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Conference

Coping with the Complexity of Safety,
Health, and Wellbeing in Construction

Conference Proceedings

Salvador, Brazil, August 1st - 3rd 2018

Editors

Tarcisio Abreu Saurin
Dayana Bastos Costa
Michael Behm
Fidelis Emuze

**Joint CIB W099 and TG59 International Safety, Health, and
People in Construction Conference**
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in Construction**

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INTRODUCTION

The International Council for Research and Innovation in Building and Construction (CIB) was established in 1953 as an Association whose objectives were to stimulate and facilitate international cooperation and information exchange between government research institutes in the building and construction sector, with an emphasis on those institutes engaged in technical fields of research.

A CIB Commission is a worldwide network of experts in a defined scientific area who meet regularly and who collaborate in international projects and exchange information on a voluntary basis. A Commission can be a Task Group (TG) with a limited lifetime, scope, and objectives, or a Working Commission (W) with a broader programme, scope, and objectives.

This particular proceeding is related to a joint conference involving W99 (Safety and Health in Construction) and TG59 (People in Construction). Since 1996, this is the 27th meeting focused on at least one of these topics, and the second that occurs in Brazil. The first was in 2003, in São Paulo.

The conference provides an international forum for researchers and practitioners to put forward discourses on how to improve safety, health, wellbeing, and the life of people in construction. The theme of this year's conference is *Coping with the Complexity of Safety, Health, and Wellbeing in Construction*. The choice of this theme is due to the recognition of the perceived limitations of the traditional scientific method, which tends to be reductionist and neglect contextual conditions in the search for generalizable findings. Complexity science (CS) offers an alternative paradigm, by stressing the modelling of interactions between agents, which cannot be fully controlled, but at best influenced on the desired direction. It is widely accepted that construction projects are complex socio-technical systems, and thus the use of CS can offer insight into new approaches for making sense and managing construction health, safety, and wellbeing (CHSW). The potential implications permeate all dimensions of

CSHW, such as the development and role assigned to procedures and rules, training, planning, performance measurement, and the design of products and processes.

Fifty-eight papers, from 14 countries are published in these proceedings, indicating that the W99 and TG59 communities are expanding around the globe. The papers are organized into three chapters: full W99 papers, full TG59 papers, and abstracts from both topics. Table 1 summarizes the number of accepted submissions, according to the publication and the presentation modality. All submissions made only as abstracts were presented in the poster sessions.

Table 1. Number of accepted submissions: presentation and publication modality

Presentation modality	Publication modality	
	Full Paper	Abstract
Parallel Sessions	46	-
Posters	6	6

Table 2 presents the number of papers submitted and accepted for both W99 and TG59.

Table 2. Number of submitted and accepted papers

Topic	Submitted as full papers	Accepted as full papers	Submitted only as abstracts*	Accepted only as abstracts*
W99	38	31	10	6
TG59	22	21	1	0

* Presented as posters

Table 3 presents the number of papers accepted by country, considering the location of the first author institution. It is also worth mentioning that eight papers had authors from more than one country, pointing out the role of this community as a forum for effective collaboration between institutions from different countries.

The 58 papers from academics and practitioners published in these proceedings have been accepted for publication after a rigorous double-blind peer review process. We are very grateful to all 38 reviewers who have contributed to improving the quality of

this conference. We would also like to thank Juliana Sampaio Álvares, Mirela Schramm Tonetto, Laura Fernandes, and Roseneia Rodrigues Santos de Melo, for their supporting work during the paper reviewing process and the preparation of the proceedings.

Table 3. Number of papers accepted, according to the country of the first author institution

Country of the first author institution	Published papers
Brazil	17
South Africa	13
UK	10
Ghana	3
USA	3
China	2
Nigeria	2
Palestine	2
Australia	1
Canada	1
France	1
Hong Kong	1
Slovenia	1
Zambia	1
Total	58

Salvador, Porto Alegre, Greenville, and Bloemfontein,

August 1, 2018

Dayana B. Costa, Tarcisio A. Saurin, Michel Behm, and Fidelis Emuze

Editors and Technical Chairs of the Joint CIB W99 and TG59 International Safety, Health, and People in Construction Conference

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CONTRIBUTIONS OF RESILIENCE ENGINEERING AND VISUAL TECHNOLOGY TO SAFETY PLANNING AND CONTROL PROCESS

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Construction projects can be characterized by their complexity and dynamism, distinguishing the construction industry sector as one of the more representative in accident rates. However, due to the evidence of accidents, the efficiency of the Safety Planning and Control (SPC) process has been questioned. Thus, the need for new approaches to leverage the construction safety is noteworthy, such as the application of Resilience Engineering (RE) and visual technologies for jobsite planning and monitoring. The RE emerges as a new conceptual paradigm for the improvement of safety. This paper presents an exploratory study in order to understand the contributions of the concept of Resilience Engineering and the use of Unmanned Aerial Systems (UAS) technology to support the SPC process. For this, a case study in a construction project was conducted, involving the following steps: (a) Diagnosis of SPC process; (b) Development of a safety monitoring protocol using UASs; and (c) Field tests to monitor working conditions with UASs. The main contribution of this work is the presentation of a theoretical framework explaining how the RE and the UASs can contribute to the SPC process, the development of a protocol for safety monitoring with UASs and the identification of resilience and brittleness factors influencing the SPC process.

Keywords: Resilience Engineering (RE), Visual technology, Unmanned Aerial Systems (UASs), Safety Planning and Control (SPC), Construction sites.

INTRODUCTION

Despite advances in construction safety management, shortcomings in the SPC process are still evident (Cambraia et al., 2010). According to Guo et al. (2017), the safety planning failure in identifying safety hazards and job hazard areas (JHAs) can be justified due to the lack of an intuitive method of representing the construction process, highlighting the need for new approaches capable of dealing with the complexity and the dynamism faced by the construction industry.

Thus, Resilience Engineering emerges as a new conceptual paradigm for the study of safety, which seeks to understand how people, under pressure, deal with the complexity and variability of a system (Hollnagel, 2006), considering the interfaces between people, technology and the work environment, thus providing an analysis closer to the complex reality (Clegg, 2000).

Recent research has shown that the use of emerging technologies such as Unmanned Aerial

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Systems (UASs) can contribute to the monitoring of working conditions at construction sites, due to the high potential of visualization through the visual assets (photos and videos) collected on the jobsite, providing a more reliable assessment of the risk (Irizarry and Costa, 2016; Melo et al., 2017). Therefore, this study has as motivation the use of the concepts of resilience engineering and the potential of visualization with the UASs to support the SPC process, providing information on risk anticipation and effective process monitoring. This paper presents an exploratory study aiming to understand the contribution of the concept of Resilience Engineering and the use of UAS technology to support the Safety Planning and Control process. This study is part of PhD thesis which aims to develop and evaluate a Safety Planning and Control model for construction sites based on Resilience Engineering concepts and visual technologies.

THEORETICAL FRAMEWORK

Safety planning and control (SPC) is a mandatory requirement under the Safety Standards Regulations, in addition to being a practice performed by companies concerned with safety management (Cabraia et al., 2010). According to Cabraia et al. (2010), SPC is recognized as one of the principal measures for the reduction of accidents, in which safety requirements must be taken into consideration in the production planning. Therefore, a more reliable workflow can contribute by reducing unexpected events that lead to accidents (Howell et al., 2002), corroborating with an increase the resilience.

The resilience, being understood as an intrinsic capability of an organization or system to maintain or recover a dynamically stable state, allowing the organization to continue operations after unexpected events or in the presence of continuous stress (Hollnagel, 2006). The RE seeks to explore and discuss the safety/production trade-offs faced by organizations (Hale and Heijer, 2006; Woods, 2006), and planning has an important role in the accommodation changing demands and risk anticipation, corroborating with the expansion of the safe work limits to which workers are exposed (Woods, 2006; Howell et al., 2002; Saurin et al., 2015). According to Hollnagel (2010), a resilience organization must develop four essential abilities, being the abilities to monitor, to respond, to anticipate and to learn. Those also need to be considered in the SPC process in order to achieve efficiency and good performance.

Woods (2006), argues that for managing risk proactively, it is necessary in a few moments to mitigate the pressure on throughput and efficiency goals, i.e., making a sacrifice judgement, in order to maintain an acceptable level of risk (Woods, 2006). The author discusses that the monitoring is a key resilience factor. This should lead to interventions to manage and adjust the capacity to adapt as the system faces new forms of variation and challenges. Then, the monitoring can contribute for the understanding of the work-as-done, meaning what actually happens over time in real situations (Hollnagel et al., 2015), due to the constant adaptations carried out during the construction phase.

The study of work-as-done has sought to understand the skills developed by workers when in operating limits zone (Rasmussen, 1997). These skills are essential in the adjustment of the performance, in order to maintain safe operations and efficiency during expected and unexpected situations (Saurin et al., 2014). Thus, it is necessary to use mechanisms to support the safety planning, the monitoring of safe work limits and the anticipation of risks. In view of this, studies have pointed out the potential use of the UASs as a tool for supporting safety

management, contributing to the increase of transparency, improvement in identification of problems, agility in the process of decision-making and reduction of inspection time on construction site (Kim and Irizarry, 2015; Melo et al., 2017).

The review of the literature presented in this section seeks to connect the RE concept and the use of the UAS technology and their contributions to the SPC process. As a result, a theoretical framework is presented in Figure 1.

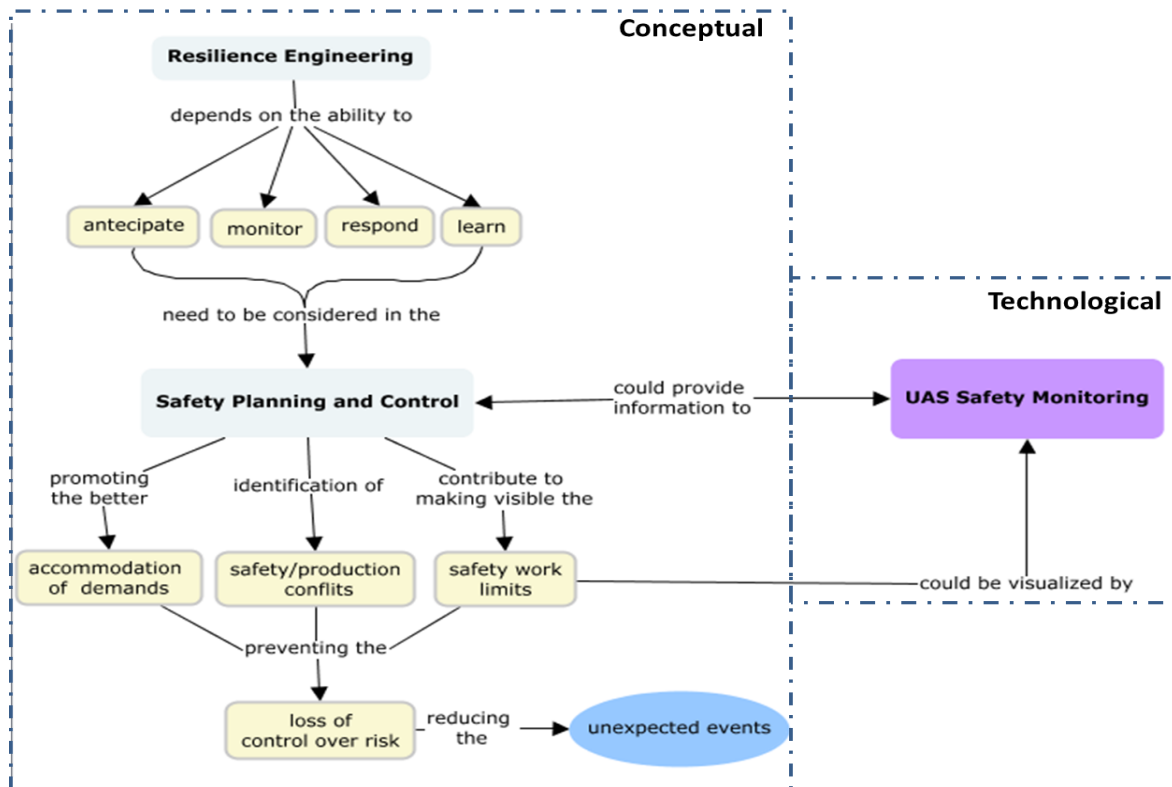


Figure 1: Theoretical Framework

METHODOLOGY

This research used the Design Science Research (DSR) concepts (Van Aken, 2004) as the research strategy, according to Figure 2. However, this paper only focuses on the step of awareness of the real problem, according to Research Design presented.

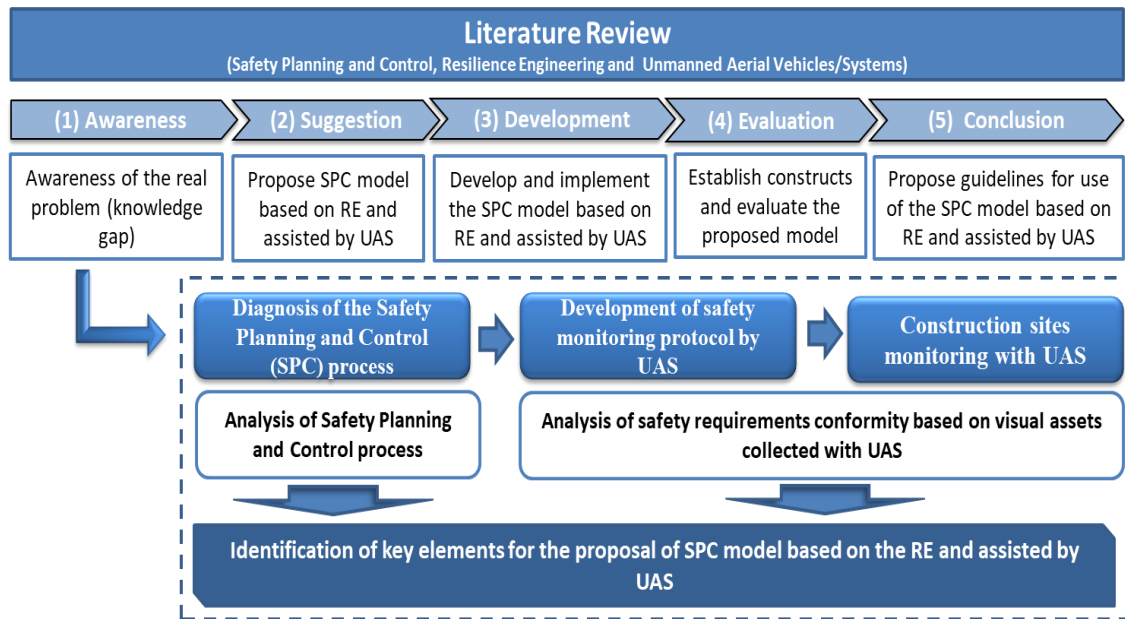



Figure 2: Research design with emphasis on awareness step

The study was conducted in a residential project, known as Project 1, from October 2017 to March 2018. Table 1 describes the main features of the project.

Table 1: Features of Case Study

Description	
Residential low-income housing project Land Area: 22,800 m ² Total of 400 units Construction time: 16 months 90 labor workers (at the moment) Constructive processes: Concrete wall structure	

Diagnosis of the Safety Planning and Control (SPC) process

The diagnosis aimed to understand the SPC process in place in Project 1 based on six requirements related to the Health and Safety Assessment Method developed by Costella *et al.* (2009). The requirements evaluated were: (1) safety management policies and objectives; (2) structure and responsibilities; (3) senior management commitment; (4) management system planning; (5) identification of safety hazards; and (6) risk assessment and corrective actions. Data was collected based on structured interviews; two interviews totaling 3 hours with safety personal and a safety engineer, informal conversations with the safety team, analysis of documents, direct observations, visual assets collected with UASs and participation in two production planning meetings on site.

Development of safety monitoring protocol by UASs

This step aimed to develop a protocol for safety monitoring with UASs (Figure 3) integrated into the safety management routine of the Project 1.

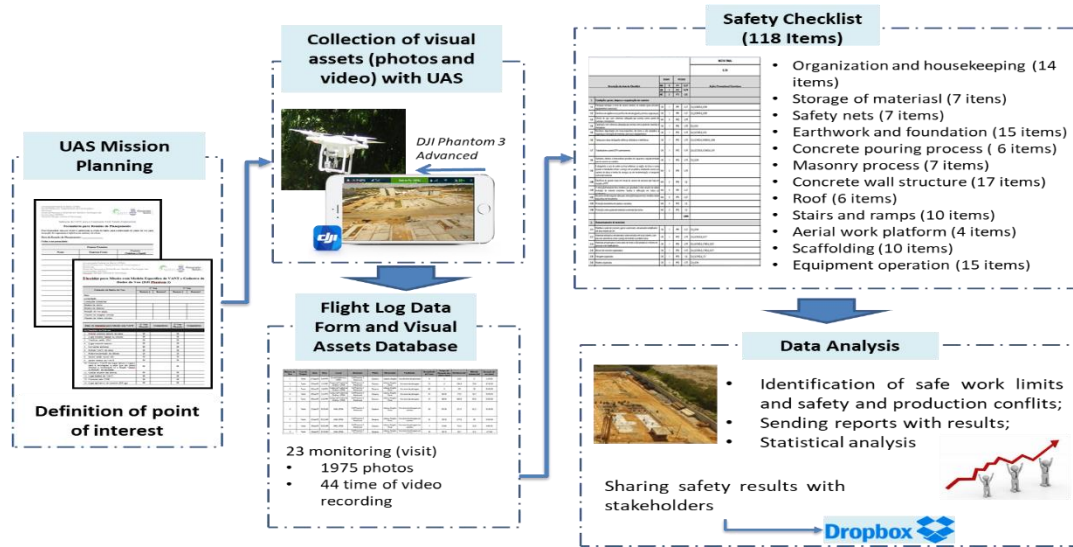


Figure 3: Safety monitoring protocol by using UASs

A check list for UASs safety monitoring was developed based on the Project 1 checklist for assessment of the construction site safety conditions, containing 294 items (includes requirement regardless documentation, as well as internal and external safety requirements) which was collected by the safety team on a monthly basis. The checklist adopted included 118 items, subdivided into 12 categories (Figure 3). 90 of 118 requirements were taken from the Project 1 checklist (only external safety requirements), and 28 additional requirements were included, based on the checklist developed by Melo et al. (2017).

Safety monitoring with UASs

This step aimed to perform tests for monitoring the safety conditions on the jobsite and identify the safe work limits through the visual assets collected with UASs. A total of 23 flights were performed with an average time of 15 minutes each. A total of 1975 photos and 44 minutes of video were recorded. After the flights, feedback with Safety Personnel for the immediate assessment was also performed. All visual assets collected during the monitoring were available for the project personnel in reports to support their decision-making process.

Two analyses were carried out throughout this study. The first one aimed to identify the sources of resilience and brittleness of the safety planning and control process, by identifying the critical processes from the perspective of monitoring and control. The second analysis aimed to evaluate the compliance with the safety requirements through the checklist, according to the Brazilian Safety Regulations, highlighting the safe work limits and the conflicts between safety/production visualized through the visual assets collected.

FINDINGS AND DISCUSSION

This section presents the results obtained from the diagnosis of the SPC process and the safety monitoring with UASs.

Analysis of Safety Planning and Control process

Concerning safety management policies and objective, the Construction Company which develops Project 1 has the safety management policies and objectives documented with pre-

established targets defined by the top managers, linked to profit participation of the safety team. The targets are defined according to the risk management and previous year's results. The safety management policy and objectives are reviewed within 24 months, and so far, this paperwork has gone through two reviews in the last five years. The safety policy and objectives are communicated to all workers during the admission training, daily safety dialogue, visual resources (banners and posters), as well as annual health and safety promotion event.

Despite this, the Company studied performs well in terms of the safety policies and objectives, and it should be noted that the established goals do not lead to continuous improvement because the targets are overestimated, and the works are not boosted to achieve better indicators. In addition, for the integration between production and safety, the profit participation of production team should be linked to the safety targets. Regarding the structure and responsibility, the safety management has an independent hierarchy. The functions and responsibilities related to safety are explicit and documented. However, conflicts between production and safety were observed during the study, caused by the absence of fall protection systems designs and the inefficiency of safety/production planning. The safety team of Project 1 is composed of two Safety Personal, a Safety Supervisor and a Safety Coordinator.

Top managers are responsible for proposing and evaluating the safety goals and monitoring the proactive and reactive safety indicators, showing a commitment to better safety conditions. On a monthly basis, reports with the project's safety compliance indicators are distributed among the safety teams for internal benchmarking, providing information for supporting the safety team decision-making and also learning from the good practices carried out in construction sites. The safety planning is developed based on the master production planning, aiming to collect information for Program of Prevention of Accident Risks (PPAR), updated every 12 months and performed on a weekly basis in order to inform safety team and the workers the activities planned for the week. The inefficiency of the planning is reflected in the working conditions and accommodation of the demands, where a high potential for improvements in order to establish a more reliable workflow was observed.

The identification of hazards of accidents is carried out in the PPAR, work permit and PCMHO (Occupational Health Medical Control Program), where there is a nurse responsible for the monitoring of occupational diseases. Factors such as production pressures are not taken into account, although there is a high workload and rigid productivity goals in some processes. During the construction site monitoring, when situations of imminent accident risk were observed, the recommendation is to stop the service until the risk has been reduced or eliminated. For low risk non-conformities, a deadline is proposed for correction. After the deadline, the Safety Supervisor verifies whether the correction has been carried out and sends the results to the Safety Coordinator. Based on the analysis, a set of factors that could influence in the resilience or brittleness of SPC process on jobsites was identified (Table 2).

Table 2: Potential factors influencing SPC process based on RE

Resilience factors	Brittleness factors
<ul style="list-style-type: none"> • internal benchmarking – promotion of learning from the success experiences; • incentive policy (such as profit participation) • pre-established targets; • safety management independent from production management; • top management commitment. 	<ul style="list-style-type: none"> • target overestimated (incompatible with safety objectives); • deficient visual management (especially during the workers' safety training); • absence of critical analysis of the indicators collected; • lack of integration between safety and production planning; • the identification of risks does not consider behavioral factors and production pressures; • the operating procedures formulated by engineers and technicians without the contribution of workers.

Analysis of safety requirements conformity based on visual assets collected with UASs

This analysis aims to verify the conformity with the safety requirements through the application of the checklist based on the assets collected with UASs (Figure 4). This indicator is calculated as the ratio of the sum of the weights of items and the sum of the weights of items checked. The weights of the items vary according to the degree of risk.

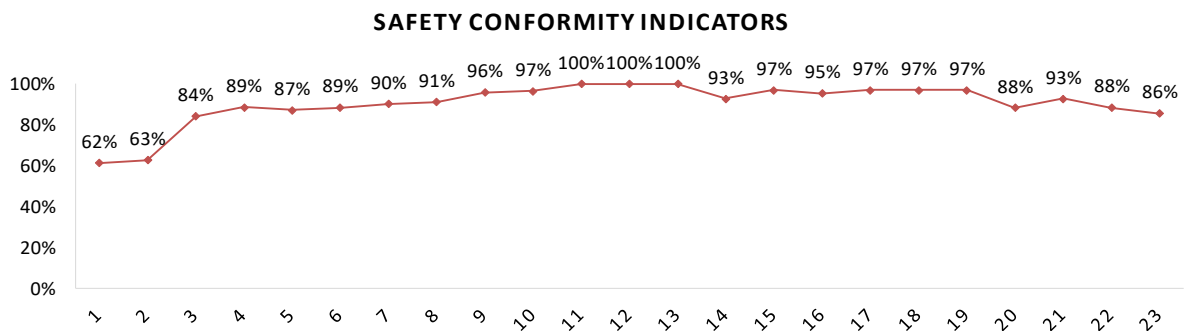


Figure 4: Results of the conformity indicator

The results show an improvement in safety conditions during the monitoring between October 2017 and March 2018. The first two visits presented results below 70%, justified by the period of the jobsite layout implementation. From the seventh visit on, a high conformity rate (above 90%) is observed, representing the fulfillment of the safety standards requirements. There is a decline of the results in the last two visits resulting from the non-conformities found in the concrete wall process. However, despite the high level of conformity presented in the Figure 4, a record of three accidents on jobsite during this period were observed, one of them being characterized as severe and resulting in 8-month layoff of the worker. By analyzing the frequency of items classified as non-conformity (Figure 5), 71% (47 occurrences) are distributed among six main requirements. The most frequent requirement was the lack of the use of Protective Personal Equipment (PPE) by employees (27% - 17 occurrences), representing a recurrent problem in construction.

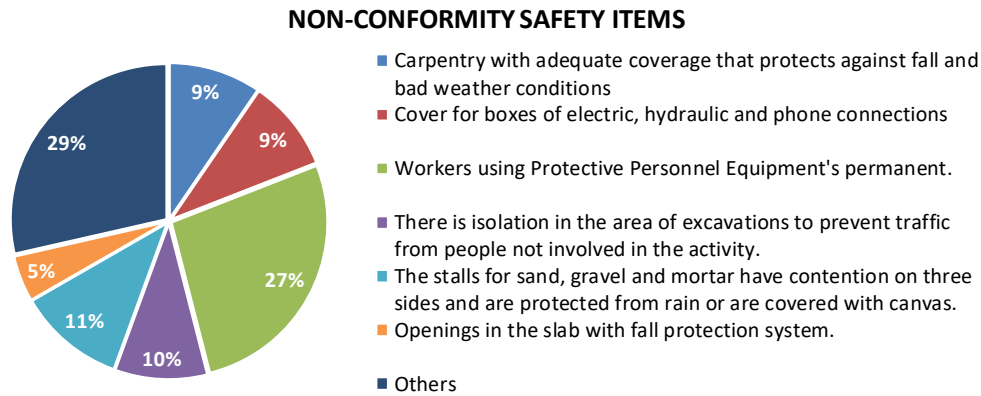


Figure 5: Results of the frequency of safety items non-conformity

Despite the high percentage of conformity and adequacy of safety standards, some situations that go beyond the safe work limits were recorded by the visual assets collected with UASs (Figure 6).



Figure 6: Situations that exceed the safe work limit recorded by UASs during the safety monitoring

Among the hazardous situations identified, the following ones can be highlighted: the improvisation of wood cutting benches in the middle of the excavation areas, in order to decrease the displacement of workers and to increase the productivity (Figure 6a); the lack of isolation of the excavations areas, causing the risk of workers falling into the cesspool (Figure 6b); the unsafe unloading of the shackles of concrete (Figure 6c); the improper use of the ladder (Figure 6 d); scaffolding without an adequate guardrail system (figure 6e); and the process of disassembly of scaffolding suspended without fall protection. Also, the process of removing suspended scaffolding without fall protection (Figure 6f) was observed. Although the worker was using a safety seat belt, there were no lifeline systems on the slab to be trussed (Figure 6 g); and the openings on the slab without fall protection systems (Figure 6h).

CONCLUSIONS

The aim of this study was to understand how the RE and the UASs can contribute to the SPC process, based on an exploratory study in a construction project. The findings show that the adoption of RE could improve the SPC process through a more reliable workflow, in order to

anticipate risks and the better accommodation of the demands, including the changing ones. In addition, the UASs monitoring was confirmed to have the ability to provide information regarding the identification of risks (such as absence of fall protection) and conflicts between safety/production (activities without adequate safeguards to ensure productivity), promoting greater transparency. The information collected with UASs can support the short-term planning, as well as perform the actual monitoring aligned with what was planned.

Despite the good practices carried out by the safety management, some opportunities for improvement were observed, such as: to propose targets compatible with safety objectives; use of technological resources (photos and videos) to facilitate the understanding of safe work limits during safety training; to integrate the planning of safety and production into all hierarchical levels; to include in the risk identification behavioral factors and pressures of production; and to include in the development of operational procedures the workers' participation, in order to plan and control the activities as they are actually carried out. New studies are being developed in order to propose a SPC model based on RE and UASs.

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EVALUATING UAS-IMAGE PATTERN RECOGNITION SYSTEM APPLICATION FOR SAFETY GUARDRAILS INSPECTION

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The construction industry is known by the high accidents rates, in which, those caused by fall from height is the second major circumstance commonly reported, highlighting the need of adoption of new technologies in order to reduce the risks and improve work conditions. In this regard, emerging technologies such as Unmanned Aerial System (UAS) associated with image pattern recognition can contribute to the automation of safety inspection processes, optimizing time and labor, and streamlining decision making. Therefore, this work aims to evaluate the feasibility of automatic recognition of normative requirements related to guardrails by means of images obtained with UAS. For this study, an experimental simulation was adopted as the research strategy, developed according to the following steps: (a) identification of the normative criteria concerned to guardrail which are possible to be visualized automatically through images, (b) a test-bed experiment, including execution of a guardrail prototype, images recording with UAS, development and application of pattern recognition algorithm, and (c) qualitative and quantitative data analysis. As main results, the study identified the guardrail safety requirement which were possible to be visualized automatically through images, as well as presents an evaluation analysis of the application of UAS-Image Pattern Recognition for guardrail safety inspection, highlighting its benefits and barriers.

Keywords: Pattern recognition, Unmanned Aerial System (UAS), Safety inspection, Guardrail.

