It is possible that LPID can blame this on the ineffective accident reporting system, but it is their responsibility to ensure that the accident reporting system is effective.

Equally, considering the accident reporting method in Nigeria and the high level of bureaucracy, other ways of reporting accidents, which are social media friendly, should be considered. Advanced methods of investigating accidents cover the chain of events leading to the accidents, investigating the parties indirectly involved. Sadly, no record of such was found during the study.

In terms of reputation management, it is evident that LPID sparingly engages in negative publicity (induced by accidents) as a means of reputation management. While this may be good, negative publicity induced by accidents may mean that casualties or damages to properties may have occurred. However, if the negative publicity is induced by findings of proactive inspections such as H&S practices, the casualties or damages to properties may be prevented.

Furthermore, the use of negative publicity by LPID may have greater effect on large organisations than on small and medium enterprises (SMEs), as it is found that large firms fear negative publicity more than the law (Fisse & Braithwaite 1993 in Amodu 2008). Therefore a positive approach to reputation management- positive publicity as Diugwu (2008) argues, may be more effective on these firms. This is because large firms and SMEs may engage in H&S so that people will view them from a positive light. As stated earlier, the use of social media can be helpful for positive and negative publicity and for educating the regulated.

Proactive regulatory measures

While the legislative process of H&S in Nigeria may be argued to be acceptable to some extent, the intervention approaches that are informed by accident reporting are not adequate. As much as command and control may not be efficient as enforced self-regulatory approaches, proactive inspections will deter organisations more than the reactive approaches. Sadly, evidence shows that few proactive inspections are conducted. Howard and Galbraith (2004) discuss the importance of proactive deterrence strategies in detail.

However, the low person power may account for the low number of inspections. There were 49 inspectors prior to 2013 when more inspectors were employed making it a little over 200 (Akpan 2013; cf. Okojie 2010). The number of inspectors compared to the population of Nigeria is insufficient. As this is the case, partnering or involving other authorities (Howard & Galbraith 2004) with larger manpower may be helpful. The educational regulatory approach can also complement the existing strategy in Nigeria. It is best practice to provide education to ensure compliance (see Fairman & Yapp 2005).

Proactive regulation through cooperating with the management of organisations
In terms of employee participation, that LPID encourages the establishment of safety committees as well as cooperation between employees and employers (Walters et al. 2005) in H&S matters offers some level of optimism. However, the input of trade unions may also be needed for improving H&S (Idubor & Osiamoje 2013), as their influence on workers cannot be overemphasised. It is therefore vital to note that to achieve the above and more, there are preconditions such as legislative influence, inspection and control, and senior management commitment (Walter et al. 2005).

On a different point, that the LPID is found not to make risk assessment compulsory is not best practice. This raises questions regarding the quality of H&S management in the organisations and the quality of the regulatory activities that LPID offers. Risk assessment helps in avoiding, eliminating or reducing risks in the workplace.

Barriers to effective regulation of health and safety

In terms of the challenges that the LPID encounters, most of these are acknowledged in studies. For instance, Okojie (2010) notes that political influence is seen to highly influence the regulation of H&S in Nigeria. She goes on to note that LPID inspectors are not able to close down firms that violate H&S laws because their owners are politicians or people in the higher echelon of power (Okojie 2010).

Equally, logistics issues (such as lack of vehicles, lack of equipment), which majority of the respondents acknowledge are consistent with Akpan (2013). It is unclear if these logistics issues are due lack of funds caused by inadequate governmental attention or due to corrupt practices from the part of LPID or due to poor management. Be it as it may, these issues can be argued to significantly hinder the activities of LPID.