INTRODUCTION

The construction industry is one of the industries with the highest levels of occupational accidents (The Industry Social Service - SESI, 2013), accounting for about 25 to 40% of fatal accidents at work among all other economic activities (Lingard, 2013). Within these statistics, there is a high incidence of accidents caused by fall from height, being the second major circumstance commonly reported, causing different types of injuries and fatalities among workers (SESI, 2013). The high occurrence of accidents in this environment evidences the need for differentiated attention in the application of preventive safety measures, seeking to reduce those statistics and, especially, to promote healthy and safe working environments.

The safety inspection is one of the safety management ways used to verify the non-conformities, however, due to the uncertain, dynamic and transient nature experienced in construction sites, this activity ends up demanding a lot of time of professionals (Toole, 2002). In regard to this, it is observed that despite the importance of Collective Protection Equipment

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(CPE) inspections in risk prevention, these are often neglected by most construction companies. These facts are increased by the demand for activities in difficult access areas, making it difficult to guarantee a safe working environment (Cambraia et al., 2010). Therefore, it is observed the need to optimize this process, making safety oversight faster and more accurate.

The use of new technologies, such as the UAS (Unmanned Aerial System) can assist in this growing demand for agility in the safety inspection process, acting as a potential tool for capturing images and videos. This tool provides easy acquisition and use, becoming a promising instrument capable of offering many advantages from the point of view of practicality and quickness in data collection (Kim and Irizarry, 2015). However, Melo et al. (2017) study shows that there is a need of improvement of the safety inspection process using UAS, due to time demanding between data collection and data processing, meaning that new ways to make this system work more efficiently are required, in order to make it more automatic and in real-time.

One solution for this is the automation of processes through the use of image pattern recognition technologies, which have been explored in several industries aiming to optimize the speed of tasks, ensuring the consistency of the data collected and bringing improvements in productivity and reduction of rework (Blanco et al., 2017). Such technologies make use of computer vision methods to segment images, identify patterns and manipulate this information in order to make automated decisions. Those actions are often made through the development of an algorithm capable to incorporate references, being able to apply the learning for several contexts. In regard to that, a variety of professional functions concerning image visualization can be replaced, given that the machine learning is introduced by an expert, ensuring reliability.

Therefore, the possibility of using technologies, such as the image pattern recognition with images collected through the UAS, can contribute to the optimization of safety inspection processes in construction sites. This optimization consists in verifying the normative criteria that can be inspected through visual technologies, using it as a support to the human inspection, reducing its time.

Hence, this paper aims to evaluate the feasibility of automatic recognition of normative requirements related to safety guardrails by means of images obtained with UAS, through experimental simulations.

APPLICATIONS OF UNMANNED AERIAL SYSTEM AND IMAGE PATTERN RECOGNITION FOR SAFETY INSPECTION

The possibility of associating the UAS with other technologies makes this tool an artifact of high potential for use in the most diverse branches of Engineering, with emphasis on construction. In the exploratory study of Irizarry and Costa (2016), an identification and evaluation of the potential applications of visual resources (photos and videos) obtained through flights executed with the UAS in construction sites were presented and, as a result, it was shown the potential of their use for monitoring of the safety conditions in construction sites.

Gheisari and Esmaili (2016) have identified safety practices that can be improved through the use of UAS, such as monitoring workers in areas close to cargo hoists (cranes) and inspecting Personal Protective Equipment (PPE). Gillins, Gillins and Parrish (2016) evaluated the

possibility of using UAS as a substitute for the human action of bridge inspection, since such an act usually involves many risks, high cost and often needs to cause traffic stoppages.

Melo et al. (2017) propose guidelines for safety inspection by imaging with the UAS making use of two case studies conducted through inspection checklists, in which exploratory flights were performed on two different types of construction sites. The results show that the UAS allows a good visualization of working conditions and can provide valuable information about the compliance with safety regulations on site. Therefore, studies evidence the potential of the use of the UAS for jobsite inspection, however, the manual analysis of visual assets stands out as one of the barriers to the use of technology.

In recent years, researchers have focused on developing automation techniques that improve performance in construction in general. Among the studies, one highlight the use of mobile sensors to recognize movement of construction equipment through supervised learning, developed by Akhavian and Behzadan (2015), and the identification of risk situations at the site caused by the use of heavy equipment (Tajeen and Zhu, 2014). Rubaiyat et al. (2016) also sought, through the use of pattern recognition techniques, to inspect the use of helmets by workers at construction sites. In general, studies show that automatic detection techniques are effective, but further studies are necessary in order to evaluate the feasibility of the application of these technologies on construction sites, focusing on faster feedbacks and immediate corrective actions.

COLLECTIVE PROTECTION EQUIPMENT (CPE)

CPE are defined as physical or functional barriers intended to prevent accidents, but not incorporated into the employee's body or clothing (Hollnagel, 2004). Those equipment should have the capacity to protect more than one person simultaneously and, once installed, do not require any additional action by workers (Peñaloza et al., 2017). Compared to PPE, CPE are of direct responsibility of the manager, not depending on the use or not of the workers, making the practice theoretically easier to implement (Peñaloza et al., 2017).

According to Peñaloza et al. (2017), CPE are the most effective strategies to reduce injuries and deaths caused by falls in height, when allowed by working conditions. Despite this, Cameron et al. (2008) affirm that, at the time of choosing and deciding to implement the protection system, other aspects end up being evaluated, such as cost, term and impact on the main work to be performed.

It is therefore important to understand the requirements and means of implementation of these systems in order to ensure that their application is appropriate to their context and ensure the effectiveness of their operation. In Brazil, NR-18 (Conditions and Work Environment in the Construction Industry) is the standard responsible for the basic requirements to be fulfilled at the project design, execution and installation of those equipment, aiming at minimizing or eliminating occupational hazards (BRASIL, 2015).

Among the fall protection equipment, one can highlight the safety netting systems and the guardrails. Both equipment work to prevent or limit the fall of the worker and materials and their main difference is that the safety netting are flexible elements while the guardrails are rigid structures. The guardrails can have different types of materials, however, regardless of the material used, it is important that the safety team make periodic preventive inspections to detect possible displacements or wear and tear that could endanger the worker's life.

METHODOLOGY

The research strategy used in this paper is the experimental simulation, performed according to the following steps: (a) definition of guardrail requirements that could be automatically inspected, based on NR-18 (BRASIL, 2015) and existing data base, (b) Test-bed experiments, (c) qualitative and quantitative data analysis.

Definition of guardrail requirements

For the justification of the use of guardrail as a relevant CPE that could be automatically inspected, an existing data base of 1401 images from previous studies (Melo et al., 2017) was used. Among the CPE analyzed in this data base, the guardrail equipment represents around 17% of the observation, only less represented than signalization of route area protection. The guardrail was also selected due to its easy visualization through the images and because of its importance, given that height accidents have great concern through all construction accidents.

The identification of the normative criteria concerned to guardrail was based on the NR-18. The following nine inspection items determined by the NR-18 for guardrails were selected to be analyzed: (1) Presence of rigid provisional guardrail type closure on all sides of slab, (2) Guardrail material must be of wood or other of equivalent properties, (3) The material used in guardrail is of good quality, without cracks that compromise its strength, (4) The rigid bulkhead shall be firmly attached to the structure of the building, (5) The guardrail is more than 1.20 meters high, (6) The guardrail has an intermediate crossbar (mid-rail) at 0.70 meters in height, (7) The guardrail has a toeboard with a height of 0.20 meters, (8) The spaces between the posts must be filled with screens and fixed to the inside of the posts, and (9) The maximum distance between the posts is 1.50 meters.

A second analysis of the existing data base of 1401 images was carried out in order to analyze the nine inspection items determined by the NR-18 for guardrails, and to identify the most suitable requirements for the development of the algorithm for UAS-Image Pattern Recognition. It was observed that the greatest difficulty of inspection came from the analysis of the material and the fixation system used for the selected equipment. However, issues regarding the dimensions, location and physical condition of the guardrails could be easily checked because of its easy visualization. In regard to that, it was decided to focus the study in the analysis of its dimensions (Table 1), items (5), (6) e (9), following the rules of NR-18 (BRASIL, 2015).

Table 1: Guardrails dimensions defined by the NR-18 (BRASIL,2015)

Constructive Element	Dimensions
Toeboard – Toprail	1,20 m
Toeboard – Midrail	0,70 m
Post - Post	≤1,50 m

Test-bed experiment

For the test-bed experiment, a guardrail prototype was developed, in which a set of markers were fixed to assist in the measurement of the guardrail dimensions by means of pattern recognition in images. Two different marker colors (blue and yellow) were used for the experiment.

For the images processing, an algorithm was developed in MATLAB platform to identify

automatically the guardrails dimensions. The algorithm developed according to Figure 1 counted on the aid of markers previously positioned in the prototype to indicate the dimensions of the constructive elements used in the object of study. It was used, as basis, the RGB color system (Red, Green, Blue), named for a model based on trichromatic color theory applied on most computer screens. The idea of the RGB system for this use is to represent each pixel with intensity values for red, green and blue colors. Thus, a color in the RGB model can be referred to by the amount of red, green and blue it contains, which can range from 0 to 255 for each one. With this conception, for each marker color used, a range of RGB values was specified, so that would be used as reference at the time of reading the images for their identification by the program.

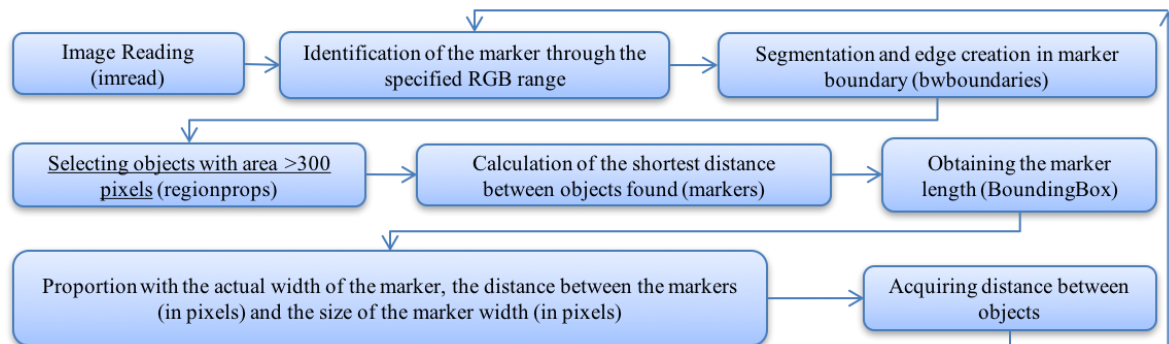


Figure 1: Flow diagram for logical concept of the developed algorithm

For data collection of the test-bed experiment, two UAS flights for images registration were performed with an average time of 15 minutes each. The flights were conducted with different distances between UAS and the prototype (2, 4, 6, 8 and 10 meters) and different UAS camera angulation (0°, 15° and 30°). A total of 419 photos were recorded.

Data Analysis

The data analysis aimed to evaluate the application of pattern recognition images collected with UAS based on the prototype developed. This analysis took into account the following variables: (a) the color and texture of the markers fixed in the prototype, (b) distance between prototype and UAS during data collection, in order to identify the distance that provides the least error in data acquisition, (c) angulation of the UAS camera, trying to understand if probable distortions due to angulation would significantly alter the results obtained, and (d) reliability of the data obtained for each of the variables and the system in general. In addition, a set of positive and negative aspects were analyzed to discuss the feasibility of using technologies adopted in real construction sites.

FINDINGS AND DISCUSSION

This section presents the main results of the study concerned the feasibility analysis of the application of pattern recognition images collected with UAS for guardrail inspection.

Evaluation of the UAS-Image Pattern Recognition System Application

From the 419 images collected and processed from the two flights, 303 were successfully recognized, indicating that when they were upload into the algorithm for processing, the program was unable to read the markers properly, discarding about 30% of the images.

As possible causes for the failures of almost 30% of the captured photos, it is believed that most of them were (a) incorrectly read by the algorithm because the pixel color in the markers was affected at the time of image capture, where most of the marker's pixels are not in the pre-established color range, affecting the delimitation of the element and damaging the distance calculations (Figure 2a), or (b) the algorithm found another element of the image within the specified RGB range and identified it as a marker, since the photos frame a series of elements that make up the façade and the surroundings of the building, not just the guardrails itself (Figure 2b).

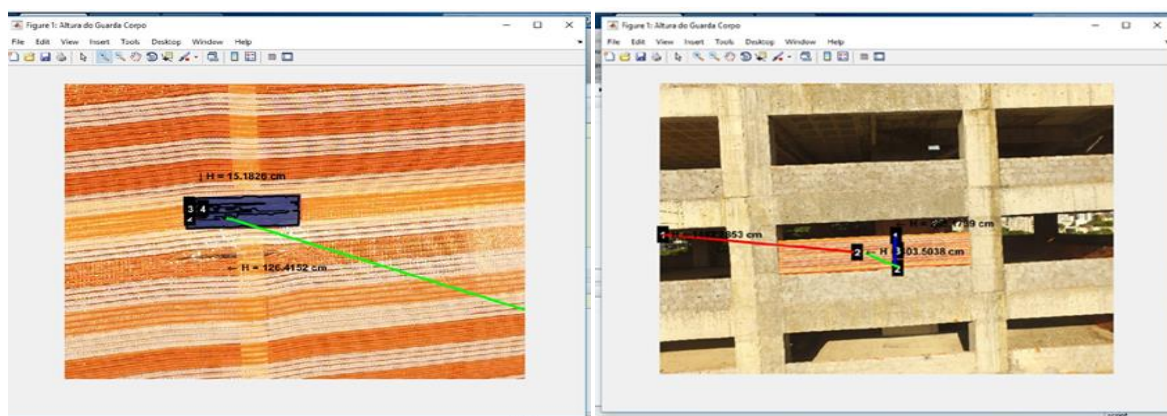


Figure 2: a) incorrect processing where a random element was recognized as marker; b) failure caused by the incorrect division of the marker in two or more.

The results indicate that, in the great majority of cases for failure (a), it was the blue marker that was responsible for the failure, noticing that a large number of high intensity pixels (close to the color white) was seen in the image at the marker region. Among the external factors that could cause such an occurrence, stands out the incidence of sunlight which was reflected by the material used to make the blue markers and influenced in the pixel colors read by the computer. Also, the blue marker was used to calculate the distance from post to post, obtaining the largest error among the three calculated dimensions (Table 2). Those facts suggest that such marker was not the most adequate for the study, probably because of the material and color chosen.

The results presented in Table 2 show the average and the error for all distances considered. It was concluded that there is no consistent relationship between the accuracy of the results obtained with the algorithm and the increase or decrease of variables. Although, it was observed that, among the distances tested (2, 4, 6, 8 and 10 meters), the position that obtained the better results was the image collected with UAS at 4 meters (Figure 3). Additionally, 91% of the photos that were taken at a distance of 4 meters were successfully processed, meaning that dispensed the need for manual correction and brought the system closer to an automated model, also supporting its better accuracy when compared to the other distances applied. The real distance between post – post is 116 cm (less than 150 cm, according to the standard – Table 1).

Table 2: Guardrails dimensions defined by the NR-18 (BRASIL,2015)

Distances UAS- Prototype (m)	Toeboard – Toprail (d1)		Toeboard – Midrail (d2)		Post – Post (d3)	
	Average (cm)	Error (cm)	Average (cm)	Error (cm)	Average (cm)	Error (cm)
2,00	115,36	4,64	65,35	4,65	114,71	1,29
4,00	123,02	3,02	69,85	0,15	120,52	4,52
6,00	125,36	5,36	73,59	3,59	122,95	6,95
8,00	123,52	3,52	71,43	1,43	122,46	6,46
10,00	125,97	5,97	72,42	2,42	124,68	8,68

In the case of camera angulations, the errors were smaller for an angulation of 15° when compared to the other variations (Figure 3). Therefore, it is possible to infer that the distance of 4 meters from the prototype associated with slope of the UAS camera at 15° to capture the images can provided better results, with lower error values.

Table 3: Results obtained from the images.

Camera Angulation (°)	Toeboard – Toprail (d1)		Toeboard – Midrail (d2)		Post – Post (d3)	
	Average (cm)	Error (cm)	Average (cm)	Error (cm)	Average (cm)	Error (cm)
0°	125,36	5,36	73,59	3,59	122,95	6,95
15°	122,66	2,66	69,01	0,99	120,94	4,94
30°	121,93	1,93	63,08	6,92	122,69	6,69

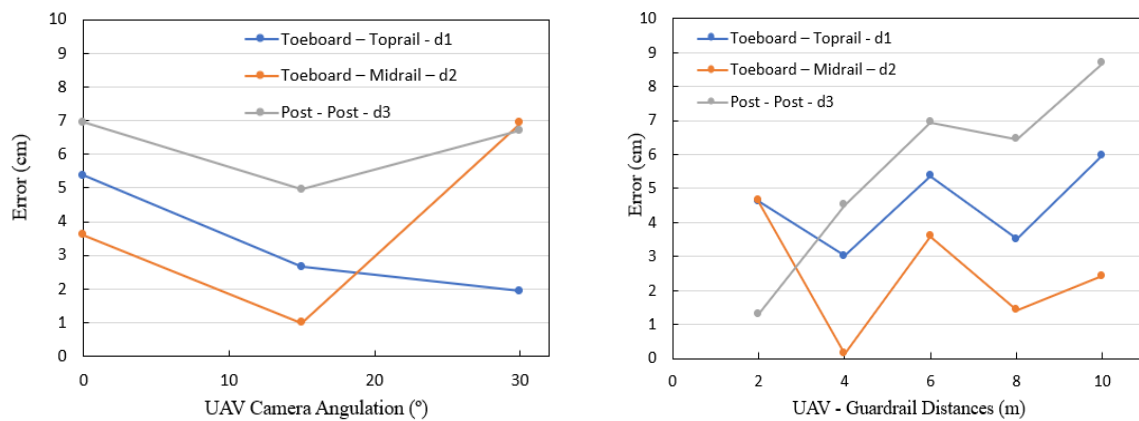


Figure 3: Relations between results obtained with image processing for the different parameters and errors obtained.

During data treatment, it was noticed that due to the proximity of the camera to the prototype, some distortions were also generated mainly in regions near by the border of the photo. For example, it was notable for d3 (Post - Post), at a 2 meters distance, that there was a non-standard point. This can be justified because it is located near by the center of the photo, therefore the distortions problems were mitigated in the calculation of d3.

Benefits and Barriers of UAS-Image Pattern Recognition System Application

By conducting the analysis of the results obtained for a more comprehensive view, some aspects could be observed in relation to the UAS-Image Pattern Recognition system as a whole, considering the practical perspective of the whole operation, meaning the barriers and benefits

of the application into a construction site. For this, the procedure was separated into four distinct stages: (1) Making and installing markers; (2) Photo collection with the UAS; (3) Image Processing, and (4) Decision making (safety inspection).

For each stage, factors that directly influenced the determination of the procedure to be or not to be adequate to the practical implementation were evaluated, considering: (a) time taken to perform the stages, (b) necessary resources, (c) ease of execution and (d) reliability of results. The conclusions were summarized in Table 4.

Table 4: Benefits and barriers of the application of UAS-Image Pattern Recognition system

Stage	Benefits	Barriers
1) Making and installing markers	Few resources needed; Option for applying different types of markers (material, colors, etc.).	Preference for installation of the markers before manufacturing the guardrail, for guarantee the correct allocation.
2) Photo collection with the UAV	Fast procedure; Ease of use of the equipment, without the need of professionals; Reduction of operator displacement, allowing the visualization of the guardrails at great heights; Easy portability of the UAV.	Flight hindered by external interferences such as wind and the incidence of sunlight; Minimal of two operators to perform the image collection (one pilot and one observer).
3)Image Processing	Ease use of MATLAB platform and development of the algorithm without the need for in-depth knowledge on the subject; Flexibility of the technique used (RGB), being applicable to different types of markers or other equipment.	Need of improvement in the algorithm to process multiple images and at the same time and to generate detailed reports; Reliability of the results obtained with the algorithm (error close to 20%); Only parametrizable requirements can be inspected through images.
4) Decision making (safety inspection)	Eliminates the physical measurement of the dimensions of the guardrail; Time reduction for safety inspection when compared to usual methods.	Time taken for the inspector to have access to the information, making it difficult to apply corrective measures in a timely manner.

Besides the benefits and barriers related to the potential of using these technologies, impacts on workers' privacy and risk of accidents were not attempted. Costa *et al.* (2016) carried out a survey identifying the issues in construction sites that used the UAS for safety inspection. The results show that the application of UAS did not interfere significantly in the construction activities and that the privacy or risk of accidents were not highlighted by workers. However, a case study in a real construction site could be applied to verify such issues, since it can be an unpredicted effect.

CONCLUSIONS

This paper aimed to evaluate the feasibility of automatic recognition of normative requirements related to guardrails by means of images obtained with UAS. A test-bed experiment was performed involving the execution of a guardrail prototype, images recording with UAS, development and application of algorithm for data processing and data analysis. The study allowed to understand important issues related to the use of pattern recognition techniques for safety inspection on construction sites, including barriers and opportunities.

It was concluded that the system has advantages, especially in the optimization of specialized

labor, reduction of displacements and ease of execution, showing a tool with potential to be implanted. However, there are still gaps that need to be filled mainly related to three important factors: 1) systematization of the execution stages, 2) completely automation of processes and 3) possibility of applying corrective measures in real time. Besides, other limitations were observed in regard to the full guardrails inspection process in which some non-measurable requirements, such as the CPE attachment to the building and its stability could not be visualized through the aerial images, and therefore precluded its entire inspection.

Therefore, further study is necessary in order to fulfill the blanks of integrating the UAS-Image Pattern Recognition system to the *in loco* safety inspections, ensuring that non-measurable issues and unintended consequences are also analyzed. Nonetheless, it is expected that the use of visual technologies can contribute in a positive way to the activities that make up the entire process of safety inspection, improving workplace safety and health in construction sites.

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AN APPROACH TO AUTOMATIC RECOGNITION OF CONSTRUCTION WORKERS' UNSAFE BEHAVIORS: A CONCEPTUAL FRAMEWORK

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The construction industry remains high accident rate and workers' unsafe behaviors are the main cause for the accidents. It's vital to detect and control these unsafe behaviors. Compared to traditional approaches (e.g. site observation), wearable-sensor-based or computer-vision-based methods make it possible to automatically recognize unsafe behaviors. However, workers' behaviors are quite complicated and their recognition usually relies on the combination of various elements (e.g. workers' actions, work types) while current studies mainly focus on single-element-based behavior recognition. This study proposes an approach to automatic recognition of construction workers' unsafe behaviors by combining multiple elements. First, critical elements for behavior recognition were selected based on literature review and different scenarios were established through the combination of these elements. Then a flow chart was developed to showcase the recognition process and a case study was conducted to assess the approach as well. The findings show the potentials to recognize unsafe behaviors using fewer elements for efficiency improvement. This study provides a systematic insight into behavior recognition and lays a foundation for onsite warning and safety management in the long run.

Keywords: Construction worker, Unsafe behavior, Automatic recognition, Element, Scenario.

INTRODUCTION

The construction industry plays an important role in national economy. However, high accident rates and casualties continue to hit the industry. According to International Labour Organization (ILO), construction workers are 3-4 times more likely to die from work accidents than workers in other industries (Comaru and Werna, 2013). Health and Safety Executive (HSE) displays similar results (HSE, 2017). Previous studies find that workers' unsafe behaviors are the main cause for the high accident rate (Suraji et al., 2001), thus it is necessary to effectively detect and control workers' unsafe behaviors.

Though relevant measures (e.g. onsite safety observation and inspection, safety monitoring by surveillance cameras) have been taken to detect and control workers' unsafe behaviors, they usually require time-consuming onsite observation or strenuous manual recognition through massive videotapes, showing limited effects and calling for more effective measures, especially automatic ones, to promptly and accurately recognize workers' unsafe behaviors from big volume of data, making it possible for onsite warning and safety management in the long run.

Recently, wearable technology or computer vision makes it possible to automatically recognize

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workers' unsafe behaviors. Specifically, workers' location or motion data can be acquired by wearable sensors (i.e. positioning tags, accelerometers) or extracted from images or videos, and then features are trained for behavior classification and recognition. However, workers' unsafe behaviors are quite complicated for recognition, which usually involves several elements (e.g. workers' actions, their relationships with surroundings) to be recognized while current studies mainly focus on single-element-based behavior recognition, which may impact the accuracy of recognition, as the same action in different environment may be safe and unsafe respectively.

This study proposes an approach to automatic recognition of construction workers' unsafe behaviors, which is structured as follows. Literatures regarding classification, description and recognition of workers' unsafe behaviors are first reviewed, followed by the methodology section. Then the approach is developed by extracting critical elements based on literature review, building different scenarios through the combination of these elements, and forming a flow chart for behavior recognition. Finally, a case study is introduced to showcase how the proposed approach works and test its performance, with discussion and conclusions provided.

RELATED WORK

Classification of workers' unsafe behaviors

Unsafe behaviors refer to risky or dangerous behaviors in violation of safety rules or regulations which may cause accidents (Man et al., 2017). Unsafe behaviors can be classified from different perspectives (e.g. unsafe behaviors due to internal or external factors, conducted unconsciously or consciously). The Chinese Classification Standards for Casualties of Enterprise Employees (GB6441-86) provided 13 categories of unsafe behaviors including erroneous operation, use of unsafe equipment, approaching dangerous places, working beneath lifting work, neglecting the use of necessary personal protective equipment (PPE), etc. Cheng and Wu (2013) figured out workers' unsafe behaviors as the main factor of major accidents in Taiwan, such as unsafe postures, improper use of equipment, failure to wear PPE, and entering dangerous areas. Guo et al. (2014) summarized various construction workers' unsafe behaviors into three categories: approaching dangerous areas, misuse of PPE and violating operation regulations. Besides, some studies provided detailed examples of construction workers' unsafe behaviors by developing a checklist based on safety manuals, accident records and onsite observation (Han and Lee, 2013; Guo et al., 2016). This section displays that workers' unsafe behaviors are mainly related to PPE and equipment use, working postures/actions and working environment/surroundings. Clear classification of the unsafe behaviors serves as the first step of the whole recognition process.

Element-based description of workers' unsafe behaviors

As a transitional step from manual behavior classification to automatic behavior recognition, it poses a question that how to recognize these unstructured unsafe behaviors. Guo et al. (2016) presented a good way to break down these behaviors by semantically describing them with several elements (e.g. action, location, resource, object worked on and nearby object and action) though some elements such as PPE use are not considered and spatial relationship among entities are not further figured out, which are also necessary for accurate recognition of workers' unsafe behaviors. Therefore, it's of great significance to nail down the critical elements, the combination of which can represent a worker' unsafe behavior, and the accurate recognition of these elements can support the recognition of the target unsafe behavior.

Automatic recognition of workers' unsafe behaviors

Based on the two sections, some elements can be selected as the candidates for the critical elements and now it comes to the question that whether it's feasible to recognize these elements from a technical perspective. Current studies on behavior recognition mainly focus on the recognition of a single element, including recognition of PPE use, workers' actions and their relationships with surroundings. Basically, for each element, there are approaches based on wearable sensors and computer vision. In terms of recognition of PPE use, some studies attach tags on PPE so that they can be detected by relevant readers (Barro-Torres et al., 2012). However, successful detection also occurs when PPE is close to the worker and the readers rather than being used by the worker. To overcome this disadvantage, some studies put pressure sensors in the hard hat to figure out whether it is worn (Dong et al., 2018). In such cases, PPE without sensors cannot be detected and these sensors may interfere workers' normal operations to some extent. Approaches based on computer vision don't have such concerns by detecting PPE from site images or videos. For example, Park et al. (2015) detected hard hats based on Histogram of Oriented Gradient (HOG) features and Support Vector Machines (SVM) while Fang et al. (2018) applied deep learning method in hard hat detection. Action recognition is another important aspect for behavior recognition. Approaches based on wearable sensors and computer vision both show potential for action recognition but the former mainly focus on productivity analysis rather than safety monitoring. Safety-related action recognition approaches are mainly developed based on computer vision. For instance, Han and Lee (2013) and Ding et al. (2018) recognized ladder-related unsafe behaviors based on 3D human skeletons and deep learning method respectively, while Yu et al. (2017) classified three unsafe behaviors using distinctive joint angle ranges. Besides, some studies focus on relationship between target worker and his surroundings (e.g. openings, edges, machines, vehicles) to detect access to dangerous areas or to predict possible collision. Guo et al. (2014) mapped workers' personal information (e.g. work type) and location data obtained by positioning techniques into BIM models where dangerous areas (e.g. openings, edges) are pre-defined to figure out whether target worker is in dangerous areas. Chi and Caldas (2012) and Kim et al. (2015) recognized various entities based on computer vision and then detected risk factors such as close proximity between the entities (e.g. between a worker and a heavy machine). The approaches above provide technical support for behavior recognition but they mainly focus on the recognition of a single element. They should be combined in order to achieve more accurate results for workers' behavior recognition.

To sum up, literatures in the three sections answers what unsafe behaviors are, what to recognize in an unsafe behavior and how to recognize them, showing the potential of work type, PPE use, workers' actions and their relationships with surroundings as critical elements for recognition.

METHODOLOGY

The study aims to propose an approach to automatic recognition of construction workers' unsafe behaviors. Figure 1 illustrates the research framework. First, literatures with regard to workers' unsafe behaviors and their recognition methods are reviewed to figure out important elements for behavior recognition and technical support for the recognition of these elements so that critical elements can be sorted out as the first step of the approach development. Then scenarios are built through different combination of the critical elements. Based on the previous two steps, a flow chart of behavior recognition is developed. Finally, a case study is conducted to display how the approach works and test its feasibility.

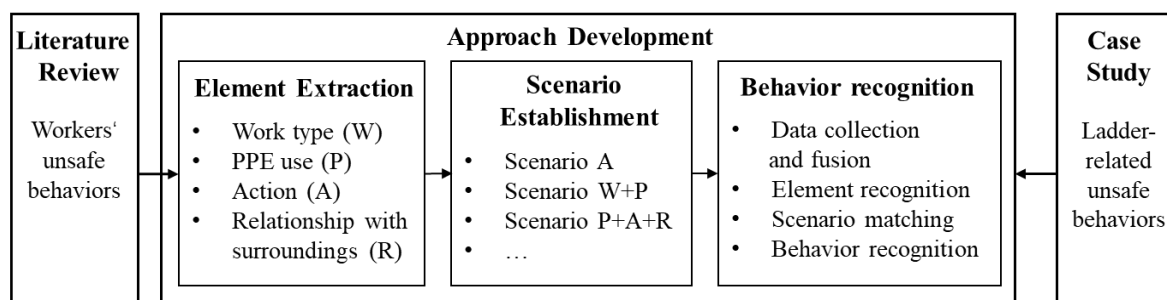


Figure 1: Research Framework

APPROACH TO BEHAVIOR RECOGNITION

The framework of the approach to automatic recognition of construction workers' unsafe behaviors is developed following three steps: element selection, scenario establishment and flow chart development for behavior recognition.

Selection of critical elements

Based on the literature review, four components of a behavior are selected as critical elements for workers' unsafe behavior recognition: a worker's work type, PPE use status, action and relationship with his surroundings.

1) Work type

Serving as the most basic identity information, work type refers to the type of work that a worker is engaged in. Each worker has his own work type (e.g. carpenter, scaffolder) and he should do the work in accordance with that. In this paper, we assume that every worker is qualified for his own work type. If a worker conducted work (e.g. operating a specific machine, entering a certain area) beyond his work scope, it's considered as unsafe. Technically, a worker's work type can be obtained roughly by the color of his hard hat or directly obtained from the labels attached to him where his work type has been pre-stored inside.

2) PPE use

PPE use refers to whether a worker properly and correctly wear or use necessary PPE (e.g. hard hats, safety belts) during his work which are in good condition and meet the requirements of certain work. There are several implications regarding PPE use. First, necessary PPE refers to the equipment that a worker must wear or use when conducting certain work, for example, hard hats are always necessary and compulsory for all construction workers in all circumstances while a safety belt is a must for a scaffolder during his work. A worker should be equipped with a specific package of PPE in accordance with his work type. Second, PPE should be in good condition, fit the worker well and meet the requirements of certain work. For instance, it's risky to wear a damaged hard hat which cannot protect the worker effectively, or to wear an oversized safety suit when operating a machine as the suit is likely to be drawn into the machine roller. Third, PPE should be worn or used properly. For example, a worker should make sure the safety buckle of his hard hat is tightly fastened, or he should hang his safety belt higher than him when dismantling ladders at height. In this study, only the first implication is considered for the element of PPE use because the rest are too detailed to be recognized technically or should be recognized with the combination of other elements (e.g. workers' actions).

3) Action

Action refers to a sequence of workers' postures, such as walking, climbing, or squatting. Simple actions with distinctive features can be recognized with static postures but in most cases, it is difficult to do so, especially when it comes to similar actions such as ascending and descending a ladder, not to mention the classification of safe and unsafe practices for the same activity. Some actions are always considered as unsafe in all circumstances while others require supplementary information (e.g. surroundings) for judgement, for example, it is difficult to tell what a worker is exactly doing only with the action of putting up a hand.

4) Relationship with surroundings

Relationship with surroundings mainly refers to the spatial relationship (e.g. proximity between A and B, A is left to B) between a worker and his surroundings, including static surroundings (e.g. openings, edges) and dynamic surroundings (e.g. other workers, vehicles, machines). If two entities are too close to each other, they are likely to collide. Sometimes, spatial relationship has further implications, for instance, if two workers are adjacent to each other, they may collaborate on a certain work. In this study, we focus on the recognition of spatial relationship without further implications. Entities of interest are first recognized and their proximity to the target worker (i.e. three-dimensional distance between the centroids of the entities) is calculated. If the value is below a pre-defined threshold, the entity is considered as a component of the worker's surroundings and their spatial relationship is represented in the form of 'worker-relative position-proximity-entity', for example, 'worker-left/near the front-1m-excavator' when the target worker is on the left side of an excavator, close to the its front and 1 metre away from it. It's noteworthy that there exists a difference, for example, when describing the relative position between a worker and a vehicle and between a worker and a ladder because the focus is different in terms of safety (e.g. if a worker climbs too high on a ladder, it's dangerous, but it's not the same case to a vehicle). Besides, when it comes to hand-held tools such as brushes, drilling machines, the relationship can be described in the form of 'worker-left/right hand-entity'. Therefore, for a specific entity, possible relative positions to it should be defined prior to the recognition stage. The entity close to the target worker is first recognized and their spatial relationship is described based on the pre-defined relative positions attached to the entity.

Establishment of scenarios

Combining the critical elements above, several scenarios are established with a specific example provided for each (see Table 1). For each scenario, only with the combination of the given elements can the according unsafe behavior be recognized. A checklist of unsafe behaviors can be developed and behaviors can be classified according to different scenarios, followed by a structured template database for behavior recognition. Table 1 provides the basic rudiment of the database, for example, Scenario 2-1 denotes it's the first scenario requiring two elements to be combined for behavior recognition and then the unsafe behavior 'Do not wear a safety belt as a scaffolder' can be labelled 2-1-1 as the first unsafe behavior under this scenario.

Table 1: Partial scenarios for unsafe behaviors

Scenario	Element	Example of Unsafe behavior
1-1	P	1-1-1 Do not wear a hard hat.
1-2	A	1-2-1 Overreach to one side with one foot standing.
1-3	R	1-3-1 Be on the top or pail shelf of a stepladder.

Scenario	Element	Example of Unsafe behavior
2-1	W+P	2-1-1 Do not wear a safety belt as a scaffolder.
2-2	W+A	2-2-1 Wedge by a painter without qualification for wedging.
2-3	W+R	2-3-1 Work at height by a carpenter without permission.
2-4	P+A	2-4-1 Wedge without eyeglasses
2-5	P+R	2-5-1 Approach edges at height without a safety belt.
2-6	A+R	2-6-1 Backwards descend a ladder.
3-1	P+A+R	3-1-1 Drill a hole on a ladder without a safety belt.

Flow chart for behavior recognition

As is seen in Figure 2, at the recognition stage, behavior-related data are collected, and the four critical elements are extracted and recognized on a technical sequence, and then scenarios are searched starting from those with a single element until matched. If there does not exist a matching scenario, the behavior is literally considered as safe. At the preliminary stage when it lacks a wide range of unsafe behaviors, manual check is conducted as the ground truth to compare with the recognition result in case there are recognition errors. If the error derives from a new unsafe behavior outside of the existing database, it will be added as a new template.

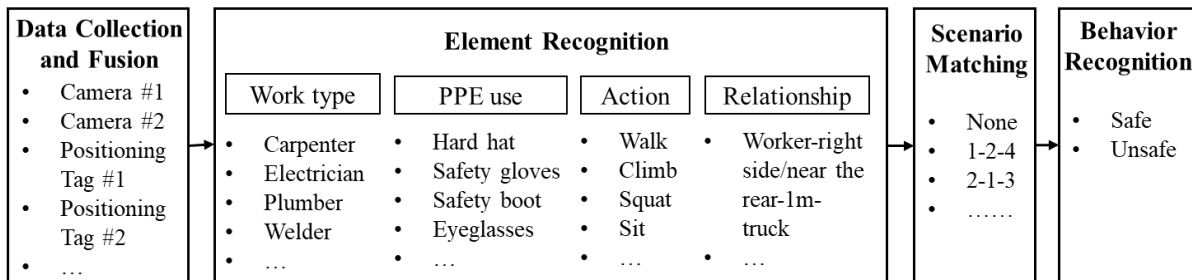

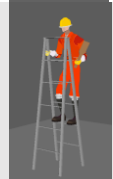


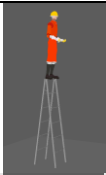
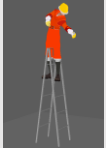


Figure 2: Flowchart of the recognition process

CASE STUDY

In Table 2, six typical behaviors related to stepladders (less than 2 metres) in indoor environment are selected based on various safety manuals, onsite observation and expert interview to showcase how the approach works and test its feasibility.

Table 2: Recognition flowchart of ladder-related unsafe behaviors

Data collection	Element recognition				Scenario matching	Behavior recognition
	Work type	PPE use	Action	Relationship with surroundings		
	Painter	Hard hat Safety suit Safety gloves Safety boots	Climb with two hands gripping	Worker-face/below-0.5m-ladder	None	Safe
	Painter	Hard hat Safety suit Safety gloves Safety boots	Climb with one hand gripping and another curling	Worker-face/below-0.8m-ladder	2-6-2 Hold a tool when ascending a ladder	Unsafe

Data collection	Element recognition			Relationship with surroundings	Scenario matching	Behavior recognition
	Work type	PPE use	Action			
	Electrician	Hard hat Safety suit Safety gloves Safety boots	Stand	Worker-top-1.75m-ladder	1-3-1 Be on the top or pail shelf of a stepladder	Unsafe
	Painter	Hard hat Safety suit Safety gloves Safety boots	Stand with body tilting to one side	Worker-two sides/below/over-1.5m-ladder	2-6-3 Overreach on a ladder	Unsafe
	Painter	Hard hat Safety suit Safety gloves Safety boots	Walk	Worker-two sides/below-1.5m-ladder	2-6-4 'Walk' a ladder	Unsafe
	Electrician	Hard hat Safety suit Safety gloves Safety boots	Stand with one hand stretching forward	Worker-two sides/below-1.5m-ladder Worker-right hand-drilling machine	3-1-1 Drill a hole on a ladder without a safety belt.	Unsafe

FINDINGS AND DISCUSSION

The case study has displayed the recognition process of the proposed approach and verified its feasibility theoretically. Several findings from the case study are discussed as follows.

Compared to the other three elements, the element 'relationship with surroundings' is found more difficult to describe, especially the relative positions between entities. In this case, relative positions to the ladder are defined prior to recognition, for example, 'two sides/below(above)' denotes the worker steps on two sides of the ladder with his knees below(above) the top of the ladder, 'face (back)' means the worker faces (turns back to) the ladder, and 'over' signifies the worker overreaches or stretches to a side. There are safety-related implications when describing the relative positions to the ladder, for instance, it's dangerous for a worker to step too high where his knees are above the top of the ladder in which case he is unable to clamp the ladder with his legs and more easily to fall down, especially when he is overreaching. For the small tools such as a drilling machine, the relationship is described simply with the word 'hand'.

Another finding is that the elements of action and relationship with surroundings seem more critical in the case above as half of the behaviors are recognized based on the two elements. Basically, it is more efficient to recognize an unsafe behavior with fewer elements during scenario matching. Some behaviors can be redistributed into a simpler scenario with less elements if accuracy is guaranteed. For the last behavior in the case study, the drilling machine is recognized because the action of standing with one hand stretching forward is not distinctive enough for classification while for the second behavior, the tool is not recognized because the action is more distinctive though the ladder still needs to be recognized because climbing a ladder shares similarity with climbing stairs in which case holding an object in one hand with another hand holding the handrail is safe. If the action itself can tell climbing a ladder from climbing stairs due to certain differences,

then the ladder is unnecessary to be recognized.

Though the case doesn't focus on technical aspects of element recognition, they are the most time-consuming step during the whole recognition process. A technical sequence exists in the recognition process, which depends on the technology adopted, for example, if all the elements are recognized based on computer vision, object detection is the top priority, followed by object tracking and action recognition. That is to say, when combining the elements together for behavior recognition, the recognition methods for the critical elements should also be merged effectively to streamline the whole recognition process and improve efficiency.

CONCLUSIONS

This study proposes a conceptual framework for automatic recognition of construction workers' unsafe behaviors through selecting critical elements from an unsafe behavior, establishing scenarios based on element combination and recognizing unsafe behaviors through element recognition and template matching. A case study of ladder-related unsafe behaviors was conducted showcasing the recognition process of the proposed approach and the findings show the potential for some unsafe behaviors to be recognized with less elements for efficiency improvement. This study provides a novel approach to behaviour recognition, laying a foundation for further applications such as warning and safety management in the long run.

Meanwhile, some limitations require future work. First, a complete checklist of unsafe behaviors should be set up to examine whether the selected elements can support their accurate recognition. If not, missing information should be figured out and added. Besides, the study doesn't reach far to technical aspects. In the future, the approach will be tested on a technical level to figure out the most time-saving and accurate but the least intrusive method to achieve good recognition results while minimizing the impact on workers so that warnings can be given promptly and properly and safety management in the long run can be conducted effectively. We will also take human right into account by talking with the workers and taking their advice before installing relevant devices. Other issues such as data fusion will also be considered.

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PREDICTORS OF SAFETY TECHNOLOGY ADOPTION IN CONSTRUCTION

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Prior studies indicate that safety performance is one of the major determinants of overall organizational success and project performance outcomes. Nevertheless, safety performance in the construction industry is still unsatisfactory and a major source of concern to construction stakeholders. In other industries where safety performance has improved, technology is leveraged extensively in order to reduce worker exposure to potential hazardous situations. Whereas, in the construction industry, the adoption of technology has been limited; although recent trends indicate an upturn in the use of technology in managing construction operations. Researchers argue that further technology adoption is needed especially with respect to safety in order to improve safety performance in the construction industry. The present study describes the intersection between safety and technology, presents the current state of technology use in safety management, proposes a technology adoption framework informed by a review of existing literature, and presents insights collected from 257 construction professionals on how to improve safety technology adoption in construction. Results from the study indicate that the use of technology in safety management is limited and currently only one-fifth of the construction industry in the US, or less, incorporates advanced technologies such as drones and wearable devices to improve safety management. In total, the framework includes 26 predictors distributed into four categories influencing safety technology adoption in construction: environment-related, individual-related, organization-related, and technology-related. Furthermore, findings from the survey indicate that all identified predictors are important to improve safety technology adoption. It is expected that the proposed technology adoption framework and the identification of influencing predictors can help improve the adoption of safety technology in construction.

Keywords: Construction safety, Safety technology, Innovation management, Adoption predictors.

INTRODUCTION

The importance of the construction industry to economic development cannot be overlooked. In 2016, the construction industry contributed approximately \$793 billion to the US Gross Domestic Product (GDP) (BEA, 2017). To produce this level of output, the construction industry relies heavily on people. In fact, the US construction industry employs approximately 70 million people and the employment rate has been steadily increasing especially over the past five years (BLS, 2018). Although the construction industry spurs the economy positively through employing a relatively high number of people, the reliance on human input as a core component in the construction process comes at a high

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cost. Poor project performance, which emanates from both the reliance on people and the dynamic and fragmented nature of the industry, is another serious concern in the industry. Over the last decade, the US construction industry has constantly recorded the highest number of workplace fatalities compared to other industries (BLS, 2017). In fact, a construction worker dies every nine hours in the US (BLS, 2017).

To reduce the number of injuries and fatalities in the construction industry, researchers and practitioners have focused on improving hazard recognition training methods, improved onsite safety supervision, job hazard analysis, and other traditional safety management methods (Hallowell and Gambatese, 2009; Jeelani et al., 2017). Lately, innovation methods such as the use of technology has shown momentum as effective means to enhance workplace safety conditions. Technologies such as Building Information Modelling (BIM), laser scanning, Unmanned Aerial Vehicles (UAV), and wearable devices have been implemented on construction projects to improve worker safety. However, a recent study conducted by the Center for Construction Research and Training (a.k.a., CPWR) indicates that only a small fraction (less than 25%) of sampled construction companies utilize emerging technologies for safety management (SmartMarket Report, 2017).

As more technologies are developed or adapted for safety purposes, it is essential to unearth ways to improve the integration of technology within safety management practices. In most cases, a technology goes through three phases prior to becoming a standard practice in an organization. These phases include technology adoption, implementation, and acceptance (or utilization). Given the level of fragmentation within the construction industry and the different construction means and methods adopted among construction organizations, it is essential to develop a technology adoption framework regardless of type of organization. This framework should be compatible with traditional project management practices typically used in construction especially with respect to safety technology adoption. Current literature on the intersection between safety and technology focuses primarily on evaluating the effectiveness of safety technologies and assessing the Return-On-Investment (ROI) of implementing safety technologies (Nnaji et al., 2018a). Technology effectiveness and ROI are two of several predictors that could influence the potential adoption of safety technologies. The goal of this paper is to investigate predictors of safety technology adoption in the construction industry. It is believed that increased safety technology adoption can curb the increasing number of workplace injuries and fatalities in the construction industry. The present study expands on findings from a prior study conducted by the researchers (Nnaji et al., 2018b).

LITERATURE REVIEW

Safety management is the application of project management techniques and best practices to improve workplace conditions and mitigate potential workplace hazards (Hinze, 1997). However, the effectiveness of many management techniques and best practices in influencing safety performance outcomes remains uncertain. That is, most project management techniques and best practices implemented to enhance workplace safety conditions focus on improving employee awareness and behaviors as they relate to safety, as opposed to eliminating potential workplace incidents. That being said, it should be acknowledged that hazard elimination in construction is not always feasible and, in many cases, construction stakeholders find themselves unable to eliminate workplace hazards. In this case, lower levels of risk controls, such as administrative controls, should be used instead. Nevertheless, administrative controls,

such as improving employee awareness and behaviors, may or may not eliminate workplace injuries and fatalities. Because of this limitation, construction stakeholders have started to turn their eyes toward other potential methods to influence project safety performance such as design for safety and the use of technology (SmartMarket Report, 2017). The present study focuses primarily on the use of technology to improve safety in design and construction. In this regard, previous studies indicate that the use of technology in the built environment has led to numerous safety and non-safety benefits (Ozorhon and Oral, 2016) although the adoption rates have been relatively slow or at least slower than other industries such as manufacturing (SmartMarket Report, 2017). In the design and planning stages of the building process, construction professionals have been incorporating virtual reality technologies into their projects to minimize potential construction hazards early in the project design phase (Waly and Thabet, 2003). Perlman et al. (2014) conducted an experimental study to examine the impact of technology, especially virtual reality technologies, on hazard identification. The study revealed that most construction professionals, even those with many years of experience, may not be able to identify a high percentage of workplace hazards when using traditional 2D drawings, but the percentage can be significantly improved when virtual reality technologies are utilized (Perlman et al., 2014). The reason that the percentage of workplace hazards identified improved when technology was utilized is that the virtual reality environment enabled through technology adoption helped visualize the physical and functional characteristics of a project, making it possible to determine potential safety and non-safety issues before the start of construction.

Many construction professionals have been using BIM to improve design features (Sebastian and van Berlo, 2010), construction planning activities (Sulankivi et al., 2010), communication among project teams (Ganah and John, 2015), and other project-related processes and outputs. All of the aforementioned improvements are also expected to lead to improved workplace safety performance. Similarly, drones have been recently utilized to improve safety performance in construction. A recent national survey indicated that approximately one-third of construction general contractors use drones to perform safety- and nonsafety-related inspections, such as reality capture (SmartMarket Report, 2017). Performing reality capture especially in high-risk situations can eliminate a significant percentage of workplace risks and lead to improved safety performance outcomes. The use of wearable safety devices, such as smart helmets, has also received substantial attention in construction over the past years (Awolusi et al., 2018) as an effective, easy-to-use, and inexpensive safety tool. Many other technologies have been previously tested and proved to be effective in improving workplace conditions and safety performance outcomes. Nevertheless, the predictors of safety technology adoption in construction on an organization level have not been adequately studied and identified. The present study aims to bridge this knowledge gap by: (1) identifying key predictors that influence adoption of safety technology in construction, (2) developing a safety technology adoption framework, and (3) validating the developed safety technology adoption framework with feedback from a panel of experts on the topic. It is expected that development and validation of the safety technology adoption framework will help construction organizations evaluate the feasibility and suitability of different technology alternatives using a standard and validated evaluation process.

METHODOLOGY

To achieve the objectives of the study, a concurrent triangulation process that relied on a cross-sectional survey of, and in-depth interviews with, construction stakeholders was utilized to provide additional contextual information on predictors of safety technology adoption in construction. First, a review of existing literature on the topic was conducted to identify predictors that influence the adoption of technology. Next, a survey designed by the researchers and approved by Oregon State University's (OSU) Institutional Review Board (IRB) for research involving human subjects was utilized to verify the identified predictors and quantify their level of importance on influencing the final decision on whether to adopt a technology or not. The survey questions were designed using a 5-point Likert-scale ranging from 1 to 5 where "1" represents not important, "3" represents neutral, and "5" represents very important. A pilot test of the survey was launched prior to the dissemination of the survey to determine face and internal validity. Subsequently, the survey was distributed nationally to elicit responses from construction stakeholders on the importance of the identified predictors. The identified predictors were then classified into four categories that influence decisions of safety technology adoption. The categories provided the basis for the safety technology adoption framework developed. Finally, in-person interviews with selected construction contractors were conducted to modify and validate the proposed safety technology adoption framework.

RESULTS AND DISCUSSION

In total, 26 predictors were identified through an integrative review process and expert panel consisting of 12 experts across industry and academia. The description and detail of the integrative review process and expert panel formation as well as the results will be reported in a separate publication. Following a close examination of the identified predictors, the researchers grouped these predictors into four primary categories: environment-related, individual-related, organization-related, and technology-related. These categories were in line with previous research on technology adoption in the field of health science (Wisdom et al., 2013). Furthermore, the grouping process was validated by the expert panel selected for this study.

Construction Safety Technology Adoption Framework

Using the information from the literature review and input from the expert panel, the researchers developed a framework that captures the primary steps in a safety technology adoption process (see Figure 1). Interest in adopting a specific safety technology in an organization is generally instigated by top management within the organization. In certain cases, a front-line worker could recommend a safety technology to the organization's upper management (bottom-up approach) but the top management would determine whether the technology is going to be adopted or not. Following a high level feasibility evaluation to determine if a need exists and if the proposed technology is a feasible tool for the organization, a more detailed assessment takes place. If the technology is not a feasible option, the adoption process is truncated. The detailed assessment phase (innovation assessment) involves the evaluation of the selected safety technology to determine if it meets certain expectations. These expectations are typically tied to the four safety technology adoption categories (environment, individual, organizational, and technology). For instance, an organization would probably either conduct a ROI or seek out information on ROI, if available. ROI is considered one factor among multiple other predictors influencing safety technology adoption. It is hypothesized that

if a technology is perceived to provide acceptable value across all four categories, the potential that the safety technology would be successfully integrated into construction operations increases.

Framework Validation

Initial validation of the proposed safety technology adoption framework was conducted through in-person interviews with a selected sample of construction contractors, as described previously. Project managers from eight highway contracting organizations were interviewed to validate the accuracy of the proposed adoption process. The companies are primarily located in the Pacific Northwest with annual revenue ranging between \$10 million and \$2 billion. Five participants indicated that although their company does not have a structured process for adopting a technology, they believe that the process described in Figure 1 is an accurate representation of the safety technology adoption process in their companies. The other participants' indicated that they have some sort of structure for technology adoption and their structure is similar to the proposed framework.

Accordingly, the researchers believe that the proposed safety technology adoption framework is a reliable and valid representation of how technology is typically evaluated for adoption in the construction industry. Utilizing the expert panel input improves the face validity of the results (Lucko and Rojas, 2010). Similar, the validation process described above improves the external validity of the study results and provides a high level of reliability to generalize the results beyond the sample study to the larger population. It would be helpful, however, if future research extends the validation process to include a larger sample size that is well-balanced and distributed across different geographical regions within the US.

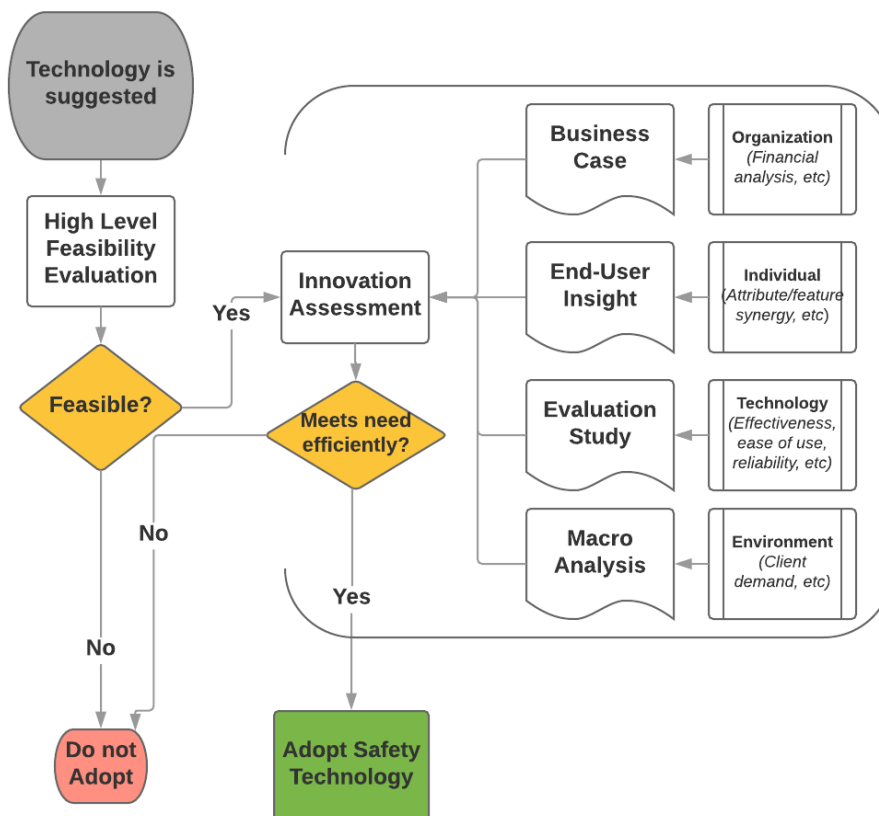


Figure 1: Construction Safety Technology Adoption Process (Adapted from Nnaji et al. 2018b)

Quantification of Safety Technology Predictors Level of Importance

A total of 257 construction professionals responded to the survey between November 21, 2017 and January 31, 2018. The respondents are primarily project managers (21%), project engineers (11%), safety managers and engineers (10%), and construction managers (14%). Fifty-seven percent of the respondent have at least 10 years of experience in the construction industry. Responses were received from the six geographical regions in the US and included companies of various sizes ranging from 10 employees to above 1,000 employees. The annual revenue of the participating companies ranges from \$1 million to above \$1 billion. Results of the descriptive statistical analysis performed on the collected survey responses indicate that all predictors identified were found to be either important or very important on influencing safety technology adoption decisions based on their median values. Table 1 shows that all predictors were rated 3 or above out of 5. The top five predictors are technology reliability (median = 5), proven technology effectiveness (4), technology durability (4), having the required features (4), and the level of training required (4). Five out of the seven technology-related predictors are rated among the 12 most important predictors. This rating suggests that although all four categories are important on influencing safety technology adoption decisions, the characteristics of the safety technology are an essential precursor to adoption. This finding is consistent with past research which suggests that technology attributes are the most important predictors of successful adoption and diffusion of technology (Venkatesh and Davis, 2000). Interestingly, technology predictors associated with cost (finance) are not considered among the top 15 predictors. This discovery is in line with Nnaji et al. (2018a) argument that the value of a safety technology should be judged independent of its cost since cost should be considered a secondary factor.

Table 1: Technology Adoption Predictors - Descriptive Statistics for Safety Technologies (n = 257)

Key Predictors	Category	Median	Mean	Std. Dev.
Technology reliability (technology consistently meets performance requirements)	Technology	5	4.33	0.87
Proven technology effectiveness (technical attributes meeting the stated performance requirements)	Technology	4	4.19	0.89
Technology durability	Technology	4	4.18	0.89
Having the required features (technical attributes)	Individual	4	4.17	0.85
The level of training required	Individual	4	4.13	0.89
The level of technical support required	Organization	4	4.13	0.89
The level of complexity	Individual	4	4.13	0.98
The level of technical support available	Individual	4	4.08	0.89
Client demand	Environment	4	4.01	0.99
Triability (end-user can try technology prior to adopting)	Technology	4	3.99	0.92
Observability (end-user can observe performance prior to adoption)	Technology	4	3.98	0.91
Organization culture (receptive to change or not)	Organization	4	3.97	1.01
Competitive advantage derived from using the technology	Organization	4	3.93	0.93
Versatility (can be utilized for more than one task)	Technology	4	3.93	0.97
Potential cost savings from using the technology	Organization	4	3.9	1.08
Peer influence (How quick users will be able to influence colleagues)	Individual	4	3.88	0.92
Top management degree of involvement (championing the adoption or not)	Organization	4	3.87	1.03
The level of compatibility with current processes	Organization	4	3.83	1.07
Government policy and regulations	Environment	4	3.81	1.08
Industry-level change required for technology adoption	Environment	4	3.78	0.97
The potential level of resistance from employees	Individual	4	3.78	1.03
Capital cost of technology	Organization	4	3.67	1.02

Key Predictors	Category	Media n	Mean	Std. Dev.
Direct competitors adopting similar technology	Environment	3	3.38	1.14
Organizations technology budget	Organization	3	3.36	1.01
Partners adopt similar technology	Environment	3	3.29	0.93
Technology brand and reputation the market	Technology	3	3.28	1.18

Not Important (1), Slightly Important (2), Neutral (3), Important (4), Very Important (5)

CONCLUSIONS

The use of technology in the construction industry is expected to ramp up as the need to improve project performance outcomes continues to increase. As a project becomes complex, potentially leading to more exertion from workers, integrating innovative methods and technology tools that enhance workplace conditions becomes essential. The present study focused on the adoption of safety technology in construction. Review of the existing literature on safety technology suggests that although the use of technology to improve construction worker safety has increased over the past few decades, the utilization of emerging technologies such as drones and wearable devices for safety management is still limited. To improve the adoption of these technologies, and other safety technologies, the important predictors that influence safety technology adoption in construction should be identified. In the present study, the researchers used an integrative literature review process, distributed survey questionnaires, utilized a panel of experts on the topic, and conducted in-person interviews with construction contractors to: (1) identify predictors that influence safety technology adoption in construction, and (2) use the identified predictors to develop and validate a safety technology adoption framework that construction companies can implement to determine whether the adoption of a technology is feasible and meets performance requirements set by the organization.