Additionally, the inadequate legislation and ineffective legal system that are found in this study are also reported in studies (Idubor & Osiamoje 2013; Umeokafor et al. 2014a). This does not support the deterrence theory-based regulatory approach in Nigeria. It is worth remembering that the underlying philosophy of sanction-based deterrence strategy is that punitive measures will hinder people from breaching the law. As the penalties of H&S laws such as the Factories Act F1 LFN 2004 is as low as 2000 Naira (equivalent to US $10) and 5000 naira (equivalent to US $24.9) (Factories Act 2004: section 3 subsection 4; section 20 subsection 2), sanction based regulatory strategies may not be effective. According to Umeokafor et al. (2014a), the regulated would rather breach the law and pay the fine than comply. Nonetheless, it is thought that despite the barriers to effective regulation or the impact of contextual issues, LPID can do more to improve H&S in Nigeria.

Furthermore, from the interviews it can be seen that LPID has the powers to make regulations (i.e products of an Act), and the Factories Act F1 LFN 2004 supports this. Although LPID claims to make regulations (i.e. product of an Act) in order to make the Factories Act clearer, what remains unclear is why LPID would not make regulations (i.e. product of an Act) to address the anomalies of the Factories Act.

CONCLUSIONS AND RECOMMENDATIONS

This paper reports a study based on document review and semi-structured interviews that has aimed at understanding the regulatory activities of the LPID so as to develop a framework of recommendations for improving regulation of H&S at the public entity level. This study evidences that the regulation of H&S in Nigeria is based on the command and control approach, and LPID relies on inspections induced by reported accidents. Worse still, this accident reporting system and other regulatory activities are evidenced in this study as poor, strengthening the positions of the critics of LPID. Also, albeit logistics, weak legal system, inadequate legislation and lack of person power are found to be among the factors that hinder the regulation of H&S, more can be done by LPID to improve H&S in Nigeria.

Against the background of this study, the following are recommended:

- The deterrence approach of the LPID should be more proactive. Given the current state of H&S in Nigeria, LPID can have educational and information strategies in the forefront of regulating H&S.
- In the absence of an efficient legal system, LPID can adopt mobile courts in a similar form to that of the Federal Road Safety Commission of Nigeria. The mobile courts may have the powers to handle some minor offences.
- It is advocated that LPID should adopt positive publicity reputation management in regulation H&S.
- Involving local authorities in H&S regulation as it is done in the UK (Howard & Galbraith 2004) can be another way that LPID can improve H&S in Nigeria.
- LPID can partner with organisations such as safety groups just as local authorities have successfully done in the UK (Howard & Galbraith 2004). This supports regulators who have limited resources. The partnership may not only be enforcement related but educational and creating awareness.
- LPID can adopt social media such as Facebook for passing H&S information. Social networking remains an effective way of passing information in Nigeria.
- LPID should adopt an accident reporting system where the victims or witnesses also report accident directly to LPID. This system should be accessible through the social media.
- Given that there are anomalies in the Factories Act F1 LFN 2004, the LPID should utilise the power bestowed on it by the Factories Act F1 LFN 2004 and make regulations (i.e. product of an Act) and code of practices to address the anomalies in the Factories Act F1 LFN 2004.

This study faced its own limitations. First, the interviewees may have been those that could provide answers that will not negatively impact on LPID so much. Second, it may be argued that the findings of this study are obvious; however, the study is an empirical evidence that validates the critiques of LPID. Besides, no or little evidence of such has been found. Further studies can examine involving local authorities in H&S regulation and using social media in H&S regulation.

ACKNOWLEDGMENT

The authors thank the anonymous reviewers whose comments helped in refining this paper. The authors also express their gratitude to the staff of LPID for providing the documentary information used for this study and for participating in the interview sessions.

REFERENCES

Aalders, M, and Wilthagen, T (1997) Moving beyond command-and control: reflectivity in the regulation of occupational safety and health and the environment. 'Law and Policy', 19(4), 415- 443

Akers R L (1990) Rational choice, deterrence, and social learning theory in criminology: The Path not taken. 'Journal of Criminal Law and Criminology', 81(3), 653 – 676.

Akpan, U N (2013) Occupational safety and health systems in Nigeria. A country paper presented at 'the African Regional Labour Administrator (ARLAC) Tripartite Workshop' on strengthening occupational safety and health system for the excluded, Zambia, November 4-8.