The results of the study show that there are 26 predictors that commonly influence the adoption of safety technologies in construction. These predictors primarily fall within four categories: environment-related, individual-related, organization-related, and technology-related. A safety technology adoption framework was developed and validated based on the obtained results from the literature review, surveys, and interviews. The framework summarizes the process required to determine the feasibility and suitability of adopting technologies by construction organizations.

It is interesting to mention that the results from surveying 257 construction professionals suggest that although all 26 predictors are important based on their median values (rated 3 or above on a scale of 1 to 5), technology durability, proven technology effectiveness, technology reliability, having the required features, and level of training required are found to be the most important predictors of safety technology adoption. Future research should focus on developing tools that can enhance safety technology adoption in the construction industry.

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SAFETY IN THE USE AND OPERATION OF RESIDENTIAL BUILDINGS: EVALUATION ACCORDING TO THE BRAZILIAN STANDARD NBR 15575

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Several studies have investigated compliance with the performance requirements proposed by the Brazilian performance standard NBR 15575. However, issues regarding safety in the use and operation of buildings have been poorly evaluated in the available literature, although they are fundamental for guaranteeing users and maintenance workers' safety. Considering that, this research aims to evaluate compliance with safety criteria in the use and operation of residential buildings in accordance with the guidelines by NBR 15575. In order to do so, case studies were carried out in four housing buildings from three different construction companies in the city of Recife, in the Brazilian state of Pernambuco (PE). Data collection considered the development and application of a questionnaire as well as the application of an adapted version of the performance standard checklist developed by the Brazilian Council of Construction Industry. It was verified that the level of compliance with the safety criteria in the use and operation varied between 47 and 60% in the companies and the criteria with lower level of attendance were related to the floor and hydrosanitary systems. The results show that, in Recife, the implementation process of NBR 15575 is still slow and requires greater involvement from stakeholders, especially regarding safety in the use and operation of buildings.

Keywords: Brazilian performance standard, NBR 15575, Safety, Use and operation of buildings.

INTRODUCTION

The concept of performance is a worldwide trend defined as the behavior of a building and its systems while it is being used (ISO 1984). That is because the current construction industry pressures, seeking improvements in the quality of products, has boosted the development of performance standards (Meacham, 2010; Silva et al., 2014).

In many countries, the initial step to develop projects is to define the performance of the building and its systems. Then, the constructive technologies to be used are defined. On the other hand, in Brazil, projects are initiated by architectural definitions, technology selection, and cost definition. Therefore, the NBR 15575 standard, known as the Performance Standard, is an important tool for changing this scenario (Oliveira and Mitidieri Filho, 2012).

Given its relevance, several studies have investigated compliance with the performance requirements proposed by the Brazilian performance standard NBR 15575. However, most of

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these studies have addressed issues regarding habitability requirements. Issues regarding safety in the use and operation of buildings have been little addressed. For Mahl and Andrade (2010), this is due to the fact that many of the items required by the performance standard are already being executed correctly by the builders and meet the necessary levels so that users do not suffer with problems to come.

In his work, Borges (2008) pointed out the obligation to meet safety requirements in the use and operation of buildings as one of the most relevant aspects addressed by NBR 15575, since such requirements are not addressed by any other Brazilian standard.

However, the research conducted by Otero and Sposto (2016) showed that on a scale from 0 to 10, the level of knowledge regarding safety in use and operation recorded index 5. This requirement also applies to those of tactile and anthropodynamic comfort, thermal, and acoustic performance, reported as being of limited knowledge by the builders.

Corroborating the low level of performance regarding this requirement, the case study carried out by Hybiner et al. (2014) identified problems regarding compliance with items related to safety in the use and operation of NBR 15575 in the access to the condominium due to pavement failures along with the steep slope for pedestrian movement.

In addition, a survey carried out by the Center for Building Technology - CTE (2016), with construction companies, developers, designers, and manufacturers in the construction sector, revealed that among the construction companies that participated, in terms of meeting the safety requirement in the use and operation, the service percentage declared by 48.5% of the constructors was between medium (60% to 80%) and low (30 to 50%).

In view of the above, this work aims to evaluate the compliance with safety criteria in the use and operation of housing buildings according to the guidelines proposed by NBR 15575 through case studies in construction companies in Recife/PE.

THE BRAZILIAN PERFORMANCE STANDARD NBR 15575

NBR 15575 is composed of six parts. The first part is conceptual and deals with the objectives, premises, and general concepts as well as the definition of the general requirements for each system. Parts 2 to 6 are to be used together with the first part and address the requirements of each specific system, which shall relate to structural systems, floor systems, internal and external vertical sealing systems, roofing systems, and hydrosanitary systems, respectively.

The users' requirements, which now stand out from the building design (Okamoto and Melhado, 2014), are related to safety, habitability and sustainability (CBIC, 2013).

In order to meet these exigencies, performance requirements (qualitative expressions of attributes) and criteria (quantitative requirement specifications) of performance were established by the standard as well as evaluation methods to measure performance (ABNT, 2013).

In order to ensure a meeting of the requirements and criteria, and to consolidate itself as a practical and easy-to-apply tool to assist all stakeholders in attendance to NBR 15575, the performance standard checklist was developed by CBIC. This instrument follows the six parts of NBR 15575, in which the extensive texts of the performance standard were summarized in small inquiries in order to facilitate the understanding of the criteria. The checklist defines the

corresponding evaluation methods, responsibilities and the necessary proofs to verify compliance with each criterion (CBIC, 2016).

SAFETY IN USE AND OPERATION OF BUILDINGS

For Santos and Hippert (2016) safety in use and operation is a requirement that must be guaranteed during the design stage in order to protect users and maintenance workers.

In each of its six parts, the Standard presents requirements and the respective safety criteria in the use and operation related to the specific systems to which they refer. Generally, these criteria address the aspects listed in Table 1.

Table 1: Main aspects addressed by the safety criteria in the use and operation of NBR 15575

NBR 15575 Parts	Main aspects
Part 1 – General requirements	Presence of ruptures, instabilities, or falls that could cause injury Presence of exposed sharp or perforating parts in building systems Existence of deformations or defects above the limits
Part 3 – Requirements for floor systems	Coefficient of dynamic friction of floor systems Signaling of abrupt differences of more than 5 mm in private areas Limitation of the maximum gap opening between floor components Presence of sharp edges on the surface of floor systems Release of perforating or sharp fragments by surface of floor systems
Part 5 – Requirements for coverage systems	Risk of slipping of coverage system components Existence of user-accessible guardrails Ability of the panels to support the action of the forces provided by the support of suspended scaffolds and light rockers Safety in the execution of activities in roof systems with slopes greater than 30% Possibility of walking people on roofs and roof slabs for assembly and maintenance operations Grounding of metal roofs
Part 6 – Requirements for hydrosanitary systems	Grounding of piping, equipment, and accessories of the hydrosanitary system Limitation of leakage current in hydrosanitary system equipment Relief and safety devices for electric accumulators Relief and safety devices for gas accumulation heaters Maximum rate of CO ₂ emitted by combustible gas equipment Existence of sharp corners and rough surfaces on parts of hydrosanitary systems Mechanical resistance of parts and appliances of hydrosanitary systems Limited water temperature at the point of use

Source: Adapted from ABNT (2013)

Although all the aspects listed in Table 1 are potential dangers to maintenance workers while they execute their activities, it is noticed that the aspects related to the coverage systems are those that demand more attention. Safety at work on inclined roofs, for example, is linked not only to a maximum slope of 30%, but also to the possibility of securing safety devices, such as fall protection equipment. On the other hand, the possibility of walking on the cover is fundamentally related to the assembly, maintenance, or installation operations to be carried out by the workers (CBIC, 2013).

METHODOLOGY

The research comprised the following steps: bibliographic review; adaptation of the performance standard checklist developed by CBIC (2016); development of a questionnaire to characterize companies and enterprises; on-site visits for data collection as well as compilation

and analysis of collected data.

The case studies performed are explanatory in nature, since they seek to explain and demonstrate the facts (YIN, 2005). According to this author, the research strategy is composed of data collection and analysis, and subsequent presentation.

Regarding the application of the performance standard CBIC's checklist (2016), it is clarified that, since this research only deals with the criteria verification of safety requirements in the use and operation, only the items referring to those were analyzed. Therefore, the version of the checklist applied in the analyzed works ended up with an adaptation of the original checklist.

The adapted performance standard checklist listed the evaluation of 20 criteria for safety in the use and operation of buildings, of which 02 are relevant to Part 1 - General requirements, 04 to Part 3 - Requirements for floor systems, 06 to Part 5 - Requirements for coverage systems and 08 to Part 6 - Requirements for hydrosanitary systems.

The requirements for Part 2 - Requirements for structural systems and Part 4 - Requirements for internal and external vertical fence systems refer to Part 1.

Through this instrument, the criteria can be evaluated as "met," "not met" and "not applicable". The classification of the criteria as "not applicable" is given by the fact that the enterprise does not have the elements to which certain criterion evaluated as "not applicable" refers.

The questionnaire sought to collect information on the characterization of the construction company (time in the market, certification of quality management systems, and number of works in progress), the enterprise (standard, number of apartments, and position of the interviewee) and the standard implementation process (participation of capacities, level of attendance to the requirements, benefits and obstacles).

To choose the companies, the following aspects were considered: multifamily residential project; not a reform work; ease of contact and availability of information. Considering the deadline for the development of the research and the shortage of companies that have, in the local scope, fully implemented the NBR 15575 in their projects, it was not possible to take, as a qualifying factor for company selection, the implementation of the performance standard and approval of the project after July 2013, the period in which the performance standard became effective.

The application of the CBIC (2016) adapted checklist as well as questionnaires were carried out during visits to the selected residential buildings. The interviews were scheduled with those responsible for the works and had as a guiding objective to understand the level of knowledge and information in the construction companies against the demands of the performance standard, as well as to understand how the process of implementation in the projects and execution of residential buildings happened as well as possible changes necessary for the application of such requirements.

Finally, the checklist was applied to verify compliance with the requirements and safety criteria in the use and operation of the buildings studied.

After this step, there was a compilation and analysis of the results obtained by comparing them

with the performance standard and literature review requirements.

CASE STUDY

Characterization of construction companies

The work involved the participation of three (03) construction companies, which, for ethical reasons, will remain anonymous and will be codified by letters. The characterization of the companies was carried out based on the answers of the questionnaire applied in the interviews during the visits to the works. The results obtained are shown in Table 2

Table 2: Characterization of companies

Item for characterization	Construction Company		
	A	B	C
Time in market	More than 40 years	More than 30 years	More than 30 years
Main activity	Construction (Private costumers)		
Certification	ISO 9001	ISO 9001; ISO 14001; OHSAS 18001	Brazilian Habitat Quality and Productivity Program (PBQP-H); ISO 9001
Amount of works in progress	05	30	06

It can be seen from Table 2 that all companies have more than 30 years of experience in the market, in which they have developed as main activity the construction of housing buildings for private clients. It was also possible to identify that all companies are ISO-9001 certified and, in particular, company B is certified by OHSAS 18001, which certifies the implementation of the health and safety management system.

Characterization of enterprises

Four (04) housing buildings were analyzed, which were codified by letter and number, where the letter refers to the construction company responsible for the work and the number to the respective enterprise analyzed. The main characteristics of the projects are detailed in Table 3.

Table 3: Characterization of enterprises

Item for characterization	Enterprise			
	A1	B1	B2	C1
Pattern	Medium	Medium	High	Modest (MCMV)
Duration of Start the work	02/2014	07/2014	04/2014	07/2016
End	09/2017	09/2017	11/2018	02/2018
Number of towers	01	02	01	10
Number of units	102	100	72	392

It can be seen from Table 3 that all developments employed conventional technologies although the pattern of buildings varied from modest to high. In addition, all works started after July 2013, during which period NBR 15575 became effective, and in particular, work C1 started three years after this deadline.

Interviewees' knowledge level on the Brazilian performance standard

In works A1, B1, and C1, the interviews were performed with engineering assistants; in work B2, the interview was conducted with a building technician. However, all these professionals have a degree in Civil Engineering. The questions sought to understand their knowledge level about the performance standard, the implementation level in the works, and the main obstacles

and benefits arising from the introduction of this standard.

It was initially found that none of the companies has the performance standard implemented. One of the corroborating factors for this is the fact that the current projects under way were approved prior to July 2013, the period in which the standard came into force.

As to the knowledge level regarding the concepts and guidelines of the performance norm, only the company B's interviewees revealed to have regular knowledge regarding the standard, stating that this came from graduate courses.

RESULTS AND DISCUSSIONS

Initially, an analysis of the level of compliance with the criteria for safety in the use and operation in general was carried out followed by an analysis of the level of compliance with the criteria for each of the six (06) parts of NBR 15575 and specifically the requirements that pose the greatest danger to the development of maintenance activities.

Level of compliance with safety criteria in use and operation

The adapted checklist of the performance standard listed the evaluation of 20 criteria regarding safety in the use and operation of buildings. The quantitative analysis of the data collected through the application of the checklist generated the results shown in Table 4.

Table 4: *Quantitative analysis of criteria meeting*

Classification of criteria meeting	Enterprise			
	A1	B1	B2	C1
Met	09	09	09	07
No met	06	08	08	08
Not applicable	05	03	03	05

From the data in Table 4, the graph of Figure 1 was generated, which presents the percentage level of compliance with the safety criteria in the use and operation obtained in each work. For the elaboration of the chart, the criteria deemed "not applicable" were not considered.

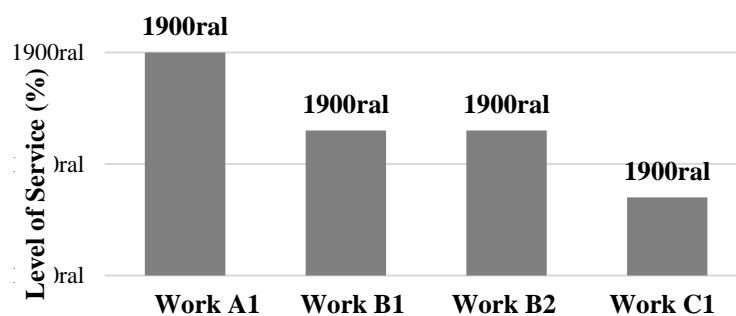


Figure 1: *Percentage of compliance with safety criteria in use and operation*

The levels of attendance shown in Figure 1 are in line with those raised by the CTE (2016), remaining between the medium (60% to 80%) and low (30 to 50%) ranges.

Comparative analysis of levels of compliance with safety criteria in use and operation

Table 5 compares the data collected through the application of the checklist while presents the averages of the levels of compliance with the safety criteria in use and operation for each part

of the standard. Table 6 presents the safety criteria compliance averages related specifically to maintenance and operation of the coverage systems, considering its relevance to maintenance workers' safety. Only the criteria applicable to the studied typologies were listed.

Tables 5 and 6 shows that:

- The criteria for Part 1 of the performance standard presented the highest level of service;
- The results obtained pointed out that the criteria with lower average level of attendance were related to Part 6 of the standard, which refer to the hydrosanitary system;
- The levels of compliance with the criteria of Part 5 - Coverage system, regarding the maintenance and operation of this system, presented a maximum service level of 50%. Thus, companies still need to act more forcefully in order to ensure the safety of maintenance workers activities.

Table 5: Summary of levels of compliance with safety criteria in use and operation

Part of the performance standard	Enterprises				Average service levels
	A1	B1	B2	C1	
Part 1 – General requirements	100%	100%	100%	50%	87.5%
Part 3 – Requirements for floor systems	75%	75%	75%	0	56.25%
Part 5 – Requirements for coverage systems	25%	67%	67%	75%	58.5%
Part 6 – Requirements for hydrosanitary systems	60%	25%	60%	60%	51.25%
Parts 1 to 6	60%	53%	53%	47%	

Table 6: Summary of levels of compliance with safety criteria in use and operation concerning the maintenance and operation of coverage systems

Question	Average service levels
Are the rails in covers accessible to users in accordance with NBR 14718?	50%
The systems or panels, intended to support suspended scaffolds or light rockers, support the action of the forces on the top and along any stretch by the force F (of the cable), according to NBR 8681, associated with the lever arm and the distance between points supplied or informed by the supplier of equipment and devices?	50%
Roofs and roof slabs provide for the movement of people in maintenance or installation assembly operations, supporting a concentrated vertical load greater than or equal to 1.2 kN at the positions indicated in the design and in the owner's manual, without showing rupture, cracks, landslides or other faults?	50%

CONCLUSIONS

The results obtained in this research corroborate with the data collected in the literature review stage, and demonstrate that, within the city of Recife/PE, the implementation process of the performance standard is still slow. It requires greater involvement from the actors, especially with regard to safety in the use and operation of buildings.

With respect to the fulfillment of the safety requirements in the use and operation of the floor, cover, and hydrosanitary systems, it was observed the service levels vary between 50 and 60%. This demonstrates that companies, while not neglecting the importance of meeting these requirements, still need to devote more attention to ensuring that ventures are safe during use and operation.

Regarding the requirements that impact the maintenance activities of the coverage system, which have a greater influence on the safety of maintenance workers, it was observed that the service levels were on average 50%. That fact reveals that companies need to pay more attention to the safety of workers not only during the execution stage, but also in the post-work phase, through maintenance. This is especially important because, with the advent of the Performance Standard, the requirement for maintenance activities is even more evident, since these are fundamental for performance to be maintained throughout the building lifetime.

As for the verification of the standard requirements, the checklist of the CBIC performance standard proved to be an excellent tool for data collection, since it is easy to understand and apply. However, in view of the experience obtained with the accomplishment of this research, it is suggested that it be applied in the post-work stage, because of the greater ease of verification for compliance with the criteria.

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RISK-HUNTING TRAINING IN INTERACTIVE VIRTUAL ENVIRONMENTS

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Safety is an everlasting concern in construction environment, as when an accident happen it is rarely harmless. In this paper, we propose a risk-hunting course in VR (Virtual Reality). With VR, we can put the trainee in a full construction environment with potentially dangerous hazards without endangering his/her safety. The novelty in our approach is to add interactions in the environment to emphasize the importance of learning to correct the errors. Instead of only having to only spot the errors, we make the trainee act to fix the error (to make it become a reflex action). This is done by having a fully interactive environment where the trainee can manipulate objects around him. A second originality of our method is to use novelty scripting techniques for virtual environments to enhance the experience. We use it guide the trainee and to add consequences to his action (For example, not fixing an error in a scaffolding may make it collapse later). Furthermore, to have a reusable course for the trainee, errors are automatically and randomly inserted in the environment at the beginning of each session. Consequently, each instance of the training is unique and can be redone by the same trainee multiple times.

Keywords: Safety, Training, Virtual Reality, BIM, Interaction.

INTRODUCTION

Architectural, Engineering, Construction and Owner-operated (AECO) Industry in France, a sector highly exposed to occupational accidents. The AECO industry is the most accident-prone sector (CNAMTS Report, 2016) in France. In 2014, 145 construction employees (excluding temporary workers) died while working in France. The construction industry accounts for 8.6% of employees (INRS, 2016) and recorded 16.3% of "accidents with work stoppage" and 26% of deadly accidents. As for the causes of accidents, manual handling is by far the most challenged category, accounting for more than half of all work stoppages (Assurance Maladie, 2016) with a rate of up to 53%. This is followed by falls on the same level with 13%, falls from height with 12%, and the use of hand tools with 9%.

An economist approach to the question shows that their cost, globalized with that of occupational diseases, would amount to 1.3% of the national wealth (Azkenazy, 2004), this cost is equivalent to ten additional days of paid annual leave per employee per year. These statistics illustrate the very dangerous nature of the sector and lead to an interest in the problem of accident prevention in construction.

Construction in France

Large companies in France have for many years been conducting a comprehensive prevention policy with the "zero accidents" plan in order to reduce their frequency rates (TF) = (number

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of accidents in first payment / hours worked) x 1,000,000.

However, the complexity and the diversity of the operating modes, the methods, the architectures as well as the contraction of the deadlines of realization have an impact (Cramif, 2000) on the level of security when carrying out the works.

Training, essential levers

Various reasons can help to explain the difficulties that prevention poses in this sector of activity: risk factors' origins are human, technical, organizational, material and are often interdependent. Statistics show that workers suffering from reduced support in the company, including posted workers, foreigners, temporary or apprentices, are most prone to workplace accidents. As an example, mention can be made of the INRS¹ report (INRS, 2014) which stipulates that accident victims of foreign origin (non-European) are three times more numerous in the building and civil engineering sector than in other sectors, the same is true for European foreign employees.

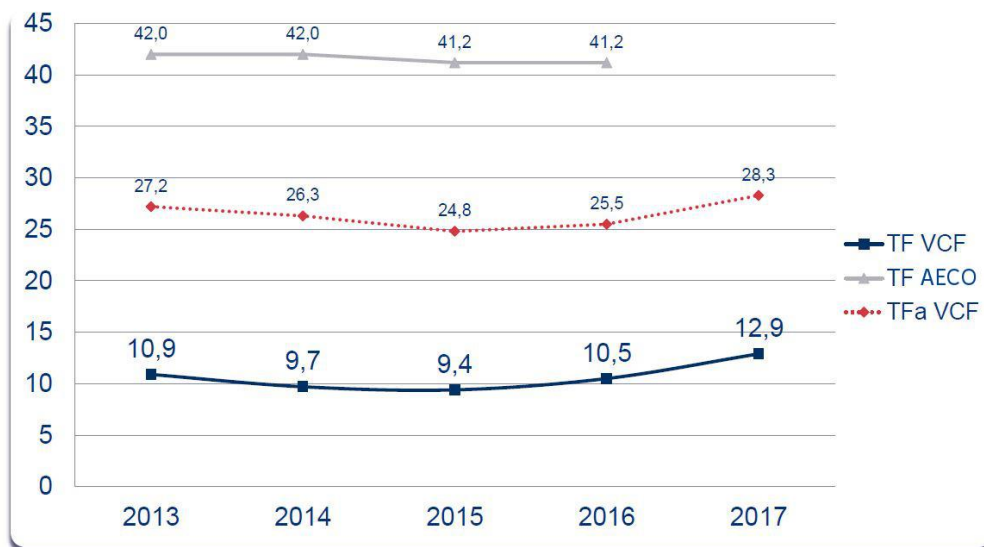


Figure 1: Evolution of frequency rate (TF) = (number of accidents in first settlement / hours worked) x 1,000,000.

These statistics highlight the lack of training and experience of these categories of workers, especially for foreigners, and also the lack of support for temporary workers, who change their job and work environment regularly. Even in large groups such as Vinci, which for many years has been conducting a comprehensive prevention policy with the "0 accident" plan, the difference in frequency rates between employees and temporary workers is still worrying.

However, a higher level of training leads to safer behavior (OPPBTP, 2017) during the construction phase.

One of the difficulties encountered in the management of training is related to temporary workers who do not always benefit from the same level of information and knowledge related to the materials and methods of construction specific to the site on which they intervene.

Recent studies demonstrate the benefits of virtual reality training (Ho and Dzung, 2010)

¹ Institut national de recherche et de sécurité, the reference organization in France for health at work.

compared to traditional training methods. But the costs involved are still high (Gao et al., 2017) in the case of virtual reality. Moreover, in both cases, the training is sequenced and does not allow the real situation as, each construction project is unique. However, the work environment has a considerable impact on the perception of risk and therefore on the behavior of employees.

For example: a driver knows that he has to stop at a stop sign, he marks the stop and can leave if the way seems clear and safe, but if a tree, hiding a car, obstructs his field of vision, the latter would necessarily be affected but not his perception of risk.

The arrival of the BIM, a working process commonly used in the construction industry, makes it possible to obtain a virtual double of the act of building.

Goal

The purpose of this study is to present a virtual reality training scenario generation method that allows the trainee to be immersed in the unique configuration of the site he / she will intervene.

CONTEXT

Overview

Traditional prevention of work-related musculoskeletal risks is oriented along two almost independent axes, the technical axis and the human axis. The limits of these approaches are currently recognised by ergonomists and some prevention professionals who are trying to create a third path. It is a matter of reconciling technical and human orientations based on the understanding of the work activity and designing, in particular, risk prevention training programs that develop the ability of all prevention actors on their own work activity and their power of action on the technical or organisational aspects of work (Teiger, 2002)

Several reasons (Choudry and Fang, 2008) explain the risky behavior of the workers: the lack of knowledge of the safety rules, the lack of respect of these rules, a non-conducive environment such as high productivity targets, psychological factors, the pride of "hard leather" in male environments such as construction, lack of training, organization of the site and a sequencing of the tasks to be performed that do not take into account the needs of the workstation.

Traditional training in risk prevention / Training in virtual reality

Virtual reality provides a relevant response to the act of training to perform tasks without dangers, train many people at lower costs from different locations (Barot, 2013), understand abstract concepts or absolve from the language barrier (written or oral), and put into practice.

There are many professions in which an error can be very expensive. When a surgeon, a pilot, a soldier or a racing driver commits an error, the consequences can be the damage to an extremely expensive equipment or injuries or loss of human life.

For this reason, medical students repeat various scenarios over and over again, using computer simulations and pilots use flight simulators as part of their training programs. In some cases, the goal is for muscle memory to take over the normal cognitive process. Of course, the value of simulation is not limited to the careers in which your money or life might be at stake. Training software exists that allows sales professionals to familiarize themselves with various scenarios. Unfortunately, whatever the objective of the simulators, something is missing for

most of them: there is no way to have a 360 degree view which does not allow a real immersion and therefore does not correspond hardly to the real world.

In the classic risk hunting paths in the field of construction, trainees are assessed on their ability to identify risks on reduced scenes and reduced tasks. They cannot be allowed to correct the problem or simulate their work on these insecure scenes, their lives may depend on it. This technology also offers interesting aspects for the trainer: scenarios can be implemented by the system itself, recording and review of sessions, trainee assisted evaluation, possibility of acting (Verna, 2000) on the level of difficulty of the exercise to assess the impact of cognitive load ...

We also note that traditional training does not allow trainees to adapt to a changing environment (Huard, 2008) so immersion into a risk hunt in reality virtual can enrich learning.

In the particular case of risk prevention, the reflex to danger is the expected result. According to the work of JB Watson, the reflex can be conditioned by the senses and participates in the acquisition of knowledge (Beauchesne, 1985) in humans. We agree with Sutherland's (1965) view that "the ultimate (virtual reality) device would be an environment in which the computer could control the existence of objects (and our interaction with them). We could sit on a chair in this environment. Handcuffs in this environment would be really coercive, and a bullet would be fatal. " The five senses can therefore be solicited (Fuchs, 2011) simultaneously, which increases the interest and commitment of the participant (Cherrett et al., 2009) in his training thus improving the acquisition of knowledge.

The limits of VR in relation to Real Education today are of a technical nature related to the use of a new technology: technical and professional skills of the developer, and acceptability of interaction techniques by trainees not accustomed to video games (training approaching a serious game). The orientation can be disrupted by the reduction of the field of vision, the movements whose latency can be problematic.

We also remember the motion sickness that can disrupt immersion in the virtual environment.

Support a time in virtual reality (VR)

The current limitations of the technology, weaknesses in the design approach, such as usability issues and the cumbersomeness of the resulting applications are not to be overlooked as sources of potential problems (Burkhardt, 2003), both for the transfer aspects between virtual situations and the real world and for the aspects of user assistance, in order to avoid difficulties induced by cognitive overload that is harmful to learning.

Lack of return

During our research on the benefits that virtual reality can bring compared to traditional training methods, we have been faced with the problem of lack of existing studies. The return of the experiments carried out does not make it possible to establish a concrete result. If the finding seems clear about the benefits of this technology during the training, its interest in the long term (Sacks et al., 2013) remains to be proven.

DESIGN OF THE RISK-HUNTING COURSE

Interactive Environment

To display and interact with the virtual environment, we can use different kind of devices with

varying degree of immersion. These devices include a screen mouse and keyboard, a head mounted display (HMD) or a CAVE™. We decided to use a HMD (HTC Vive) in our case because these kinds of system can be easily transported and deployed in training centres while allowing a good degree of immersion. The trainee wears a headset that cover his field of view and shows him the virtual environment and can move in a limited play-area by physically walking. The trainee also has two controllers to interact with the environment in a few different ways (shown in Figure 2).

Walking and teleportation is used to navigate in the environment. The trainee can physically move in the play-area to navigate through the virtual environment. The play-area being much smaller than the virtual environment, a second way of navigating through teleportation is implemented. By pointing with the left controller, the user is able to teleport (which move the play-area location in the virtual environment) to reach unattainable locations.

Use and grab objects. Some object in the scene are usable and interacting with them can trigger certain effects (e.g. interacting with a closed door will open it). To interact with an object, the trainee has to point it with the left controller and press the interact button. This method allows to interact with an object without having to physically reach it. Also, some object in the scene are grabbable. These objects can be grabbed by pointing them with the right controller and hold the grab button.

Taking instruction: the trainee can get instruction from his superior in form of dialog pop-up.

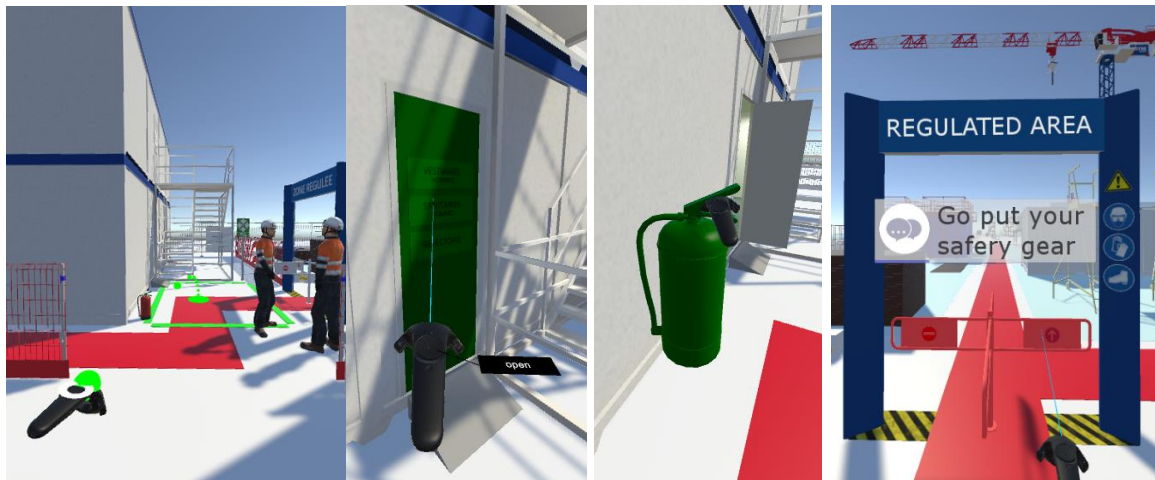


Figure2: Examples of the different ways to interact with the environment. From left to right: teleporting to a new location, remotely interacting with an object, grabbing an object and getting instructions

Accustoming to VR

Before letting the users go to the full construction environment, we make them first go through a smaller environment. In this first environment, the trainee is tasked to find and wear all mandatory safety gear. This scene end by going through the turnstile that lead to the construction site. Any attempt to go through the turnstile without the necessary safety gears is denied.

From the point of view of pedagogy, this scene makes sure that the trainee gains a good habit of wearing all the necessary safety equipment and does not forget anything.

In terms of VR training, this scene is used as an acclimatisation time for the trainee to learn how the system work. This small scene contains a few instances of the main interactions for the trainee to play with. The trainee can learn to navigate in the environments, take instruction (which tell him to wear the safety equipment) and interact with objects. For the trainer, this scene is used to assess the capabilities of the trainee in virtual enjoiments and help him get used to the setup if necessary. After this accustoming phase, the trainee can proceed to the second scene which is the construction site.

Introducing Errors

For the construction site, we defined for this risk-hunting course a list of type of errors we wanted to include. Different kind of error can be inserted: Object can be added in the scene, existing object can be modified or existing objects can be removed. One example of the type of error is the misplacement of the fixings of a PTE platform (see Figure 4). For each type of error, we then procedurally try to find every possible way to create an instance of the type of error. In the case of our example, this mean iterating over all the PTE platform fixings and trying to find for each of them an incorrect location. With all these possible error instances, we are then able to randomly select which error to use for each trainee. This selection can either be completely random, or made around areas of interest if we want to define a specific path for the trainee.

Scriptwriting

Scriptwriting is used at two levels to manage the risk-hunting course: global-guidance and error-scriptwriting. Global-guidance is tasked with guiding the trainee in the environment. A scenario is written to list the events (or chain of events) that the trainee must do to fix the errors. The scenario is modelized with the Petri net formalism.

Since the virtual environment encompass a whole construction site and we want the trainee to be exposed to certain errors we inserted in specific areas of the construction site, we need a way to direct the attention of the trainee to these specific areas. This is achieved by giving instructions to inspect or do something in specific area to force the trainee to go near error instances. These instructions are written in the scenario and are given to the trainee automatically during the simulation.

Error-scriptwriting allows us to define how errors must be corrected and what consequences will happen if they are not corrected. Each type of error has a scenario that describe how this error can change over time depending on the action of the trainee. Figure 3 gives a simplified example of such scenario. This error-scriptwriting is used to improve the pedagogy of the training by allowing us to describe two important elements: what action(s) must be done to fully correct the error and what might happen if the error is not corrected.

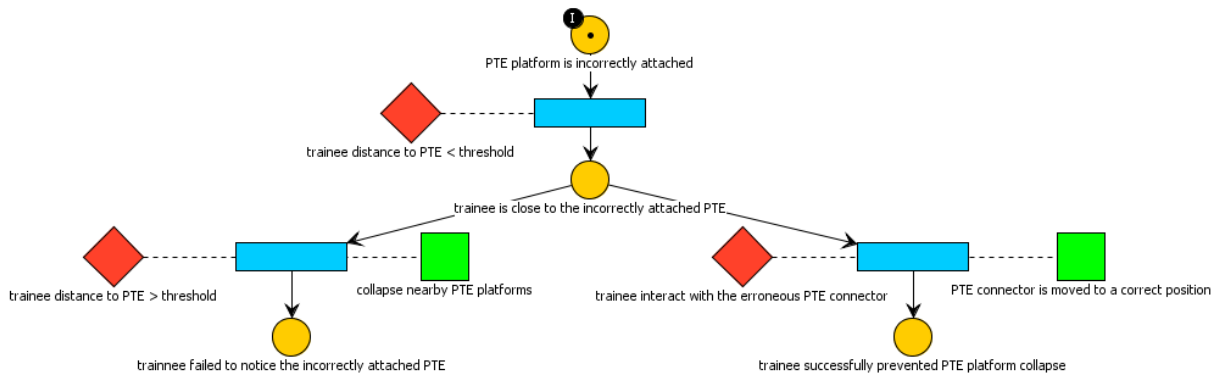


Figure 3: Example of an error-scriptwriting scenario for the misplacement of fixings of PTE plat. Yellow circle represents the possible states (with the initial state marked with a 1). Blue rectangle represents transitions between states with red diamonds being condition to be able to trigger the transition and green squares being consequences of the transition.



Figure 4: Example of misplacement of fixings of PTE platform in the virtual environment. On the left, one fixing is misplaced (circled in red) and placed above an opening. On the right, this is what the trainee will see if he walks away from the PTE platform if he does not signal the misplacement of the fixing (This corresponds to the bottom left state in Figure 3).

Feedback after the Training

Along the training, the behavior of the trainee is recorded and a score is attributed depending on the errors he corrected or missed. We also give the list of the errors he has not corrected and the action that should have been done to correct them. This feedback can be used as a starting point for a debriefing between the trainer and the trainee.

USER STUDY

A user study will be performed with construction worker to assess the effectiveness of this form of training. In this user study, the VR training will be used in conjunction of standard training in the context of standard training days organized by the company. The goal of the user study is to evaluate the acceptability of VR training for construction worker as well as evaluate the short and long-lasting effects of the training. The acceptability of VR-training is evaluated with questionnaires (standards) for perceived-workload, presence and sickness after

the training. Efficiency of the training is evaluated with a knowledge test performed before the training, after the training and one month after the training.

CONCLUSIONS

In this paper, we presented a risk-hunting course in VR that highlights interactivity and scriptwriting in the virtual environment to improve the involvement of the trainee. We also presented the methodology we will use to evaluate the acceptability and effectiveness of this method of training.

For this training programme, we used the same scenario for every trainee. In future work, we want to have multiple scenarios that induce varying levels of stress and danger by adding more errors and changing the conditions (e.g. the weather). These scenarios could be used by the trainer to tailor the experience of each trainee depending on his/her past performances. Furthermore, we want to add real-time analysis of the performances of the trainee while he is in the virtual environment to adapt it to their specific behaviour. We could monitor the error the trainee makes to introduce other instances of the same error to focus the training toward the trainee weaknesses.

Another area of improvement would be collaborative risk-hunting, this would improve the fidelity and logistics of the training. In real-life work conditions, workers are not alone in a construction site. Having a collaborative environment for the training would allow a more faithful experience. Furthermore, current trainings are organised for a whole group of trainees. In this context, it is difficult to include a new part in the training that must be done and managed individually. This is one of the reasons that make the introduction of VR in training centre difficult, but collaborative training where multiple people could be trained simultaneously could alleviate this problem.

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THE USE OF BUILDING INFORMATION MODELLING TO PROMOTE HEALTH AND SAFETY MANAGEMENT ON CONSTRUCTION SITES IN ZAMBIA

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Construction sites are hazardous and are prone to high levels of risk that require much effort to be expended in order to protect the health and safety of the individuals working on the sites. The industry is therefore in need of an effective management method for occupational health and safety management on sites that can identify potential hazards and allow for their elimination before they occur. In spite of extensive studies in the area, very little research has been done in developing countries like Zambia. This study therefore aims at investigating how Building Information Modelling (BIM) can enhance the management of health and safety on construction sites in Zambia. The study data were obtained through structured survey questionnaires distributed to contractors and consultants. The results show that the Zambian construction industry has a number of practices being observed that can allow the use of BIM to improve health and safety management. The study also showed that there were factors that would hinder the integration of BIM such as lack of knowledge of how to use the system, technology related risks, interoperability risks and process related risks. The study contributes to the body of knowledge by providing information on BIM integration in health and safety management to the field under study.

Keywords: Hazards, Employees, Health and Safety Management, BIM.

INTRODUCTION

The construction industry is considered to be among the most exposed sectors when it comes to occupational accidents and it is one of the most injury-prone industries in the world over. On-site risks and hazards are inherent to the industry and only increase as a project progresses (Adnan et al., 2009). Zambia recorded a total number of 85 fatal accidents from years 2007-2014 and 600 non-fatal accidents within the same period (Chifungula, 2015). Some of the contributor's site accidents include the presence of different building teams carrying out specified works and the constantly changing work environment characteristic of a construction project (Rozenfeld et al., 2010). Creating safe and healthy workplaces must be made a priority if on-site accidents are to be avoided or prevented. However, data on deaths, accidents or diseases directly related to construction work is not readily available in Zambia due to the extensive underreporting culture of the industry; therefore, making it difficult for interested parties i.e. government, employers to evaluate the health, social economic implications and the effectiveness of actions taken to prevent accidents (Siziya et al., 2010). Slips and falls are the most common cause of fatal accidents on construction sites accounting for 39% of cause of

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deaths in construction. These statistics are an underestimation because most people do not usually relate their illness with their line of work accidents (Siziya et al., 2010). Further, in most sectors other than the mining sector there is no requirement for post-retirement check-ups accidents (Siziya et al., 2010). In Zambia records of deaths are kept, but that is just an end in itself, as there are no follow ups on the causes of the illness so as to take the measures to prevent similar cases in the future. This is further worsened by the lack of research on occupational health and safety in Zambia so that problems may be identified and measures taken to curb them accidents (Siziya et al., 2010). Even though falls from heights or objects falling on people are the common cause of accidents, manual handling accounts for more days of sick leave and loss of earning capacity than any other factor accidents (Siziya et al., 2010).

CONTEXT

Causes of Occupational Accidents

Safety concerns have always been paramount in the construction industry. Jobsites are complex environments, with workers from multiple trades interacting in challenging physical environments (Anon., 2013). Challenging physical environments that include manual operation of heavy machinery, the need to work from heights and even the amount of works needed to be achieved at a given period contributes to site safety concerns. Ahmed et al. (2006) states that, accidents at work occur either due to lack of knowledge, lack of training, a lack of supervision, a lack of means to carry out the task safely or alternatively, due to an error of judgment, carelessness, apathy or downright reckless. This calls out for much attention to ensure worker safety in the industry and promote positive production.

The causes of accidents include workforce casualization i.e. the use of casual workers due to the labour intensive nature of construction works, transitory work environment (i.e. changes from substructure works to superstructure), actual site conditions, and the nature of the work itself (Hadikusumo and Rowlinson, 2002; Thompson, 2014). Health and safety hazards may be divided into three categories, namely, the physical injury hazards, physiological hazards and the ill-health hazards (Davison and Tomasin, 1996). Accidents can also be viewed as originating from a technical or human error (Chi and Wu, 1997). The technical error could be in using technologically advanced machinery, whilst human error may be attributed to the unskilled level of users or indeed, sheer negligence. The multiple accidents causation theory postulates that there are many contributory causes leading to accidents (Phoya, 2012).

Other schools of thought categorize causes of accidents into behavioral and environmental factors (Taylor et al., 2004). Behavioral factors include attitudes, skills and knowledge. The attitude aspect may be evident in workers that execute works that are repetitive in nature as they become too complacent with the job to be mindful of safety. Such workers often pose a danger to others and their workplace. Skills and knowledge become obsolete with the advancement of technology or the introduction of new work sections. Environmental factors include worksite hazards, work procedures and processes; these contribute to injuries (Taylor et al., 2004).

Construction site accidents have great economic and social impacts; they can lead to injuries, permanent disability and even death of the affected employees. Injuries and permanent disabilities not only affect the injured employee but their families too. On a larger Scale, death of an employee has the potential to affect the business and country's economy in terms of lost

manpower and productive man hours (Chifungula, 2015). A workplace has the potential to affect an employee's quality of life, job security, career opportunity and progression, income and may cause post-traumatic stress among other effects Sawacha (1999).

Occupational Health and Safety Management

Occupational health deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards (Anon., no date). Occupational health and safety addresses many types of workplace hazards such as chemical, physical, biological, psychological, ergonomic and accidental, it also enforces safety practices and examines legal perspectives (Anon., 2017). To create a safe and healthy work environment, planning of site management and operations is necessary prior and throughout the construction process. Chau et al. (2004) note that planning is the starting point of all management functions. Comprehensive planning and the efficient layout of site facilities are important factors contributing to successful construction management (Chau et al., 2004). Another important aspect towards safe working environments is the communication between the involved teams of safety hazard areas. The sharing of information between all the parties involved about project schedules, risks, queries, procedures, methods and operations is important to achieving health and safety on the work site (Vecchio-Sadus, 2007). This encourages site teams to be mindful of areas occupied by other team members, to take caution and to avoid incidents. Zhang et al. (2013) noted that safety planning in construction is generally done separately from project execution planning and involves different actors. This outlines the need to incorporate safety planning at an earlier stage than during the construction stage and that such data should be accessible to all the teams involved. Zhang et al. (2013) go on to say that the separation of the two planning processes and the resulting lack of communication create difficulties for safety engineers to analyze what, when, why, and where safety measures are needed for preventing accidents.

Zhang et al. (2013), point out that construction site safety often remains the sole responsibility of the contractor. Meaning construction site safety is often thought of way after design and project execution plans are complete. Contractors should be considered a member of the design team, allowed not only to manage construction but also to help manage the information that is being communicated in order to build the facility (Hardin, 2009). The design team in most cases have very little knowledge of how the processes they have designed would impact the safety of the ones involved in the production of the facility; hence they might not have the necessary information for safety planning. The contractor is the team player with ground information of how the processes are carried out in details, his input is important in the possible hazard and risk identification during the construction process.

Approaches to Occupational Health and Safety Management

Occupation health and safety management in the construction industry in Zambia is highly the responsibility of the contractor and the client. For larger projects, a safety engineer may be engaged to manage site safety. Current safety planning approaches are primarily text-based, standalone, check-sheet type tools, which are accessed either via paper or through software interfaces (Zhang et al., 2013). The current safety management practices are dependent on manual observations from past projects which implies information of accident records stored in either hardcopy or softcopy form are frequently referred to in order to get information of possible hazards and risks that could occur. This process can be defined as being labour

intensive and error prone as no two sites are the same. It would be wrong to conclude that events that took place on a previous project, no matter how similar, will occur on the other as team members will be different, methods and processes will be different. There are a number of tools that are used by the safety engineers and contractors to insure the safety of site personnel. These tools include the occupational health and safety act, factories act, toolbox talks, training and Labour inspection system. These tools have been found to increase hazard recognition skill and improve safety performance.

Criticism to Occupational Health and Safety Management Practices

The aforementioned systems, though necessary and useful for health and safety on construction site, can further be enhanced to provide optimal health and safety for workers. The traditional methods are labour-intensive, time-consuming, and thus inefficient and the observed result can be error-prone due to subjective judgments (Zhang et al., 2013). Chan-Sik and Hyeon-Jin (2013) attest that in general, the safety information being used on sites does not reflect the factors involved in the real construction work environments, which makes it more difficult to identify latent safety risks and deliver the right information at the right time to the right workforce during construction work. Building designers and health and safety managers unfortunately still lack a collaborative work method. The digitisation of the work environment allows for simulated inspections and information based analysis of the job site phases (Getuli et al., 2017).

Zhang et al., (2013) suggests that the link between planning for safety and work task execution is often weak; for example, many contractors use two-dimensional drawings (2D) or field observations to determine hazard prevention techniques. Since their approach is manual and based on experience, the observed results are often error-prone due to subjective judgments of the decision maker (Zhang et al., 2013). The industry is in need of improving the inefficiencies of the existing paper-based and manual safety process in place (Zhang et al., 2013). This is so because paper-based safety processes require one to read through past records to find a similar situation as the current to find out the proper way to deal with the issue at hand. This process is labor intensive and time consuming. Another negative aspect is that each construction site, although tasks are similar, present unique happenings making it difficult to pin-point when exactly an accident will occur so as to take precaution. Analysis and causation of accidents and historical data provide valuable but general information for safety planning. These are, however, not sufficient to predict when and where accidents occur on unique construction projects (Zhang et al., 2013). Building Information Modelling (BIM) is a tool that can be used for proactive, other than reactive project site planning and programme scheduling.

Building Information Modelling

The growing implementation of BIM in Construction and Facility Management is changing the way site safety can be approached (Zhang et al., 2013). The utilization of BIM technologies can result in improved occupational safety by connecting the safety issues more closely. Once a 3-D model is created, it can be used for many purposes including worker safety training and education, safety planning and employee involvement (Rajendran, 2011). Using 3D or 4D site co-ordination models allows contractors to plan for site logistics, develop traffic layouts and identify potential hazards at jobsite which can aid in preparing a more realistic site safety plan (Salman, 2012). Therefore, using BIM models, the project team can perform detailed analysis to plan the sequence of operations at the jobsite (Salman, 2012). BIM can be applied to issues

of worker safety training and education design for safety; safety planning (job hazard analysis and pre-task planning); accident investigation; and Facility and maintenance phase safety (Rajendran and Clarke, 2011). For these tasks, safety and health professionals can use 3D renderings generated from the BIM models and walk-throughs animations. In addition, 4D phasing simulations focused on the safety procedures can be generated to show how temporary safety elements and areas of concerns transition throughout the duration of a project (Rajendran, 2011). BIM can also be used to check the compliance of buildings design models with building codes and planning restrictions, with countries like Singapore and the UK being notable examples (BuildingSMART, 2006; Martins *et al.*, 2016). The traditional manual observation is inefficient, error-prone, and the observed result can be easily effected by subjective judgments.

METHODOLOGY

The data for the research study was collected from a target group of project team consultants who are involved in design of the facility, namely the architects and civil engineers. Contractors and general site workers were also selected adhering to their experience and knowledge of real time on site activities and occurrences. The study was a researcher administered data collection strategy and the collection point were Lusaka and Kitwe towns of Zambia. This is because the professionals being targeted have most of their offices situated in these areas.

The information is both qualitative and quantitative. The main data collection tool were survey questionnaires, two (2) types of questionnaires of which one was designed for professionals in the industry (contractors, quantity surveyors, architects and civil engineers) and the other was for general workers on construction sites. They were handed out, completed and returned. These methods were chosen because they are an inexpensive and efficient way of reaching a large number of respondents and obtaining data. The questionnaire and interviews assured participants of anonymity and that the data collected was purely for academic purposes. The study administered one hundred and fifty one (151) questionnaires to the respondents; an average of 69.9% response was obtained giving a valid sample representation allowable to carry out analysis. Some of the questions that were asked can be summarised as follows; what is the frequency of accident occurrence? What are the common types of accidents? At what stage in construction is health and safety planning done?

FINDINGS, ANALYSIS AND DISCUSSION

The Current Health and Safety Management Practices

A five point likert scale (i.e. very low, low, moderate, high and very high) was used to examine the level of accident occurrence on construction sites. The data indicated that 25.81% of the respondents have very low accident occurrence, 38.71% of the respondents indicated that the occurrence of accidents was low. These figures represent a total of 64.52% of respondents who indicated site accidents occur at a low rate. However, literature review records high occurrence of accidents as reported by the Workers Compensation Fund Control Board of Zambia. The contrast between the two maybe due to the fear that the respondents had of losing their jobs and in turn protected their employer. This was one of the limitations faced in this research. The most common types of accidents that occur on construction sites in Zambia include slips and falls, falling objects, over execution (fatigue) and falling from heights. These accidents cause most of the harm as they can lead to permanent disability or even death.

Four phases of construction were selected to analyse at which point site health and safety planning is currently being done, these stages include the feasibility stage, design stage, procurement stage and construction stages. The planning and design phases provide a vital opportunity to eliminate hazards before they appear on a job site (Zhang et al., 2013). The data shows that health and safety planning is largely done at construction stage (93%) while health and safety planning at other stages such as the feasibility stage (42%), design stage (32%), procurement stage (39%). This indicates that BIM can be implemented throughout the phases of construction especially at the construction stage. The construction stage is the best time to carry out site specific training to site workers which is directly related to their surroundings. Site specific induction intended to provide guidance and information in dealing with hazards. 60% of the respondents conduct this type of training, however this can be limiting as information is borrowed from past projects.

The efficiency and effectiveness of the construction process strongly depend on the quality of communication (Hoezen et al., no date). Communication is simply the exchange of information in order to convey a message and good communication involves being able to transmit your message so it is received and understood by the intended recipients (Anon., 2016). Due to high illiteracy levels of site workers site health is communicated to face to face other than written documentation. Site safety meetings are carried out at an agreed time on the construction site with an agreed agenda to discuss issues of safety concerns. These are important meetings as they highlight the areas of the site that pose threats and by so doing reducing the chances of incidents.

Awareness and use of New Technology -Building Information Modelling in the Zambian construction industry

The field survey showed that the majority of the professionals in the construction industry, represented by 61% of the respondents, have heard and know about BIM. However, all the information they have gathered was from reports, journal publications and construction news headlines done by the western countries such as the UK and the United States of America.

Therefore, it can be noted that BIM is not being used in the Zambian construction industry at the moment. However, the professionals in the industry are taking a keen interest in learning more about the system and how it works. This was revealed by responses from the field survey when asked on willingness of the individuals to carry out the necessary requirements to implement BIM. The successful implementation of a new system in an area is dependent on how much is known about the system by the area population and their willingness to adopt the system. This section of the survey aimed at finding out how knowledgeable individuals are of BIM and the software packages that support the use of BIM in order to assess the feasibility of BIM application in Zambia. 67% of site workers agree that using a visual aid can help reduce the occurrence of accidents on construction sites.

Implementation of BIM in Zambia

The site safety management practices performed in Zambia that would allow for BIM to be integrated and applied. However there are limitations posed to the success of this proposal such as the cost of implementation, the limited knowledge of how the system works and the time constraint to be faced during programming of a suitable application to address site concerns of Zambian construction sites. These challenges can be overcome i.e. using a client led approach

to use BIM from project start to finish.

CONCLUSIONS

BIM can be used to improve the quality of site safety management by adding an effective method of communication of site hazards to site personnel. This is so as it would better their understanding of the environment and operations. The research reveals site safety management practices performed in Zambia that would allow for BIM to be integrated and applied. However there are limitations posed to the success of this proposal such as the cost of implementation, the limited knowledge of how the system works and the time constraint to be faced during programming of a suitable application to address site concerns of Zambian construction sites.

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IDENTIFYING INTERACTIONS BETWEEN RESILIENCE ENGINEERING AND BIM FOR SAFETY

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Building Information Modeling (BIM) has been increasingly adopted in the architecture, engineering, and construction (AEC) sector and several studies have recommended the use of BIM for construction safety. However, these studies usually adopt normative and linear safety models, which assume the feasibility of the full identification and control of all hazards in advance. By contrast, Resilience Engineering (RE) is a new paradigm for safety management, which recognizes the emergent nature of safety and accidents, which arise primarily from the interactions between humans, technologies, and the environment. This paper discusses the role played by BIM in construction safety through the lens of RE. In order to support this discussion, a matrix relating the four RE potentials (anticipation, monitoring, response, and learning) with the BIM abilities for construction safety was developed. The cells of this matrix correspond to the interactions between BIM and RE, setting a basis for the identification of the BIM strengths and weaknesses from the RE view.

Keywords: BIM, Resilience Engineering, Interactions.

INTRODUCTION

This study explores two initiatives that have the potential for improving the theory and practice of construction safety: Building Information Modelling (BIM) and Resilience Engineering (RE). BIM is a new approach for the design, construction, and facilities management in which a digital representation of the building process supports the exchange and interoperability of information between project stakeholders (Eastman, Teicholz, Sacks, & Liston, 2011). In turn, RE is a new paradigm for safety management that “aims to enhance the ability of a complex socio-technical system to adapt or absorb disturbance, disruption and change” (Hollnagel and Woods, 2006). Although these approaches have different academic and practical origins, there appear to be potential interactions between them for safety management. This study presents an exploratory discussion of these interactions, setting a basis for future research.

Research using BIM for safety has found benefits that can promote resilience. BIM not only helps to plan for safety upfront during the design phase but also during the construction stage, once it assists in planning safe work packages, controlling and monitoring safety performance (Benjaoran and Bhokha, 2010). According to Liu, Al-Hussein, and Lu (2015), BIM produces information and models that can be intuitively understood, thus helping workers and managers

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to assess the risks of the work environment. This paper discusses whether the BIM abilities of planning, controlling and monitoring safety can support resilient performance. This discussion is based on a conceptual and structured analysis of the interactions between the four potentials of resilient systems (Hollnagel, 2011) and the BIM strengths pointed out in the literature.

BACKGROUND

BIM for safety

Several studies have pointed out that BIM can greatly benefit the Architecture, Engineering, and Construction (AEC) industry. Some applications of BIM include scheduling, clash detection, construction progress tracking, design visualization, data integration, cost estimations, implementation of lean construction and improved team member collaboration (Martínez-Aires, López-Alonso, and Martínez-Rojas, 2018)

The use of BIM for safety can operationalize the Prevention through Design (PtD) concept (Melzner et al., 2013), which aims at protecting construction workers through the consideration of safety requirements in the design process. For instance, Zhang et al. (2013) developed algorithms that automatically analyze a building model to detect fall safety hazards and suggest preventive measures. Qi et al. (2014) developed a PtD software that compiles construction safety best practices, in such a way that contractors have the opportunity to plan safety measures to address construction site hazards from the beginning of the project.

Different studies are also using BIM for safety in the production planning phase. For Hartmann et al. (2012) the BIM models are a means of improving the visualization and understanding of the building elements at the beginning of the said phase. Another example is a study by Kim and Teizer (2014) in which BIM and safety rules were applied to model the scaffolding installation process and to identify hazards.

Furthermore, 4D BIM can provide insights into site layout and methods for managing and visualizing up-to-dated plans and site status information. In addition, 4D BIM supports safety communication in various situations, such as warning about risks (Sulankivi et al., 2010). Park and Kim (2013) proposed a framework for construction safety management and visualization system that integrates BIM, location tracking, augmented reality (AR), and game technologies. This framework supported the risk identification skills of workers, and enhanced the real-time communication between workers and construction managers.

BIM for safety key areas were identified by Martínez-Aires et al. (2018) in a systematic review. They are: 4D schedule and planning, visualization/simulation, collaboration and communication, and hazards identification. Martínez-Aires et al. (2018) also identified *construction or safety management* as another BIM for safety key area. However, in the present paper, this area is interpreted as covered by the others.

Martínez-Aires et al. (2018) defined 4D as 3D plus schedule. According to Kiviniemi et al. (2011) BIM can be used first to link the construction methods to building objects and second to make those visible and more understandable via animations, offering insights into the life cycle of the built environment. Also, BIM can improve communication across the project stakeholders (Martínez-Aires et al., 2018). Lastly, BIM supports hazard identification as a result of the thoughtful analysis of 4D plans, simulations, and better information exchange between stakeholders (Martínez-Aires et al., 2018).

Resilience Engineering

Resilience engineering (RE) has been pointed out as an alternative for the management of safety in complex socio-technical systems (Hollnagel, Woods, and Leveson, 2006). RE focuses on how people, alone or together, cope with everyday situations – large and small – by adjusting their performance to the conditions. An organization's performance is resilient if it can function as required under expected and unexpected conditions, including changes, disturbances, and opportunities (Hollnagel, 2017).