Amodu, T (2008) The determinants of compliance with laws and regulations with special reference to health and safety: A literature review. Health and Safety Executive Retrieved on 14-07-14 from http://www.hse.gov.uk/research/rrpdf/rr638.pdf

Diugwu, I A (2008) 'A Framework to evaluate critically health and safety Strategies in Supply Chains in the UK' Doctoral Thesis Coventry University. Retrieved from http://curve.coventry.ac.uk/open/file/b45289ac-aa13-b64c-fb20-f155ed0de66b/1/diugwucomb.pdf

Diugwu, I A, Baba, D L, and Bima, A M, (2013) Research and legal underpinnings of the Quantity Surveyor as a Health and Safety Manager. In Ibrahim, A D, Adogbo, K J, and Ibrahim, Y M (eds), '1st Annual Research Conference (AnReCon)', 3 - 5 September, Abuja, Nigeria. The Nigerian Institute of Quantity Surveyors, 243 - 252.

Ezenwa, O A (2001) A study of fatal injuries in Nigerian factories. 'Occupational Medicine', 51(8), 485 – 489.

Fairman, R and Yapp, C (2005). Enforced self-regulation, prescription, and conceptions of compliance within small Business: The impact of enforcement. 'Law and Policy', 27(4), 491 - 519.

Federal Republic of Nigeria (2004). 'Factories Act, CAP F1, LFN 2004'. Federal Government Press, Abuja, Nigeria.

Gracia Martinez, M, Fearne, A, Caswell, J, and Henson, S, (2007) Co-regulation as a model for food safety governance: Opportunities for Public-Private Partnership. 'Food Policy' (32), 299-314.

Guest, G, Bunce, A, and Johnson, L (2006) How many interviews are enough? An experiment with data saturation and variability. 'Field Methods', 18(1), 59- 82.

Howard, M and Galbraith, A (2004) Factors influencing local authority health and safety interventions and enforcement activity: Part one: interventions. Health and Safety Executive (HSE) Report.

Hutter, B M and Amodu, T (2008) 'Risk regulation and compliance: Food safety in the UK'. NCP. 04219. London School of Economics and Political Science, London, UK.

Idubor, E E, and Oisamoje, M D (2013) An exploration of health and safety management issues in Nigeria's efforts to industrialize. 'European Scientific Journal', 9 (12), 154-169.

Manu, P (2012) 'An investigation into the accident causal influence of construction project features', A Doctoral thesis University of Wolverhampton. Retrieved from http://wlv.openrepository.com/wlv/bitstream/2436/265178/1/Ackon%20Manu%20PhD%20thesis.pdf

Okojie, O (2010) System for reporting occupational diseases in Nigeria. 'African Newsletter on Occupational Health and Safety', 20(3), 51-53.

Okokon, I B, Asibong, U E Archibong, F Monjok, E (2014) Work-related traumatic injury in the paper-producing Industry in Nigeria: A case of the Nigerian Newsprint Manufacturing Company Limited, Oku-Iboku, Akwa Ibom State, 'Family Medicine & Medical Science Research', 3 (4), doi: 10.4172/2327-4972.1000143

Umeokafor, N I, Igwegbe, O, Umeadi, B, Evanggelinos, K, Lundy, S, Isaac, D, Jones, K, and Umeokafor, K (2014a) The pattern of occupational accidents, injuries, accident causal factors and intervention in Nigerian factories. 'Developing Countries Studies', 4 (15) 119-127.

Umeokafor, N I, Umeadi, B, Jones, K, and Igwegbe, O (2014b) Compliance with occupational safety and health regulations in Nigeria's Public Regulatory Entity: A Call for Attention. 'International Journal of Scientific and Research Publications', 4(5), 302- 304.

Walters, D, Nichols, T, Connor, J, Tasiran A C and Cam S (2005) The role and effectiveness of safety representatives in influencing workplace health and safety. Health and safety executive (HSE) Research report 363.

Winter, S C and May, P J (2001) Motivation for compliance with environmental regulations. 'Journal of Policy Analysis and Management', 20(4) 675- 698.