Furthermore, RE explores the gap between work-as-imagined and work-as-done. Work-as-imagined is what should happen. Work-as-done is what actually occurs in the workplace. Once the actual management of work obviously must refer to what in fact is happening, and not to what we suppose is happening, it is essential that the management of work is based on a description or representation – a model – that is as realistic and accurate as possible (Hollnagel, 2017).

Hollnagel (2011) proposed four potentials of resilient systems (Figure 1): responding, monitoring, anticipating and learning. In the RE perspective, a system is resilient only if the four potentials are present.

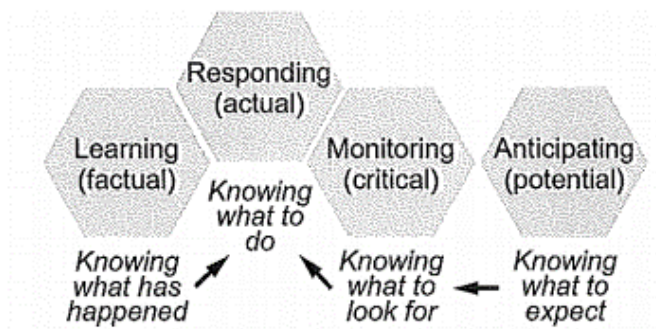


Figure 1: The four potentials of resilient systems (Hollnagel, 2011)

Responding accounts for the ability to respond to regular or irregular variability, disturbance, and opportunities. It is operationalized through adjusting how things are done, activating prepared actions or creating a new manner of doing things. *Responding* includes knowing what to do, when and how to respond (Hollnagel, 2011).

The second RE potential is *monitoring*. It is related to the ability to monitor what affects or could affect an organization's performance in the near term (threats and opportunities alike). Monitoring is knowing what to look for. It must cover changes in the environment in addition to changes of the system itself. Effective monitoring must be proactive recognizing upcoming situations and making use of leading indicators (Hollnagel, 2011).

Learning is also a RE potential. This is the ability to learn the right lessons from the right experience, independently if there were successes or failures. It can also be defined as the ways in which an organization modifies or obtains new competencies, knowledge, and skills (Hollnagel, 2011).

Finally, *anticipating* is the fourth RE potential. It is the ability to know what to expect or to anticipate developments further into the future. It means being able to predict potential

disruptions, constraints, new opportunities or changing operating conditions (Hollnagel, 2011).

EXPLORING THE INTERACTIONS BETWEEN BIM AND RE

In order to identify the interactions between RE and BIM, a matrix was created as shown in Table 1. This matrix relates the four aforementioned RE potentials with the BIM for safety key areas. Table 2 presents the rationale for the interactions.

Table 1: Interactions between BIM and RE

BIM for safety	Resilience Engineering potentials			
	Responding	Monitoring	Anticipating	Learning
Visualization/ simulation	1	1; 2; 3	4	5
Identifying hazards			6; 4	
4D schedule and planning			7; 8	
Collaboration and Communication	9	10	11	12; 13

Table 2: Rationale for the interactions between BIM and RE

No.	Rationale for the interaction	Sources
1	Information related to safety and production can be automatically monitored and visualized in real-time. This increases situational awareness of workers, equipment operators, or decision makers in a construction site or in a remote location.	Cheng & Teizer, 2013
2	BIM increases the awareness of project participants on safety hazards, including workers, for example, in daily meetings and enable better decision-making.	Zhang <i>et al.</i> , 2013
3	Shen and Marks (2015) provide a framework for near-miss data collection and visualization within a BIM platform.	Shen & Marks, 2015
4	Simulation can be used to visualize the workplace and identify potential collisions and other job site hazards.	Zhang <i>et al.</i> , 2013
5	Three-dimensional immersive data visualization can be used to train workers in a virtual environment.	Teizer, Cheng, & Fang, 2013
6	Rule-based checking algorithms can check BIM models for safety hazards early in the design and planning process.	Melzner <i>et al.</i> , 2013
7	4D models avoid costly on-site improvisation.	Martínez-Aires <i>et al.</i> , 2018
8	4D models provide tools to anticipate conflicts between production tasks.	Martínez-Aires <i>et al.</i> , 2018
9	BIM is used to share knowledge, provide information and to offer a solid foundation for decision-making the throughout the lifecycle of the project.	Martínez-Aires <i>et al.</i> , 2018
10	BIM supports the collaborative creation, management, dissemination, and use of information through the entire product and project lifecycle.	Shen <i>et al.</i> , 2010
11	Clash detection increases the ability to eliminate safety issues on a worksite before the work starts.	Alomari, Gambatese, & Anderson, 2017
12	Data referring to safety on a construction site can be shared with all interested parties.	Ganah & John, 2015
13	BIM is used to improve workers' education or training.	Park & Kim, 2013

Table 2 suggests that BIM can promote the four resilience potentials. For the most part (40%) interactions are related to *anticipating*, once BIM is very useful in the design phase to anticipate

hazards and the corresponding possible accidents. For example, clash detection can detect design errors and avoid conflicts in the construction phase, also reducing the gap between work-as-imagined and work-as-done. To promote the *anticipating* potential, different BIM approaches may be used such as visualization, simulation, rule-checking and 4D planning.

The *responding* and *monitoring* potentials are also supported by BIM, representing 13.3% and 26.7% of the interactions, respectively, although the empirical evidence in this respect is more limited in comparison with the contribution for the anticipating potential. Possible practical examples could be related to: the use of BIM for comparing different technological strategies for controlling hazards (i.e. supporting the responding potential); and the use of BIM as a basis for the identification of leading indicators of construction safety (i.e. supporting the monitoring potential).

The *learning* potential is related with 20% of the matrix interactions. It can be operationalized through the discussion of the data produced by all BIM applications for safety. More specifically, learning can result from training workers in a virtual environment for everyday situations or unsafe situations.

Overall, it seems that BIM visualisation and simulation can promote all of the four potentials, which are themselves connected with each other. These BIM tools can increase the awareness of project participants, enable better decision-making, visualize the workplace, identify hazards and can be used for the training of managers and workers. In other words, BIM can reduce the system perceived complexity once it is easier to comprehend the system through its visualization and simulation in a model.

It is also worth noting that BIM produces a structural model of the building as a technical product, rather than the construction site as a socio-technical system. A structural model identifies the main parts or components of a system and shows how they are statically connected or linked (Hollnagel, 2017). However, BIM is more limited in terms of producing a functional model. This is a model that describes functions rather than components, and also indicates both which functions depend on each other and what form the dependencies assume (Hollnagel, 2017). This is a relevant limitation of BIM due to the importance of a functional model to understand resilience. As an alternative, the functional model could be developed through the Functional Resonance Analysis Method (FRAM) proposed by Hollnagel (2012). The FRAM also sheds light on work-as-done, while BIM focuses on work-as-imagined. In fairness, BIM 4D models also offer some functional insights since they can represent the macro dynamics of some operations over time.

Furthermore, BIM is usually applied to construction safety in order to identify what may go wrong or fail. Although this supports the anticipating potential, it is also a drawback from the RE view, which places a stronger emphasis on understanding what goes right. RE assumes that performance variability is also present when things go right, which is much more common than failures and therefore offers much more learning opportunities (Hollnagel, 2017).

Lastly, Tables 1 and 2 show that the BIM functionality of collaboration and communication has relevant interactions with RE. BIM facilitates the sharing and dissemination of information between different design and construction teams connecting distinct phases of project lifecycle. Thus the abilities of monitoring, responding and learning can benefit from more collaboration

and communication.

CONCLUSIONS

The aim of this paper was to carry out an exploratory investigation of how BIM can promote resilience. From the literature review, it was realized that the studies involving BIM for safety were not addressing Resilience Engineering directly, but many of the advantages of BIM support the RE potentials. Thus, a matrix was proposed showing how BIM and Resilience Engineering interact and how BIM can promote resilience in construction. The results showed that BIM strengths from the RE view are related to its potential for the anticipation and monitoring of hazards. BIM seems to be less useful as a means to respond to adverse situations and increase learning. BIM has also limitations in terms of shedding light on work-as-done, learning from what goes right, and functional modelling of the construction site as a socio-technical system.

As for future research, it is proposed: (i) the investigation of empirical evidence to support the discussed interactions; (ii) the development of a combined BIM and FRAM study, which can provide complementary structural and functional models of construction processes, setting a basis for a systems-oriented safety management approach.

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RISK ASSESSMENT IN 4D BUILDING INFORMATION MODELING FOR MULTISTORY BUILDINGS

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Research has shown that site safety hazards can be addressed during construction and reduced or even eliminated in the early stages of a project before a project starts. Identifying construction hazards at the design stage can be difficult, especially for those who do not have adequate knowledge and experience with respect to construction processes and safety. Several tools have been created to assist design professionals with implementing the concept of prevention through design (PtD). This paper presents research that proposes to integrate risk factors based on an online tool titled Safety in Design Risk Evaluator (SliDeRule), which quantifies risks at the object-level in multistory buildings, with a building information model and a construction schedule. The proposed approach shows potential to help designers assess safety risk for the entire building and incorporate risk concerns during design modification and alternatives selection. Moreover, safety risks can be visualized and simulated to identify when and where high-risk tasks will occur. The proposed process may also be beneficial to contractors in several ways, such as modifying schedules to reduce risk levels in a particular time period, hazard recognition, control measures selection, site planning, and safety communication.

Keywords: Building Information Modeling (BIM), Risk assessment, 4D, Site safety planning

INTRODUCTION

Prior research has often attempted to identify construction phase factors and controls that lead to a safe construction site from the point of view of contractors. Research and publications in this area have mainly focused on the constructor's role because governing safety regulations such as those promulgated in the US by the Occupational Safety and Health Administration (OSHA) place the responsibility for safety on the employer's shoulders (Gambatese and Hinze, 1999). Recent studies reveal that site safety hazards, in addition to being addressed in the construction phase, can also be reduced or eliminated in the early stages of the project (Behm, 2005), and it is more effective and economical to do so in the design and redesign process (Manuele, 2013). However, a lack of designer knowledge regarding safety and construction processes (Toole and Gambatese, 2006), and limited availability of design-for-safety tools, guidelines, and procedures has hampered hazard mitigation during design (Gambatese, 2004). Researchers have developed tools to provide designers resources for hazard recognition and risk mitigation in the design. Nevertheless, the majority of current tools are text-based

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standalone tools, which are either in paper or software format (Ku and Mills, 2010).

To overcome limitations and inefficiency associated with these tools, building information modeling (BIM) and BIM-based tools offer new approaches to “design out” or minimize hazards and risks by integrating 3D models with construction procedures and safety knowledge through iterative design processes. Kasirossafar et al. (2012) confirmed this opportunity through a survey conducted in 2012 revealing that 75% of the participants, who were either university professors or experienced designers and engineers, believed that construction accidents could be predicted and preventable through BIM implementation in the design phase. It is believed that the process of applying BIM can be viewed, to some extent, as a systematic way for managing risks (Zou et al., 2017). Furthermore, the use of BIM has been extended in multi-dimensions, such as 4D BIM that links time-related information with data in 3D models. Many research efforts have been drawn to promote site safety utilizing simulation and visualization features in 4D BIM. Examples include site planning for temporary structures (Sulankivi et al., 2010; Zhang et al., 2015) and site planning by integrating safety scores of various trades with site-specific temporal and spatial information (Choe and Leite, 2017).

However, with respect to the hierarchy of controls, the majority of past research efforts have focused on exploring BIM applications in the lower levels of the hierarchy (e.g., engineering and administrative controls), while the control measures at the top levels (e.g., elimination and substitution) are generally considered more effective and reliable than the lower level controls. When addressing safety issues in BIM, most studies have also only targeted a specific type of site hazard (e.g., falls). To address the limitations of previous research, this paper proposes an object-oriented approach to assess construction risks based on unit risk factors for design elements with consideration given to frequency, severity, and exposure, and to support decision making in the selection of design alternatives in multistory buildings using 4D BIM.

BACKGROUND RESEARCH

Hazard identification is a fundamental aspect of implementing the PtD concept as unrecognized site hazards lead to unmanageable hidden risks. PtD tools aim to help designers recognize hazards, and some have also been designed to suggest how to mitigate the hazards. The tools have been developed in multiple platforms, such as the checklist-based software “Design for Construction Safety ToolBox” (Gambatese et al., 1997) and web-based tool “Total-Safety” (Carter and Smith, 2006). Similarly, public agencies have published training tools or guidelines to assist designers in identifying hazards in their designs. An example is the hazard identification training tool (OSHA, n.d.), which aims to assist non-safety professionals in finding common hazards on construction sites. Additionally, researchers have recognized that visualization tools enable designers to better detect time-space conflicts to prompt hazard recognition, such as fall identification using BIM (Zhang et al., 2015), and to facilitate communications between designers and builders, such as safety dialogue through virtual reality (Sacks et al., 2015).

Building upon identified risks, many studies have focused on quantifying the level of risk in order to support decision-making. Methods for quantifying safety risk and sources of risk data are inconsistent (Hallowell and Gambatese, 2009). For example, there are studies evaluating risk to construction trades based on frequency and severity using historical data from the US Bureau of Labor Statistics (BLS) (Baradan and Usmen, 2006; Choe and Leite, 2016). Past

research has focused on quantifying risk using expert judgement with considerations of frequency, severity, and exposure for construction activities in office building projects (Frijters and Swuste, 2008). There are studies of concrete formwork construction (Hallowell and Gambatese, 2009), studies to assess risks associated with design features for roof maintenance (Cooke et al., 2008), and studies of safety risk during residential building construction (Gangoellis et al., 2010). However, to date, there is a lack of studies that have evaluated risk at the individual design element level. Focusing safety risk research on the design elements to be constructed could be an efficient way to link risk data with BIM, as BIM is an object-oriented parametric digital representation (Azhar, 2015).

A number of studies have analyzed temporal and spatial safety risk with a schedule-risk integration approach, some of which are presented in Table 1. When incorporating risk factors with project schedules, some studies did not take into account the amount of exposure to the hazard as a factor influencing the risk. In addition, a drawback of existing methods for schedule-risk integration is that the studies conducted to develop the models were not conducted from the designers' perspectives, as the approaches required designers to have adequate construction and safety knowledge to evaluate the risks of a project, e.g., knowing the approximate number of workers required for a construction task and the expected duration of the task.

Table 1: Past endeavours with respect to schedule-risk integration

Author(s), Year	Risk Quantification Consideration	Contribution
Yi and Langford (2006)	Risk intensity associated with high-risk locations, processes, occupations, and environment factors	Proposed a method to incorporate historical accident data with a schedule to estimate the fall risk distribution of a project
Rozenfeld et al. (2009)	Frequency, Severity, Exposure	Developed a model called CHASTE (Construction Hazard Assessment with Spatial and Temporal Exposure) to combine risk factors with schedules to evaluate risk levels for work teams, activities, or areas
Hallowell et al. (2011)	Risk effects of an activity on another activity	Developed an approach to link quantified pair-wise interaction risks among highway construction tasks based on experts' judgments with a schedule
Choe and Leite (2017)	Frequency, Severity (Based on Choe and Leite (2016))	Used 4D BIM to integrate risk data in regards to construction trades with activities in a schedule for site safety planning

According to Frijters and Swuste (2008), the designers' main concerns in using PtD tools are that the design process is not significantly disrupted and that their freedom in designing is not impaired. Considering risks at the object level, the present study offers designers a method that can return a desirable result in terms of risk assessment, and help with design modification and alternative selections without having serious impacts on the design process and creativity.

METHODOLOGY

The proposed approach to risk evaluation and mitigation during design consists of four steps: 1) safety risk quantification for design elements and construction activities; 2) incorporation of risk scores with 4D BIM model; 3) project risk simulation and risk assessment analysis; and 4) design alternative selection. The proposed method is illustrated in Figure 1.

Safety Risk Quantification for Design Elements

This study adopts the risk quantification and assessment method proposed by Dharmapalan et al. (2014) because it enables quantification of the risk at a design element level. Dharmapalan et al. identified the major construction activities associated with each potential design option for each typical design element in a multistory building. The risk was firstly quantified at the activity level using survey results from construction field personnel, and the cumulative results were used to assess the risk for each design element. In terms of risk quantification, the unit risk was generated based on severity and frequency, expressing the risk in the units severity/worker-hour. Then, exposure was incorporated to determine the cumulative risk for each design element using standard productivity measures to express the risk in severity/unit of measurement of the design element. As a result, the safety risk of 141 design elements and 683 construction activities were quantified in their study. Table 2 shows the unit and cumulative risk values of two sample design elements. In addition, the risk model was programmed to a web-based tool titled Safety in Design Risk Evaluator (SliDeRule); it is ready for designers to use. To determine the absolute safety risk associated with a complete design, the total cumulative risk factor for each element within the design is multiplied by the total quantity of the design element, and then the products for all of the design elements are summed to get the total risk for the complete design.

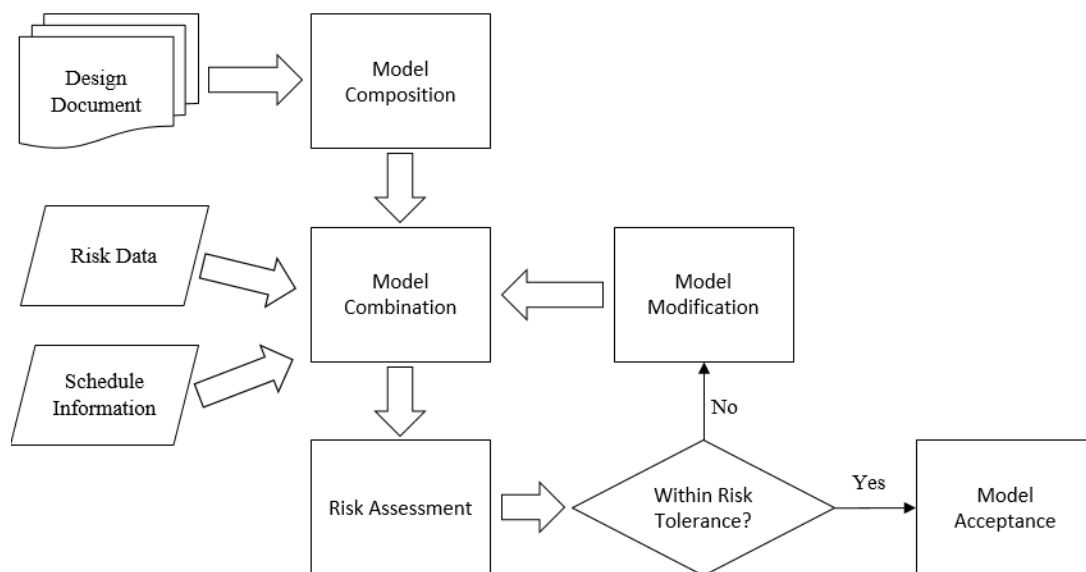


Figure 1: Graphical Representation of Proposed Design Risk Assessment and Mitigation Method

Table 2: Risk values for steel H-pile and One-way joist slab

System	Subsystem	Design Element	Unit of Measurement	Total Unit Risk (severity per worker-hour)	Total Cumulative Risk (severity per unit)
Foundation	Deep Foundation	Steel H-pile	Length of pile (vertical linear feet)	0.29	0.02
Structural Frame	Slab	One-way joist slab	Volume of concrete (cubic yards)	1.57	1.26

Incorporating Risk Values with 4D BIM Model

The second step, after the development a 3D BIM model based on the original design, is to link the quantified risk values with corresponding design elements in the 3D model. Design element details such as configuration and material type for each object in a 3D model can be extracted from the 3D model or design documents. These details are then used to connect with the identical design elements in the risk quantification model. Based on the corresponding relationships, the unit risk can be assigned to each object in the model. Furthermore, objects in a 3D model contain useful geometric attributes, such as length, area, and volume. Similar to the procedures for performing a quantity take-off based on a BIM model, after gathering the unit risk and quantity information in the matched unit of measurement, the risk associated with an object can be calculated. Thus, the risk quantification of the entire project can be achieved by combining the risks associated with all of the objects present in the 3D model.

The integrated risk result from a 3D model alone is not sufficient to assess temporal and spatial exposure to safety hazards on site. Given the long-duration of many construction projects, the extremely complex and dynamic working environment, the involvement of multiple specialty contractors, and crowded work spaces, detailed risk assessments over time and in individual work spaces are required. This information can assist designers with incorporating timely safety considerations into designs. Hence, a 3D model is further combined with a work breakdown structure and project schedule. With the incorporation of this additional project data, the risk value for a specified span of time, and for a specific work area on site, can be calculated.

4D Model Simulation and Risk Assessment Analysis

With the help of linking the construction activities with 3D objects, through simulation a 4D model can be used for visualizing the construction sequences on a timeline for the entire project. The 4D model also benefits both designers and constructors in a collaborative environment and in recognizing unscheduled design elements. Designers may identify potential design deficiencies with respect to safety or constructability issues and make adjustments before the risk assessment analysis.

By incorporating safety considerations, the 4D model helps in identifying when and where high-risk tasks are scheduled. According to past designs, contingency plans, and contractors' work experiences and safety records, a pre-defined risk tolerance could be determined by stakeholders, either based on a unit of time or unit of area. By comparing the project's risk score with the pre-defined threshold, designers are able to make informed decisions whether to change the design to alleviate risk concerns for high-risk tasks, time periods, and work areas. In this way, the decision made does not purely rely on the designers' knowledge and experiences, but incorporates that of experienced construction personnel.

To illustrate the process, a pilot test was conducted using the technical school structural model from the online Revit sample project files (<https://knowledge.autodesk.com/support/revit-products/getting-started>). The model consists of various structural components including steel piles, concrete columns and framing, and exterior concrete walls. As shown in Figure 2, the 3D model was integrated with a work breakdown structure and a schedule using the software Synchro PRO (<http://www.synchroltd.com/>). The risk factors from SliDeRule that are associated with each design element were uploaded to the 4D model. Using Synchro PRO, the

daily risk for each task is calculated, as shown in one of the work breakdown structure columns and displayed in the daily risk graph in Figure 2. The result shows that pouring concrete slabs are associated with high risk (e.g., pouring 1st concrete floor during weeks 5 and 6). Additional analyses can be conducted to determine time periods during the project and locations on the project where there are particularly high levels of cumulative risk.

Design Alternative Selection

While the pilot test did not extend to this step, if modifying the design is determined to be the best plan of action, designers could revise the design at the object level or work with the contractor to adjust both the model and the schedule to reduce the accumulated risk. Designers could repeat the process several times until the identified risk is acceptable. When applying the process, design professionals should critically evaluate the results to ensure accuracy and make design element selections and design modifications wisely.

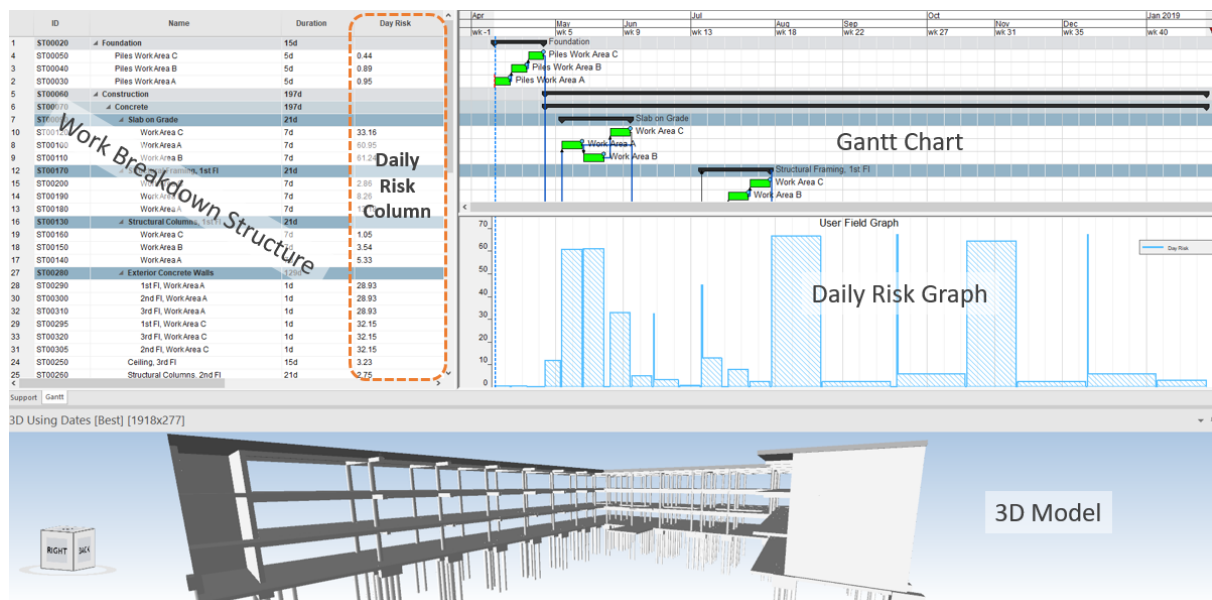


Figure 2: Preliminary Risk Result from a Revit Structure Sample Model

EXPECTED BENEFITS AND LIMITATIONS

The proposed method offers potential for improving risk assessment when designing a multistory building through incorporating risk values with design elements and further implementing the concept of “design for safety” in practice. Several potential benefits of the proposed method are identified as follows:

- For designers: Through the risk quantification of each design element, designers are able to gain an idea about risk levels for each building system (e.g., foundation and structural frame), subsystem (e.g., column, beam/girder), and design option (e.g., precast beam, one-way solid slab), even though the designers may not personally have sufficient knowledge about safety and the construction process to assess the hazards and quantify the risk. After risk data and schedule information are incorporated with the design model, designers can acknowledge the presence of high-risk tasks (when and where they will occur) and, based on a pre-defined threshold, adjust their designs to eliminate the hazards or substitute in less hazardous materials or design components. Further design iterations might bring safer

results. However, time and budget should be considered when deciding on the number of iterations to make and the acceptable risk threshold.

- For constructors: As mentioned previously, the proposed method helps contractors to discover deficiencies in the schedule, such as checking if all design elements are assigned to be built. Also, the process provides a way for contractors to offer input during the early stage of a project, which improves the effectiveness of risk mitigation and avoidance. In addition, builders are able to plan ahead for safety resource allocations within a high-risk period or work area. Meanwhile, they could use the risk information to re-sequence high-risk activities during construction (e.g., risk leveling).

Although the proposed method can benefit designers in several ways by helping to design for safety, there are some limitations and challenges associated with the process. The most significant deficiency in the proposed tool so far is related to the content in SliDeRule. If the risk factors of the design components in the facility are not quantified and not included in the SliDeRule tool, then the risk score of a design with those elements is unachievable. The risk score of a similar element could be used; however, the results may not be accurate. Moreover, the building processes for the design elements in SliDeRule are assumed to be independent in the present study. Risk interactions among incompatible tasks are not considered.

CONCLUSIONS

The proposed method benefits designers by helping them acknowledge differences in risk scores for various design elements and provides safety knowledge to designers about their designs. After risk simulation and visualization, designers are informed about high-risk tasks, work periods, and work areas. Based on this risk information, designers can communicate with contractors to identify design errors and deficiencies to promote safety in order to control hazards before they are present on the site. The method enables attaining higher levels of the hierarchy of controls. Through an iterative design process, designers are able to produce plans that mitigate constructability issues and contain fewer safety concerns, along with gaining more knowledge about risk, site safety, and construction sequencing.

The proposed method also benefits contractors. During the design phase, contractors may participate in an early stage of the project which helps to identify and provide safety controls in the design, to discover errors in schedules, and to offer opportunities to plan for the construction work. During construction, contractors could utilize the high-risk activity, work area, and time information presented in the 4D model to allocate safety resources, select risk control measures, and communicate with subcontractors regarding the anticipated hazards.

While this approach requires input from both designers and contractors, it is recommended that the approach is implemented on projects with integrated project delivery methods such as design-build. In this way, the two entities work together and closely. The delivery method helps to shorten the design iteration process, improve the quality of the design, and ensure the development of a safe design.

Future research is recommended related to two aspects: risk quantification and 4D model applications. As mentioned previously, the major drawback of the proposed method is that it builds upon the risk scores of design elements. However, the risk for only a limited number of design elements has been quantified. On the other hand, the risk scores used in the present study were based on safety experts' opinions; they are applicable for general building sites and

might not be suitable when considering site-specific conditions. Future research could be conducted to compile a knowledge-based BIM system with extended design elements containing risk factors from empirical data. Additionally, designers and contractors would benefit from suggestions in terms of risk management of each design element in the model.

As for 4D model applications, future research should apply the proposed method on actual multistory building projects to examine the effectiveness and feasibility in risk mitigation and prevention. Information regarding designers' acceptance and contractors' perception of the proposed approach should be solicited, as they are the end-users of the tool. In addition, the current application only relates to multistory buildings; further research could be performed to examine if this method can be extended to other infrastructure components as well.

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DEVELOPMENT OF A DESIGN FOR OCCUPATIONAL SAFETY AND HEALTH CAPABILITY MATURITY MODEL

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Design for occupational safety and health (DfOSH) is growing in prominence in the construction sector. Consequently, designers (as individuals or organisations) are expected to mitigate occupational health and safety risks through design. In order for design firms to effectively do this, they need to have adequate capability in respect of DfOSH. However, there is limited empirical insight regarding DfOSH capability as well as robust mechanisms for ascertaining the DfOSH capability of design firms. Drawing on the capability maturity concept, this study through three iterations of expert focus group discussion presents a preliminary DfOSH capability maturity model. The preliminary model captures DfOSH capability attributes mapped onto five stages of capability maturation. The model is undergoing review and testing by industry experts to ensure its practical utility within industry. It is anticipated that through the testing of the preliminary model, the eventual DfOSH capability maturity model would be beneficial to several industry stakeholders, particularly design firms by way of self-assessing their capability in order to understand the areas of capability deficiency and strength. Clients who appoint design firms could also use the model as part of pre-qualification arrangements in selecting design firms with adequate DfOSH capability.

Keywords: Design, Design for occupational safety and health, Prevention through design, Safety in design, Capability maturity model.

INTRODUCTION

The construction sector is one of the highest contributors to work-related accidents and illnesses. For instance, in the UK, the Health and Safety Executive (HSE) (2015) estimates that yearly about 3% of construction workers suffer from work-related illness, and about 3% sustain an occupational injury resulting in 1.7 million lost working days. The rate of fatal injuries to workers in the construction sector is about 3.5 times the average rate of fatal injuries to workers in all industries, and also the rate of non-fatal injuries in construction is about 1.5 the average rate in all industries. In terms of occupational illnesses, the prevalence rate of self-reported illness in construction is also higher than the average rate in all industries (HSE, 2015). One of the prominent initiatives to address the OSH situation in construction is design for occupational safety and health (DfOSH), also known as ‘prevention through design’, ‘design for safety’, and ‘safety in design’. While there is a growing body of research on DfOSH in construction,

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empirical work on DfOSH capability of design firms (or more broadly organisations with design responsibility) is sparse (Manu et al., 2017). This study thus examines DfOSH capability. In particular, it presents a maturation model for DfOSH capability. The next section presents a brief overview of DfOSH and capability maturity to provide the underpinning for the development of the DfOSH capability maturity model. The research method applied and a preliminary version of the model are subsequently presented. The implications stemming from the preliminary model and concluding remarks are finally presented.

LITERATURE REVIEW

DfOSH involves anticipating and eliminating or minimising OSH hazards and risks in the design process of a building or structure in order to eliminate or minimise the risks of occupational injury and illness to construction and maintenance workers (Schulte et al., 2008). The prominence of DfOSH is rooted in studies which have highlighted design as a contributory factor in the occurrence of construction accidents and injuries (e.g. Behm, 2005; Gibb et al., 2006; Manu et al., 2014). In the study by Behm (2005), undertaken in the USA, 42% of 224 construction fatality cases were linked to design. Research by Gibb et al. (2006) reported that up to 50% of a 100 construction accident cases that were studied could have been mitigated through choices in the design. From these studies, it is evident that design is an important factor in construction accident causation and has therefore resulted in the growing prominence of DfOSH as shown by the legislative support for its practice in some countries e.g. UK, Australia and Singapore (see the Work Health and Safety Acts and Regulations in Australia, the Construction (Design and Management) (CDM) Regulations 2015 in UK, and the Workplace Safety and Health (Design for Safety) Regulations 2015 in Singapore).

DfOSH requires that designers (as individual professionals or organisations) take into consideration the OSH implications of their design decisions during the design stages of built assets. The UK CDM regulations, now in its third iteration (i.e. CDM, 2015) after previous versions (i.e. CDM 1994 and CDM 2007) require that designers reduce foreseeable risk as much as possible through their decisions when preparing or modifying designs. The CDM 2015 has also introduced a new requirement in respect of the organisational capability of construction organisations to undertake their operations in a manner that protects workers from OSH injuries and illnesses. Regarding design firms, this can be considered in terms of their capability to implement DfOSH on projects. However, regardless of legislative requirement for DfOSH organisational capability, the contribution of design to the occurrence of occupational incidents in construction makes it imperative for design firms to have adequate capability to implement DfOSH on projects. However, lacking in the growing body of DfOSH academic literature is empirical work into DfOSH organisational capability (Manu et al., 2017). Aligned to this, Toole and Gambatese (2017) presented a theoretical piece on the levels of implementation of prevention through design (PtD) on projects, in which they suggested organisational characteristics and project processes that will enable adoption of PtD. There is thus lacking empirical research to shed light on the constituents of DfOSH organisational capability and mechanisms by which it can be reliably assessed.

Regarding organisational capability assessment, in the construction sector and other sectors, whilst there are various approaches for assessing performance (e.g. key performance indicators (KPIs), balanced score card, and excellence models), one of the prominent approaches for assessing organisational capability in a domain as part of process improvement is the capability

maturity model (CMM) (Paulk et al., 1993; Strutt, et al., 2006; Succar 2009). Although originally developed for the domain of software development by the Software Engineering Institute at Carnegie Mellon University, the CMM represents a generic framework for continuous process improvement and hence, has been applied in several areas in construction including: change management; project, programme and portfolio management; asset management; building information modelling; and supply chain management (see Succar 2009; Mahamadu et al., 2017). In OSH, CMM has also been applied although not specifically to DfOSH e.g. the safety culture model by HSE (2000). The application of CMM in several areas in construction including OSH as a robust process improvement tool thus supports its application to DfOSH to produce a DfOSH capability maturity model.

RESEARCH METHOD

In order to develop a DfOSH capability maturity model, it is important to establish: (1) the key process areas (i.e. the DfOSH capability attributes); and (2) the maturity levels (Maier et al., 2012). The following subsections presents the steps undertaken to address both.

Determining the DfOSH Capability Attributes

The key process areas of a CMM can be derived from: (1) the originator's experience and reference to established knowledge in the relevant domain; and (2) a panel of experts in the domain, especially where there is limited prior literature about the domain (Maier et al., 2012). This study used a panel of construction industry experts due to the limited empirical work regarding DfOSH capability. Three iterations of expert focus group discussions (FGDs) were held in order to identify the attributes that determine DfOSH capability of organisations. In order to select suitably qualified and experienced experts in the domain of DfOSH, the guidance of Hallowell and Gambatese (2010) regarding the criteria for selecting experts (e.g. a professional with expertise in the subject of inquiry, and a minimum of five years of experience) was followed. In line with that, a total of eight experts were engaged in the three FGDs. The three FGDs mainly involved the experts engaging in brainstorming and reviews which were aimed at identifying the capability attributes and refining the attributes. Each FGD session took about two hours and they span over a 10 month duration. From the brainstorming exercises, the views of the experts regarding capability attributes were recorded, collated and synthesised through re-reading and thematic analysis. The iterative nature of the FGD sessions enabled elicited attributes to be reviewed and refined by the experts in subsequent FGD sessions in order to ensure appropriateness and clarity of the attributes. Through the review and refinement, the experts agreed on the DfOSH capability attributes at the third FGD session, and afterwards the maturity levels were formulated as discussed below.

Formulating the Maturity Levels

Capability maturity models commonly use five maturity levels (Maier et al., 2012) in line with the original CMM by Paulk et al. (1993). Similarly, in this study, five maturity levels was adopted, with level 1 being the lowest maturity level and level 5 being the highest maturity level. The concept of the capability maturity model is such that progression to, or attainment of a higher maturity level is pre-conditioned on the attainment of lower maturity levels, so for instance, in order for an organisation to be at maturity level 5 in a capability attribute it should have already met the requirements for the lower levels.

Based on a review of several CMMs, Maier et al. (2012) noted that formulating maturity levels involves: (1) using a top-down or bottom-up approach; (2) consideration of the information source; and (3) consideration of the formulation mechanism. In the bottom-up approach, measures of maturity are determined first, before definitions are written to reflect the measures (Maier et al., 2012). In the top-down approach, the emphasis is first on what represents maturity, before how it can be measured (Maier et al., 2012). This approach is most appropriate if the field is relatively new (Maier et al., 2012). This approach was mainly used given the limited empirical work on DfOSH capability. Regarding what represents maturity in each key process area, it is important to establish the underlying notion of maturity and to do that several information sources can be useful e.g. existing literature relating to the key process areas (Maier et al., 2012). Existing CMMs and best practice guides on subjects that are related to the DfOSH capability attributes (e.g. the risk management maturity model (RM3) by the Office of Road and Rail and Health and Safety Laboratory (2017)) were reviewed in addition to maturity indicators (explained in the results section) suggested by the FGD experts in order to obtain an understanding of what represents maturity in each of the DfOSH capability attributes. This understanding informed the underlying notion of maturity which was then used in formulating the maturity level descriptors for each of the DfOSH capability attributes. Regarding the formulation mechanism for the maturity level descriptors, in line with the suggestion by Maier et al. (2012), in the first instance, the descriptors for the maturity levels at the extreme ends (i.e. level 1, being the lowest level, and level 5, being the highest) were formulated (based on the underlying notion) such that level 1 represented no or very low maturity and level 5 represented the highest level of maturity which is also depicted by regular reviews within the capability attribute in order to ensure continuous improvement. Secondly, the mid range maturity level descriptors (i.e. from level 2 to level 4) were deduced from the underlying notion and formulated accordingly. For the purpose of illustration, excerpts from the eventual DfOSH capability maturity model are presented in the results section.

RESULTS AND DISCUSSION

The FGD experts are: a senior design manager; an architect; two occupational health and safety professionals; a civil/structural engineer; a health and safety consultant and civil engineer; a senior quantity surveyor; and a project manager. Each expert is affiliated to at least one professional body, which includes the Association for Project Management, Association for Project Safety, Chartered Institute of Building, Institution of Civil Engineers, Institution of Occupational Safety and Health, Institution of Structural Engineers, Royal Institute of British Architects, and the Royal Institution of Chartered Surveyors. The minimum years of experience in professional role and the minimum years of experience in construction are 10 and 15 respectively. In the main, the experts are suitable for the study as their roles and experience relate to design, OSH management, DfOSH, and selection of project organisations, which under CDM 2015 requires consideration of organisational capability in respect of OSH.

From the FGD brainstorming and reviews, 18 DfOSH capability attributes were identified. Additionally, the FGD experts suggested examples of maturity indicators (i.e. items, activities or practices that could evidence maturity) for the DfOSH capability attributes. The 18 DfOSH capability attributes elicited from the FGDs are: (1) skills of design staff in relation to DfOSH; (2) knowledge of design staff in relation to DfOSH; (3) experience of design staff in relation to DfOSH; (4) access of design staff to competent advice; (5) role definition for design staff

and the recruitment of design staff into roles; (6) design staff training in relation to DfOSH; (7) DfOSH policy; (8) top management commitment to DfOSH; (9) DfOSH research and innovation; (10) corporate experience in implementing DfOSH on projects; (11) organisation's design quality management systems/processes; (12) organisation's design risk management systems/processes; (13) organisation's project review systems/processes for learning DfOSH lessons; (14) systems/processes for management of outsourced/subcontracted designers; (15) organisation's physical work resources; (16) organisation's ICT resources; (17) intra-organisational collaboration in implementing DfOSH; and (18) inter-organisational collaboration in implementing DfOSH.

For the sake of brevity, Table 1 presents excerpts of the DfOSH capability maturity grip. It shows five capability attributes mapped onto the five maturity levels. It also shows the underlying notion that informed the formulation of the maturity level descriptors for each of the five capability attributes. From Table 1 it can be seen how the underlying notion for each of the capability attributes was used to deduce descriptors depicting increasing maturation in the capability attributes.

Table 1: Extracts from DfOSH Capability Maturity Model

Capability Attribute	Underlying Notion of Maturity	Maturity Levels				
		Level 1	Level 2	Level 3	Level 4	Level 5
Inter-organisational collaboration	Higher maturity levels would be characterised by developing and maintaining long-term relationship and strategic relationship planning, while lower maturity levels would be characterised by lack of shared vision.	Company/design office (DO) shows no commitment to the shared OSH vision of projects they are involved in.	Company/DO shows limited commitment to the shared OSH vision of projects they are involved in.	Collaboration by company/DO with other project team members is usually only reactive.	Collaboration by company/DO with other project team members is usually proactive in order to ensure effective delivery of OSH and other project objectives.	Company/DO continuously develops and sustains long-term collaborative working relationships with other organisations in order to harness and continuously improve collective expertise relevant for DfOSH or construction OSH in general.

Capability Attribute	Underlying Notion of Maturity	Maturity Levels				
		Level 1	Level 2	Level 3	Level 4	Level 5
DfOSH policy	As maturity increases, company DfOSH policy becomes clearer, well-communicated within the organisation, and interpreted and applied consistently by all managers/supervisors and staff.	No policy on DfOSH.	Vaguely worded policy statement or out-of-date policy statement on DfOSH. Policy has not been communicated within the organization.	Clear company/DO policy on DfOSH setting out the intention(s) on DfOSH. The policy is communicated within management and staff, but managers/supervisors and staff have inconsistent interpretations and applications of the policy.	Clear company/DO policy on DfOSH setting out the intention(s) on DfOSH. The policy is well-communicated within the organisation and to external stakeholders. The policy is consistently interpreted and applied the same way by all managers/supervisors and staff.	Clear company/DO policy on DfOSH setting out the intention(s) on DfOSH and recognising that DfOSH is not a separate/add-on task but an integral part of a design workflow, productivity and competitiveness. Policy is consistent with other best-performing organisations' policies. Policy is reviewed regularly to drive continuous improvement that is in line with the best-performing organisations.
Organisation's ICT resources	Higher maturity levels would be characterised by exploitation of cutting edge computing and information technology facilities that support DfOSH.	No or very little ICT resources (including software and hardware) to support DfOSH.	ICT resources that support design function (including DfOSH) are available but not standardised across company/DO. Specifications of ICT resources are basic and not consistent.	ICT resources that support design function (including DfOSH) are available and standardised across company/DO. Specifications of ICT resources are just adequate and standardised.	ICT resources that support design function (including DfOSH) are widely available, standardised and managed according to a resource plan. Specifications of ICT resources are advanced and of a high standard.	Cutting-edge ICT resources that support design function (including DfOSH) are available, standardised and considered as a core measure of operational excellence. Specifications of ICT resources are the most up to date and of the highest standards.

Capability Attribute	Underlying Notion of Maturity	Maturity Levels				
		Level 1	Level 2	Level 3	Level 4	Level 5
						ICT resources are regularly reviewed for their up-to-date suitability to ensure continuous improvement in the use of digital technologies for design function (including DfOSH).
Design staff continuous professional development (CPD) in relation to DfOSH	As maturity increases, there would be regular provision of DfOSH related CPD training for design staff. In addition, design staff would regularly undergo performance and development review, which informs their CPD training.	No provision of DfOSH related CPD training for design staff. No structured performance and development review (PDR) for design staff to ascertain staff performance and training needs.	Rare provision of DfOSH related CPD training for design staff. Design staff PDR is rarely undertaken.	Occasional provision of DfOSH related CPD training for design staff. CPD training is usually reactive. Design staff PDR is sometimes undertaken.	Regular provision of DfOSH related CPD training for design staff. CPD training is usually proactive. Design staff regularly undergo PDR.	Design staff CPD training and PDR are integral to the organisation's human resource development strategy/plan and they are embedded within the organisation's human resource development practices. PDR procedures and organisational human resource development strategy/plan are reviewed to ensure their up-to-date suitability and continuous improvement.

For example, for DfOSH policy, whereas at Level 1 there is no company policy regarding DfOSH, at level 5 there is a clear policy that is regularly reviewed and updated. Between these two extremes, there is progressing and distinct maturation as the DfOSH policy improves from being vaguely worded and not communicated (at Level 2) to being clear, communicated, but inconsistently interpreted and applied (at Level 3), and then being clear, communicated, and consistently interpreted and applied (at Level 4).

The emergent DfOSH capability attributes have resemblance to some of the key process areas used in existing capability maturity grids. For example, Strutt et al.'s (2006) design safety capability maturity model for the offshore sector proposed attributes such as education and training, research and development, organisational learning, and managing of safety in the supply chain. The safety culture maturity model by HSE (2000) also included attributes including 'training', 'management commitment and visibility', 'learning organisation', and

‘safety resources’. Outside the area of safety, Succar (2009) proposed a building information modelling maturity matrix which composed of capability attributes labelled as ‘BIM competency sets’. These attributes included leadership, human resources (encompassing competencies, roles and experience), physical infrastructure, hardware and software.

The DfOSH capability attributes (e.g. DfOSH CPD training, DfOSH research and innovation, organisation’s project review systems/processes for learning DfOSH lessons, systems/processes for management of outsourced/subcontracted designers, top management commitment to DfOSH, ICT resources and physical resources) share similarities with the above mentioned attributes in the models by HSE (2000), Strutt et al.’s (2006) and Succar (2009), although the DfOSH capability attributes have specific relevance or focus on the implementation of DfOSH by construction organisations with design responsibilities (e.g. architectural design consultancy firms, engineering design consultancy firms, and design and build contractors). In broad terms, the DfOSH capability attributes also reflect the categorisation/classification of attributes used in existing capability maturity grids such as ‘technology’, ‘process’ and ‘policy’ (Succar, 2009).

Overall, the study has shown that the capability maturity concept, as applied to several subjects in construction and in other disciplines, can be applied to DfOSH capability. Within topical areas of construction such as building information modelling (BIM), there has been a proliferation of maturity models including those used by industry stakeholders for organisational BIM capability assessment (see Sebastian and Berlo, 2010). For instance, Sebastian and van Berlo (2010) BIM capability tool is used in the Netherlands for benchmarking the BIM performance of design, engineering and construction firms. These generally attest to the practical utility of capability maturity tools. Similarly, the DfOSH capability maturity model could therefore be beneficial to several construction sector stakeholders including: construction clients (and their representatives) who commission construction projects and appoint firms with design responsibilities; and design firms (e.g. civil/structural engineering, architectural and building services engineering) who have design responsibilities on projects. However, the DfOSH capability maturity model in its present form is preliminary and therefore requires further review and testing by industry professionals in order to ascertain its practical utility. Further development and subsequent expert evaluation of the preliminary DfOSH capability maturity model is currently underway.

CONCLUSIONS

DfOSH is increasingly gaining ground in the global construction sector of several countries. It entails firms in design roles producing designs that are safer for workers to build and maintain. Such firms therefore need to have the appropriate level of capability in terms of DfOSH. Design firms would have varying DfOSH capability and it is important that they understand their current capability so that they are able to improve. Likewise it is imperative that construction clients, their representatives or entities engaging the services of design organisations are also able to ascertain the DfOSH capability of those organisations. This ongoing study is addressing a significant research gap regarding DfOSH capability by presenting empirical work which is leading to the development of a DfOSH capability maturity model. The model shows five distinct levels of maturation in distinct DfOSH capability attributes drawn from focus group discussions with a panel of industry experts. To ensure its practical utility, the model is at a stage of review and evaluation by industry experts. It is anticipated that through the review and

expert evaluation, valuable feedback would be obtained to further improve the model. It is also expected that the eventual maturity model would be beneficial to industry stakeholders including, clients by way of assessing the capability of design firms they appoint, and also to design firms by way of undertaking self-assessment of their DfOSH capability in order to improve.

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HAZARDS IN OCCUPATIONAL SAFETY IN THE ALUMINUM FORMWORK SYSTEM

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The aluminum system formwork was implemented during the growth of the building construction sector and has been widely used, due to the applicability of the Brazilian Federal Government's “*Minha Casa Minha Vida (MCMV)*” Program. The execution speed is ideal for building condominiums with high repeatability, a noticeable feature of the MCMV Program. This system involves several stages and different professionals in a daily production cycle, which requires different and specific accident control measures associated with investments in occupational safety at construction sites. This work aims to identify and analyze the hazards of accidents in the activities of the aluminum formwork system. To identify the hazards, systematic observations and photographic records were carried out at two construction sites in the state of Pernambuco that used the aluminum formwork system. The methodology adopted in the research is based in the “method of risk assessment and control for civil construction” (BARKOKÉBAS JUNIOR et al, 2004) in the fields of occupational safety engineering and to structuring certain stages of this research. The results are likely control measures for specific accidents per stage of the construction system.

Keywords: Hazards, Aluminum formwork system, Hazard identification.

INTRODUCTION

According to the Social Security (2017), in the year of 2015 the number of occupational accidents registered a reduction of 14% in relation to the 2014's accidents in Brazil. The civil construction sector, despite registering a decrease of 19% compared to 2014, is still one of the six sectors that together represent approximately 25% of the accidents.

The reduction of accidents in construction is associated not only with the retraction of the sector, due to the political crisis, but also with the investments from companies in occupational safety. Regarding the occupational safety sector, the construction systems must be studied in advance in order to identify and analyze the possible accident risks in the execution stage, in order to eliminate and/or minimize those accidents.

According to the Brazilian Portland Cement Association – ABCP (2013), there are records of construction companies that have been using the aluminum formwork system in Brazil for more than 16 years, even though 70% of them have been using this system for less than 5 years. The system use has been disseminated by the applicability in construction works of the Brazilian Federal Government's “*Minha Casa, Minha Vida*” Program, due to the system speed, with a

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single-day cycle from assembling frame and form to concreting walls and slabs.

Ganar and Patil (2015) state that the use of the aluminum formwork system has been a growing trend in recent years in many countries, due to the housing deficit. The system is increasingly used since it is considered a technology capable of rapid construction, good quality, durable, and low cost for mass housing construction. The aluminum formwork system is still sparsely approached in scientific articles regarding the specific study of indicators and hazards.

Considering this context, this paper aims to identify the hazards in the aluminum formwork system at two construction sites in the Brazilian state of Pernambuco as well as to propose control and preventive measures. The suggestion is to use the identification of hazards at a construction work with the aluminum formwork system for prevention in other construction works using the same system.

THEORETICAL FORMWORK

Aluminum formwork system

The system is by definition from the NBR 16055 standard (ABNT, 2012) a "structural element, self-supporting, on-site molded, with a length greater than ten times its thickness, and capable of supporting load in the same plane of the wall".

In this unique system, all walls, floor slabs, columns, beams, stairs, balconies, together with door and window openings are cast in place in a single-site based operation. The resulting building structure is very strong, accurate in dimensions and tolerances, with a high-quality finished concrete surface. Typical cycle time of 1 floor every 4-5 days or 1 single-storey house a day are achieved (Robinson, 2011). Figure 1 shows the execution cycle.

Samant (2014) highlights the main advantages of the system as follows: the system comprises the entire structure of the building; it is customized to meet project requirements; unmatched speed in construction; high-quality finishing; cost effective; high reuse of the form; unskilled labor.

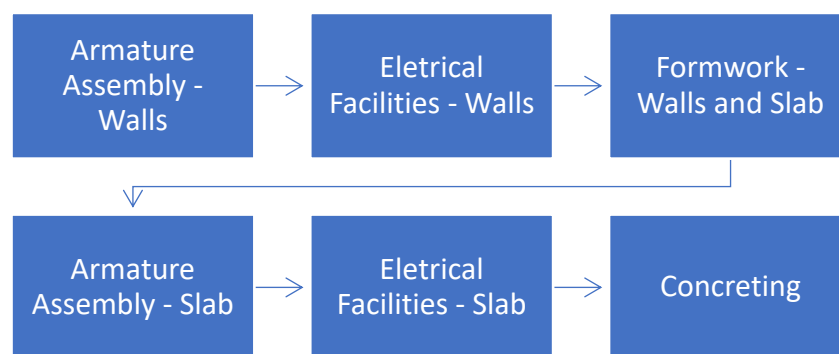


Figure 1: Execution cycle

The aluminum formwork system involves different stages and professions. The main stages are armature assembly, electrical facilities, formwork, and concreting. The main professionals involved are assemblers, bricklayers, electricians, plumbers, and servants. Each step involves different hazards to workers, in addition to the hazard of working at height.

Occupational safety in construction

According to Martins and Serra (2003), occupational safety in construction is defined as the set of measures adopted with the objective of reducing occupational accidents and diseases as well as protecting the worker's integrity and ability to perform their work. The measures must also comply with current technical standards and laws.

The adopted safety measures should be defined in the activity risk assessment. Howard (2008) affirms that one of the best ways to predict and control accidents, illnesses, and deaths at work is to minimize or eliminate risks and hazards in advance in the project design process.

In construction, workers perform a great diversity of activities, each with a specific risk associated with them. When performing a task, the worker is directly exposed to its associated risks and passively exposed to hazards produced by nearby co-workers (Barandan, 2004).

METHODOLOGY

The adopted methodology refers to systemic observations at two construction sites in the Brazilian state of Pernambuco. They occurred within a period of two months, with a total of 32 on-site visits. The visits followed the methodology below:

- Identification of the system stages;
- Characterization of each stage;
- Direct observation to identify the hazards at each stage;
- Proposal of preventive measures after identifying the hazards.

The preventive measures proposed in this study are not necessarily carried out in the observed construction sites.

RESULTS

This study sets out to identify the hazards in the observed activities. The control measures per system stage are as follows:

Armature assembly

A welded screen and steel bars for reinforcements are used for wall assembly. A welded screen is used in the center of the wall, except when the wall thickness exceeds 15cm. In this case, two welded screens should be used. "All openings with a horizontal dimension greater than or equal to 40cm shall be reinforced with horizontal reinforcements on the upper and lower faces [...]" (ABNT, 2012, p. 14).

Figure 1 presents the hazards identified in activities of the stage of armature assembling both in the walls and slabs.



Figure 1: (a) Armature assembly - walls (b) Armature assembly – slab

Table 1 presents the activities of each stage of the system and their respective hazard, identified in visits to the construction works

Table 1: Hazards – Armature

Work activity description	Hazard
Cutting the screens	Cutting/Drilling Electrical shock
Cutting of rebar for reinforcements - With POLICORTE	Strange matter in the eyes/face Noise
Cutting and bending of rebar for reinforcements - MANUAL	Cutting/Drilling
Handling / Application of screens and reinforcements	Cutting/Drilling
Application of reinforcements above of the window openings (internal area) with use of bench	Falling
Mooring of screens and reinforcements with wire	Cuttling
Transport of screens and reinforcements in case of upper floor	Material fall
Application of screens and reinforcements in case of upper deck and slabs	Falling
Falls on the slab	Cutting/Drilling

Electrical Facilities

The application of pipes and electrical boxes should happen after assembling the frames and before assembling form panels, for wall installation (Figure 2). Pipes must be fixed to the wall armatures to prevent them from being displaced during concreting (Construction Community, 2012).



Figure 2: Electrical facilities

Table 2 presents the hazards identified in the activities in the stage of electrical facilities.

Table 2 – Hazards Eletrical installations

Work activity description	Hazard
Fixing of passages and conduits boxes using wire	Cutting
Fixing of passages and conduits boxes in slabs using wire	Fall
Fixing styrofoam for hydraulic passages using wire	Cutting

Form assembly

In the aluminum formwork system, modular formworks are used in differently sized panels. The assembly begins with the wall panels, followed by the slab panels and then locks and struts. For the form assembly specifically, the team counts with approximately 25 employees.



Figure 3: Formwork

Table 3 presents the hazards identified in the activities in the stage of assembling walls and slabs.

Table 3: Hazards form disassemble

Work activity description	Hazard
Panel handling	Ergonomic
Positioning of external panels - upper floor	Falling
Locking the neighboring panels with steel pins	Noise
Locking of neighboring inner panels with pins - top	Falling
Applying mold release agent to panels	Chemical risk
Positioning of slab panels	Ergonomic
Slab shoring positioning	Material fall risk
	Noise
Positioning of aligners	Mechanical shock
	Trapping or pressing fingers
Transport of panels for upper floor	Material fall

Concreting

In the concreting stage, the concrete must be released to the desired location through pumping, known in the region as “pump spear”. It is a truck with a system of pumps and a high-height spear, as shown in Figure 4. Table 4 presents the hazards identified in the activities of concreting stage.



Figure 4: Concreting

Table 4: Risks and hazards in the concreting stage

Work activity description	Hazard
Concrete vibration	Noise Vibration Electrical shock
Form hammered	Noise
Slab twisting	Faling Ergonomic

Form disassembly

Table 5: Hazards in the disassembly process

Work activity description	Hazard
Removal of aligners	Noise Mechanical shock Trapping or pressing fingers
Removal of steel pins	Noise
Panel handling	Ergonomic

After the identification of the hazards in each step, the following safety proposals for each risk

are presented:

- Cutting/Drilling: Marking of the cut and bend area; Protection of edges; Use of goggles; Use of scraped or nitrile gloves;
- Electric shock: Inspection and use permission of Policorte electric saw by a mechanical engineer; Signaling in the area of tool use; Grounding of the tool; Use of RD, Use of emergency button;
- Foreign matter in eyes/face: Risk warn signaling; Facial protector;
- Noise: Ear Protector;
- Falling: Lateral protection of seats; Use of parachute belt; Life line; Bodyguard on perimeter;
- Fall of material: Isolation and identification of the lifting area;
- Ergonomic: Training for weight lifting; Labor gymnastics;
- Chemical hazards: Impermeable gloves;
- Mechanical shock: Use of gloves;
- Imprisonment or finger press: Use of anti-smashing gloves.

CONCLUSIONS

The aluminum formwork system has been widely used. It is extremely important to identify the hazards in each step. This research sought to identify these hazards in order to assist constructors who will use this construction system.

Different hazards of the system were presented. Each stage has several associated hazards, and the worker may be exposed to several hazards in the same activity, considering only the activities of the aluminum formwork system.

Both the presented risks and the preventive measures might be used as data base for applications in other construction works. They can be useful both to ascertain the presence of these risks and others as to verify whether constructors and other professionals are taking the necessary preventive measures.

In the proposed measures, different preventive and control measures are suggested, including proposed measures for control and prevention of accidents.

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ASSESSMENT OF SAFETY PERFORMANCE MEASUREMENT SYSTEMS: AN EXPLORATORY STUDY FROM THE RESILIENCE ENGINEERING AND COMPLEXITY PERSPECTIVES

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Construction projects are complex socio-technical systems, characterized by a dynamic work environment and a rich network of external and internal interactions. Safety management must be compatible with this complex nature of construction. The Resilience Engineering perspective is a proactive approach for safety management that looks for ways to enhance the ability of organizations to function as required under expected and unexpected conditions. The aim of this study is to assess the safety performance measurement system of a construction project by assessing the resilience potentials and the aspects of complexity that have an impact on safety performance. Multiple sources of evidence were applied such as interviews, documents, procedures and direct observations. The adopted approach allowed for the identification of gaps and strengths of the assessed safety performance measurement system.

Keywords: Safety Performance Measurement, Resilience Engineering, Complex Systems

INTRODUCTION

Construction companies usually adopt reactive indicators such as the number of fatalities and injury rates, to monitor and track organizational safety performance (Janicak, 2009; Hinze et al. 2013). In fact, many construction companies are limited only to generate the reactive safety indicators required by the legislation. However, there is a consensus that these failure-focused metrics are of little use in helping organizations drive continuous improvement efforts (Agnew, 2013). In this sense, the rise of Resilience Engineering perspective was driven by the realization that established approaches to safety were ineffective and even a hindrance for progress (Haavik et al., 2016). The Resilience Engineering perspective is associated with the organizations' abilities to learn and adapt by creating safety in an environment subjected to constraints and trade-offs (Wreathall, 2006). As such, resilience is a means of coping with system complexity (Hollnagel and Woods, 2006). This study aims to assess the safety performance measurement system of a construction project by assessing the resilience potentials and the aspects of complexity that have an impact on safety performance, in order to improve and facilitate the everyday activities that are necessary for acceptable outcomes.

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BACKGROUND

Organizational resilience potentials

The resilience of an organization cannot be engineered merely by adding standardized operating procedures, safeguards, and barriers. Rather, it requires continuous monitoring of system performance and margins to assure a safe operation (Madni and Jackson, 2009). A practical way proposed by Hollnagel (2015) to support organizational resilience is through the management of the four potentials of resilient systems, namely:

- (i) *The potential to respond*: implies knowing what to do, or being able to respond to regular and irregular changes, disturbances, and opportunities by activating prepared actions or by adjusting current mode of functioning;
- (ii) *The potential to monitor*: implies knowing what to look for, or being able to monitor that could seriously affect the system performance in the near term, positively or negatively;
- (iii) *The potential to learn*: implies knowing what has happened, or being able to learn from experience, in particular to learn the right lessons from the right experience;
- (iv) *The potential to anticipate*: implies knowing what to expect, or being able to anticipate developments further into the future, such as potential disruptions, constraints, new opportunities, or changing operating conditions.

The Resilience Assessment Grid (RAG)

The Resilience Assessment Grid (RAG) developed by Hollnagel (2015) is a questionnaire-based method designed to measure the aforementioned four potentials. Also, the application of the RAG may produce insights into possible indicators of resilience (Ray-Sannerud et al., 2015). The RAG is intended to be administrated repeatedly over a period of time (Hollnagel, 2017), making sense of circumstances and situations. The RAG has been applied in several sectors, such as the emergency departments (Hunte and Marsden, 2016), railways (Rigaud et al., 2013) and Air Traffic Management (Patriarca et al., 2017). The sources of evidence for answering the questionnaire are usually qualitative data collection techniques such as interviews, observations, and documents. It is also possible, but not mandatory, to assign scores for each of the topics included in the questionnaire.

Construction projects as complex socio-technical systems

The study of complexity in construction projects has gained attention in recent years due to the managers' demands for setting up organisational structures which are compatible with complicated contracting, increased legislative controls, changing technology, as well as the need for developing a resilient workforce (Bakhshi et al., 2016). According to Qazi et al. (2016), the increasing complexity of construction projects also has been attributed to the growth in the size of projects and the challenging characteristics of each unique project.

The TOE (Technical, Organizational and Environmental) framework

The TOE framework was developed by Bosch-Rekvelde et al. (2011) and can be used as a basis to assess the complexity of an engineering project. A protocol-based questionnaire with 49 questions was developed to give a footprint of the project in terms of where complexity can be expected to arise. Thus, three aspects of construction projects were clustered as follows: (i) technical dimension in terms of content (e.g. interrelations between technical processes, new technology, quality of requirements); (ii) organizational dimension in terms of social and

management methods (e.g. number of different project methods and tools, expertise and skills availability, contract types, resources); (iii) environmental dimension in terms of parties involved and their perspectives (e.g. government and market influence, variety of stakeholders perspectives).

The study of Brady and Davies (2014) applied the TOE framework in two large infrastructure projects by characterising the complexity dimensions that influenced project management. For example, the use of modular design, pre-fabrication, off-site testing were recognized as contributing factors for the management of complexity in megaprojects. On the other hand, the study of Floricel et al. (2016) applied the TOE framework to develop hypotheses about how complexity influences construction projects and their performance, e.g. they hypothesized that technical complexity could affect the workforce performance negatively, while environmental (market) complexity could support innovation.

METHOD

An exploratory case study was carried out in a construction company based on three direct observations and five interviews with safety and site managers. The research process was divided into four stages, as follows: (i) understanding the organizational structure and existing safety management practices adopted by the company; (ii) adaptation and application of the RAG questionnaire; (iii) application of the TOE questionnaire; and (iv) assessment of indicators.

The studied company

The company is a large size construction firm that has been operating for 30 years in Southern Brazil. The administrative and management staff are company's own, while the construction workforce is 100% outsourced (e.g. electrical, hydraulic, drywall subcontractors, etc.). It has about 10 safety technicians on site and 1 safety engineer who coordinates safety management across all construction projects. The case study was carried out in a construction site of residential buildings, during the stage of finishings (interior and exterior plaster) and hydraulic and electric services. The buildings structure made of cast in situ concrete beams, slabs and columns. The project has 17.000 m² of total area and 10 buildings with three floors each.

Understanding the organizational structure and existing safety management practices adopted by the company

Data was gathered from various information sources: interviews, documents, procedures and direct observations. As a starting point, informal interviews were conducted with the site manager (civil engineer), safety engineer and safety technician in order to learn about the management practices of the construction project. Documents and procedures related to safety were analysed and the existing safety performance indicators were identified. Six hours of direct observations were conducted over three visits to the construction site. A semi-structured protocol was used in order to obtain an overview of the safety hazards and preventive measures in a normal working day.

Resilience Assessment Grid (RAG)

To address important aspects of each potential (respond, monitor, learn and anticipate) four interviews were conducted with the site manager, safety engineer and safety technician of the selected project. Initially, the original RAG questionnaire proposed by Hollnagel (2015) and

containing about 60 questions was reviewed by the researchers in order to adapt it to the construction context. Then, a pilot interview was conducted with the safety engineer in order to assess the clarity of the questions.

From the original RAG, 25 questions were maintained since they addressed core issues associated with each potential and seemed to be clearly applicable to the construction domain e.g. *How often are the measurements made? Continuously, regularly, every now and then? How have the indicators been defined?*). In turn, 7 questions were adapted from the original in order to make them easier to be understood. For example, the question *Is there a trade-off between safety and productivity?* was adapted to *How are conflicts between safety and productivity managed? In which construction phases are these conflicts more likely to occur?* Furthermore, 29 new questions were proposed in order to address operational aspects of safety management more directly - e.g. *are ergonomics requirements considered when purchasing personal protective equipment and tools? How is the safety performance of subcontractors monitored?*

As such, the final version of the RAG consisted of 61 questions. The interviews were digitally-recorded, fully transcribed, and lasted on average two hours. The interviews started with a brief introduction of the aim of this study, as well as an introduction to the field of Resilience Engineering. Also, the researcher explained the concepts of the four potentials in the context of their activities in the construction site. Table 1 presents the profile of the interviewees and duration of interviews.

Table 1: Profile of the of interviewees and duration of interviews

N. of interviews	Job	Experience in the construction industry	Duration
01	Site manager	12 years	1h 46min
02	Safety Engineer	5 years	1h 57min
01	Safety Technician	6 years	2h 18min

Based on the obtained responses, the interviewees were asked to assign scores using a scale ranging from 5 (excellent) to 0 (missing) in order to point out to what extent the potentials were present in the construction project.

The TOE (Technical, Organizational and Environmental) framework

The TOE framework was used in this study to analyse which complexity aspects are more emphasized by the existing indicators in the construction project. The TOE questionnaire was applied to the site manager since he was expected to have a broader view of the contributing factors to project complexity during the construction phase. The interviews were recorded, fully transcribed, and each lasted on average one hour. The interview started with a brief discussion about the meaning of project complexity from the site manager point of view.

During the questionnaire, he was asked to give examples about how these complexity aspects influenced safety performance. Some examples of the questions are: *(i) Are there uncertainties in the technical methods to be applied? (ii) Are there interfaces between different disciplines involved in the project (mechanical, electrical, chemical, civil, finance, legal, communication, accounting, etc.) that could lead to production problems?* The interview was digitally-recorded, and the transcripts were studied in depth to identify the elements contributing to

project complexity. After the interview, project documentation was consulted as a complementary source of data.

FINDINGS, ANALYSIS AND DISCUSSION

Overview of the existing safety performance measurement system

Since the construction company had only recently implemented a formal safety measurement program, archival records were limited to the previous two years. All safety metrics were proactive, once the focus of measurement were not on losses (e.g. accidents or lost time injury rate), but on the level of adequacy and compliance of legal requirements as preventive measures. The frequency of collection varied according to the indicator type (Table 2). Two out of the three existing indicators were collected on a monthly basis: the index of compliance to the main Brazilian safety regulation applicable to construction safety (NR-18) and an estimative of fines for non-compliance with the NR-18.

The third indicator, which assessed the compliance of safety documents with internal and external standards, was partly collected on a daily basis (e.g. work permits to carry out risky and intermittent activities) and partly monthly, such as workers training and subcontractor documentation. The monthly collection of safety indicators was performed by the safety engineer while the daily collection was performed by the safety technician who reported to the safety engineer once a week.

The indicators were collected manually and then processed in an electronic spreadsheet. There was a gap of 15 days between the collection of indicators and their report in meetings. The analysis of results was carried out in monthly meetings involving the safety engineer, safety technician, production and quality department, and site management staff in order to have an overview of the key performance indicators.

Table 2: Type and frequency of indicators collection

Safety indicators	Frequency of collection	Type
01. Index of adequacy to the NR-18 standard	monthly	proactive
02. Estimation of fines for non-compliance with NR-18	monthly	proactive
03. Index of documents compliance	monthly/daily	proactive

Resilience Assessment Grid (RAG)

Given the limited space of this paper, only the nine indicators identified for the potential to respond were selected as a basis for the discussion. Indicators that were rated with the highest scores by the professional interviewees had a significant presence in the construction project. These indicators were: the “frequency of safety meetings” (5 = excellent), “number of corrective actions implemented with delay” (5= excellent) and “frequency in which subcontractors and other departments participate in safety meetings” (4= satisfactory). However, the company had no formal indicators that could confirm whether or not these perceptions were consistent with reality.

Instead, management was mostly focused on the compliance with legal requirements and the associated documents, in order to prevent the shutdown of the construction site by the local labour inspectorate. Figure 1 shows the results for the respond potential. Since some indicators meet the nominal criteria (3 = acceptable) for the required ability, there are improvements to

be made.

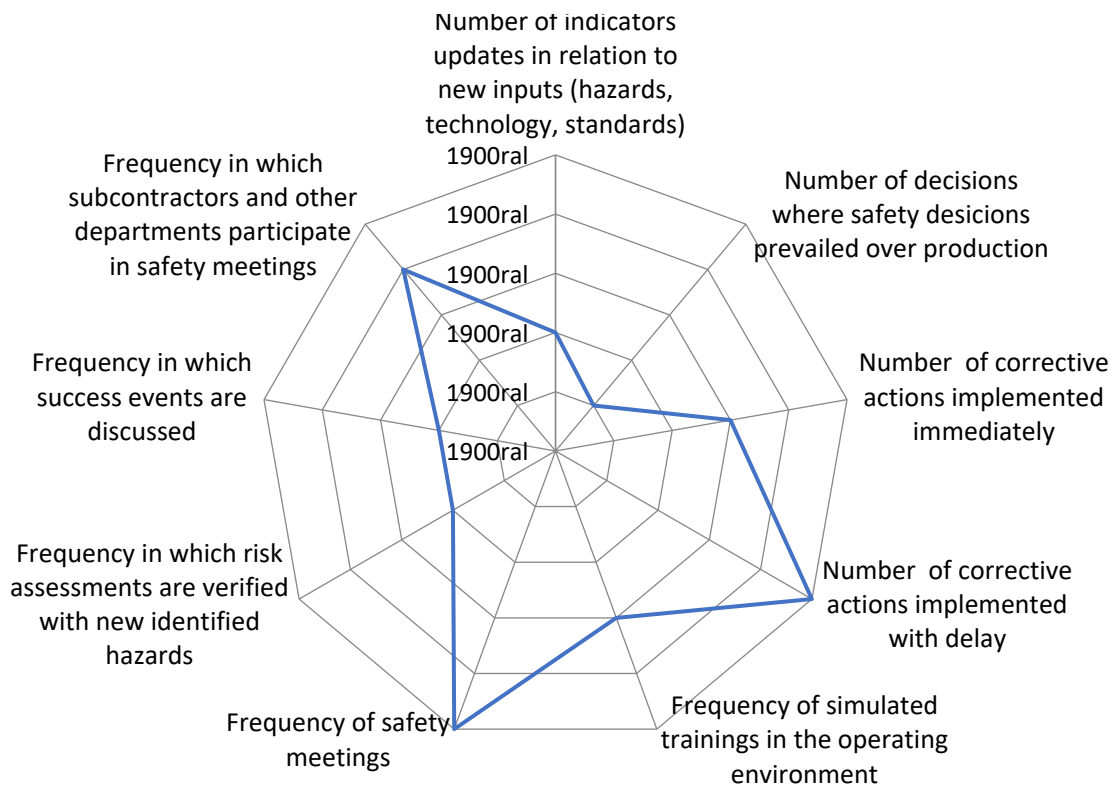


Figure 1: Assessment of indicators relating the ability to respond

TOE Framework

According to the site manager, the main aspects of complexity that influenced the safety performance in the construction project were:

- The large number and diversity of legal requirements and standards documentation related to a variety of equipment, materials, machines, work permits, site conditions, etc. that must be monitored every day, was pointed out as a technical complexity aspect that had a negative impact on safety performance. Since the safety technician spends most of his time dealing with paperwork, many events in the work field are not identified and investigated. This technician was in charge of controlling the compliance with 115 requirements set by regulators. In safety inspections, the regulatory authority may apply severe penalties for non-compliance that could maintain the construction site closed for several months. For this reason, the company was focused on measuring the estimation of penalties as a way to demonstrate the potential “damage” in terms of money and lost working days for non-compliance with legal requirements.
- The organizational complexity aspect pointed to interface problems or incompatibilities between different design disciplines that could cause rework and, in consequence, increase the exposure to risks. However, the site manager reported that there was no accurate information

on the number and impacts of the said reworks. A countermeasure suggested by the manager was to organize meetings involving designers from the different disciplines and, if possible, supported by Building Information Modelling (BIM). This was expected to support clash detection for the identification, inspection and reporting of interferences before the construction phase.

- Unlike technical and organizational aspects, an example of environmental complexity was pointed to influence positively on safety. According to the site manager, construction projects bring together people from a variety of disciplines from different departments and external to the organization (e.g., labour inspectors) in temporary groups to solve problems in real time. The construction project involved outsourced workforce from different ages (from 20 to 60-year old) and years of expertise in civil construction (from 2 to 40 years). Thus, the variety of stakeholder's perspectives was viewed as a positive influence on safety performance, for example, in ways to better execute a material or the ability to discover unique solutions.

Assessment of indicators

Table 3 shows the complexity aspects emphasized by the indicators. It is noteworthy that safety metrics collected by the company were mainly focused on the complexity of technical aspects of the construction project, especially those related to legal requirements. Also, the uncertainty of environmental influences (penalties) from the regulatory body in safety inspections is often monitored.

The indicators 04, 05, 06 identified through the RAG method as measures for the potential to respond were pointed out by the interviewees as successful functions performed during the construction project. Although these indicators were not collected and analysed by the company, the integration into the measurement system could represent an opportunity to reinforce the potential to respond, as well as to optimize organizational and environmental aspects in order to take into account all dimensions of the socio-technical system.

In this sense, the high frequency of safety meetings and the participation of subcontractors and other departments in these meetings could be explored as a feedback channel to reduce, for example, the interface problems and incompatibilities arising between different design disciplines in order to minimize the amount of reworks. Also, the examination of the environmental complexity in terms of variety of stakeholder's perspectives on site could have positive influences for the potential to respond regarded to new and creative ways of maintaining progress in the face of disruptions that can arise during the course of the project.

Table 3: Complexity aspects emphasized by indicators

Indicators / complexity aspects		Technical	Organizational	Environmental
Collected by the company	01. Index of adequacy to the NR-18 standard	X		
	02. Estimation penalties for non-compliance with NR-18	X		X
	03. Index of documents compliance	X	X	
Highly present	04. Frequency of safety meetings		X	
	05. Number of corrective actions implemented with delay		X	
	06. Frequency in which subcontractors and other departments participate in safety meetings		X	X

CONCLUSIONS

By monitoring the resilience potentials and the key complexity aspects that influence safety performance, a holistic assessment of the studied safety performance measurement system was possible. In this paper, the results of the assessment of one of the resilience potentials (respond) were presented and indicators were identified as successful functions performed during the construction project. The technical complexity of the project, as well as the complexity of the interactions with the legal and regulatory external environment, created a significant bureaucracy that drained the attention and resources of the safety staff. As such, these had little time to improve the safety performance measurement system, which was focused on technical hazards. In fact, the bureaucracy itself should be regarded as an organizational hazard detrimental to safety, although it was not acknowledged as such by the interviewees. By contrast, an example of beneficial complexity was related to the social interactions in the safety meetings, which offered opportunities for the exchange of relevant knowledge for safety management. The frequency of these meetings was a complexity aspect covered by the safety performance measurement system.

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ASSESSMENT OF HEALTH AND SAFETY COMPLIANCE IN THE NIGERIAN CONSTRUCTION INDUSTRY

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Occupational health and safety hazard is a threat to the construction sector because it is responsible for various illness, injuries and fatalities in the industry. This leads to delay in the provision of infrastructure, and reduction of its contribution to the gross domestic product. This study examined the level of compliance with health and safety regulations and the challenges of ensuring the health and safety of construction workers in the Nigeria construction industry. Data were obtained from safety personnel and construction professionals using questionnaires through a convenience sampling method. One hundred and thirty-eight were used for the analysis out of one hundred and sixty-eight that was distributed to the respondents. The questionnaire was analyzed using SPSS V 24 adopting Factor analysis and mean item score. The findings show that construction workers compliance to health and safety requirements is below average while the factor analysis shows inadequate safety equipment, low awareness to occupational health and poor compliance to health and safety requirements are the major challenges hindering the compliance rate. The study recommends that safety personnel should embrace the use of innovative ideas like radio frequency identification for effective monitoring and involve construction workers when drafting the health and safety policies.

Keywords: Construction Industry, Health Hazards, Occupational Health and Safety, Safety Regulations.

INTRODUCTION

The urgent need of minimising the increasing rate of occupational accident and work-related illnesses have been a subject of focus over many years. It is noted that issues of health and safety in the workplace pose a great threat all over the world especially for the sustenance of development in the society. The international labour organisation ILO (2001) posited that accidents and illness related to work contribute significantly to the yearly death ratio thereby leading to a substantial loss in a country labour force. Despite the threat of health and safety to the sustainability of the society Umeokafor et al. (2013) suggested that its development in Nigeria's construction industry is still at the infancy stage with no precise regulation providing direction in health and safety management in the country.

Bima and Abdulateef (2015) submitted that occupational health problem in the construction industry is an unavoidable aspect of the job but is manageable as indicated by safety records in most advanced countries. However, in Nigeria authors such as (Koehn et al., 2000, Idoro, 2007) opined that in practice, the occupational health of construction workers is poorly managed

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coupled with poor safety conditions of construction sites thereby causing numerous accidents on the sites.

Nuwayhid (2004) posited that majority of the injury experienced by the construction professionals occur on construction site. Agbede, et al. (2015) affirmed that various activities that take place on the construction sites such as work process and work procedures increase the possibility of accidents to occur. Idoro (2008) submitted that the construction industry is a major source of occupational accidents, injuries, ill health and fatalities. Likewise, Ju and Rowlinson (2013) reported that all over the world workers in the construction industry have higher tendencies to be killed compared to workers. Significant research has been conducted on construction workers safety and health. Idoro (2008) evaluates health and safety management efforts as correlates of performance in the Nigerian construction industry. Belel and Mahmud (2012) examined the safety culture of Nigerian construction workers. Oluuase (2014) conducted a study of safety management in the Nigerian construction industry. Agbede, et al. (2015) evaluated health and safety management practices in the Nigerian construction industry. Gaps still exist, and more information is needed to understand the compliance level of construction workers to health and safety management including the challenges confronting site managers and contractors towards enforcing health and safety on their various construction sites. Sources of occupational hazards on construction sites were not examined. Hence the need for this study centered on improving the health and safety of construction workers.

HEALTH AND SAFETY IN THE NIGERIAN CONSTRUCTION INDUSTRY

Initially, safety was viewed as each own company problem with little attention paid to occupational health and safety but after the various industrial based disaster in Europe especially the Flixborough accident in 1974 that almost wiped out an entire. This prompted the implementation of occupational health and safety to become an integral part of any organisation (Ahassan, 2001).

Occupational health and safety grew as industrialisation spread from one country to another, so also did the health hazards and risk associated with different works (Asogwa, 2007). Hamid et al. (2004) reported that it has grown to the extent that occupational health is now accepted as a devoted area of medicine requiring special attention in countries such as Europe and America. It is evident that developed countries are regarded as the pioneers of industrialisation. Bluff (2003) suggested that a country economy will keep thriving when the issues concerning the overall health and safety of the workers within the country are given adequate attention towards reducing the accidents experienced at the workplace.

However, developing countries still have a long way to go before achieving the acceptable health and safety standard (Diugwu et al., 2012). Nguyen et al. (2015) asserted that most policymakers in developing countries are more concerned about pressing needs such as the absence of malaria, HIV, and cancer than forming policies from scientific findings related to health and safety. Dahun (2013) gave another reason for poor health and safety in developing countries and concluded that they are poor research into the development of a good health and safety culture. Oluuase (2014) reported that most construction and production sector in developing countries concentrate on profit than implementing health and safety policies in their organisations and this hinders the development of health and safety within the organisation. Verma, Purdham, and Roels (2002) examined the barriers to health and safety from another

angle and related it to the broad nature of the subject as it involves a combination of different subjects like biology, physics, chemistry, engineering, psychology and law connecting health and safety practice with different disciplines.

Taiwiah and Mensah (2016) opined that the barriers to health and safety in a workplace could be related to the complexity, conflicting demands, and behavioural issues among employees and employers.

The construction industry functions as the pillar in most country's economy and Nigeria is not an exception as it assists in boosting the economic performance thereby attracting foreign investors. This creates more job opportunities for the youths thereby contributing to the general development of the country. The construction industry has funded above 5% in the Gross Domestic Product (GDP) growth of the country, and also responsible for the capital growth of the country (Diugwu et al., 2012). According to the National Bureau of Statistics (2015), the industry made a remarkable impact to the national gross domestic product at 3.05% increment in 2012 and also the employment of 6.9 million workers into the industry (Koehn et al., 2000).

Idoro (2008) reported that the accidents and injuries experienced by construction workers within the construction industry are higher when compared to developed countries. Umeokafor et al. (2014) attributed the poor occupational health and safety within the Nigerian construction industry to the lack or absence of prescribed health and safety policy for the construction industry (Beleel and Mahmud, 2012).

Agbede et al. (2015) gave another reason for poor health and safety in the country and related it to the poor enforcement of health and safety law especially from the federal ministry of Labour in charge of monitoring occupational health and safety law.

Overview of Health and Safety in Sub-Sahara Africa

Clarke (2005) reported that just like other countries the health and safety in Ghana grew by the development in industrialisation which implies that a substantial number of Ghana populations are exposed to workplace physical, chemical, biological and psychological stress. Ghana labour Act 2003 (act 651), Ghana atomic energy Act 204 of 1963 that was developed out of radiation protection instrument L1 1559 of 1993 and many others) with the intention of protecting their workers. Avotri and Walters (2009) opined that the act above, legislation, and laws operate under different organisations to facilitate prompt enforcement of the law, but it has not yet achieved success on issues regarding health and safety.

However, despite the health and safety regulation for the construction sector, the construction industry's health and safety records has not improved significantly thereby making the construction health and safety a major form of concentration for construction researchers, industry stakeholders and the government (Agumba and Haupt, 2009). Smallwood et al. (2009) submitted that part of the reason occupational health and safety is poor within the construction industry is that contractors do not comply with the requirement of OHSA and the Construction Regulations (CR) 2003 in South Africa.

METHODOLOGY

This study was on construction workers and safety officers to determine the level of compliance to health and safety regulations. Researchers such as Muijs (2011), Blaikie (2010) and Almalki (2016) reported that any research conducted and analysed in number format while employing

various mathematical methods could be referred as quantitative research.

The study used a convenience sampling method because it is convenient, quick and inexpensive. It comprises of close-ended questionnaire which was used for collecting of data from respondents comprising of construction professionals such as builders, quantity surveyors, engineers and land surveyors within Lagos state Nigeria.

A total of one hundred and thirty-eight (138) were used for the analysis out of one hundred and sixty-eight (168) that was distributed to the respondents. The questionnaire is broken down into three sections with the first section examining the level of compliance of the respondents to occupational health and safety regulations, the second section examines the causes of accidents on construction firms, and the third section looks at challenges of ensuring occupational health and safety on construction site. The response from the questionnaire was analysed using SPSS (statistical package for social science).

FINDINGS, ANALYSIS AND DISCUSSION

The respondents were asked to rate the level of compliance of their organisation to the following health and safety regulations using a five-point Likert scale from very high to very low, and their response is presented in Table 1. The table shows that the construction firms within the study area do not comply with occupational health and safety judging from the low mean score attributed to all the occupational health and safety regulations.

Table 1: compliance with occupational health and safety

Health and safety regulations	Mean	Rank
Provision of PPE	3.81	1
Signpost indicating danger zone on construction project site	3.76	2
Provision of health and safety facilities	3.71	3
Payment of medical bills of injured worker	3.72	3
Site office health and safety management structures	3.67	4
Providing health and safety supervisors on construction site	3.67	4
Head office health and safety management structures	3.62	5
Safety policy for the company and some selected project	3.60	6
Strict measure against contractor who makes safety violation during the execution of project	3.57	7
Updating health and safety plans after completion of projects	3.53	8
Health and safety insurance cover for sites	3.50	9
Open display of health and safety regulations	3.48	10
Health and safety training for site safety supervisors	3.42	11
Informing employees about hazards on site	3.37	12
Rewarding workers for safe work behaviour	3.32	13
Compliance with health and safety regulations	3.30	14
Provision of health and safety incentives	3.18	15
Framework for health and safety implementation in the company	3.00	16
Proper documentation for accidents and policy violation during the execution of projects	2.90	17
Undertaking periodic safety management auditing	2.50	18
Publishing lessons learned from incident investigations	2.00	19

However, the table reveals that provision of PPE for the construction workers is the

occupational health and safety regulation that are often complied with by construction firms. Followed by provision of various sign post indicating danger zones, provision of health and safety facilities, providing safety supervisors on construction site, developing safety policy for the organisation and updating health and safety plans after completion of projects.

Causes and Prevalent Form of Accident on Construction Sites

In a bid to provide solution to this objective the respondents were presented with possible occupational hazards that occur on construction site and the respondents were then requested to rate the most frequent occurring accident using 5 = very frequent, 4 = frequent, 3 = neutral, 2 = low and 1 = very low and the outcome is presented in Table 2.

Table 2: prevalent form of accident on construction site

Accidents on constructions	Mean	Rank
Scaffolding accidents	4.64	1
Welding accidents	4.50	2
Stepping or kicking abandoned objects	4.42	3
Falls from ladders	4.30	4
Power tool accidents	4.00	5
Accidents from faulty machinery	3.97	6
Lifting equipment failure	3.64	7
Trench Collapses	3.60	8
Traffic accidents	3.50	9
Electric shock injury	3.46	10
Crane accidents	3.40	11
Forklift truck accident	3.25	12
Holes in flooring	3.18	13
Unsafe safety harnesses	3.12	14
Compressed gas accidents	3.10	15
Accident caused by fire or explosion	2.95	16

A look at the table shows that the construction industry is characterized by numerous accidents as all the form of accidents has a high mean score. The table reveals that the major accident or occupational hazards experienced by the respondents are scaffolding accidents, welding accidents, stepping or kicking abandoned objects, falls from ladders and power tool accidents with a mean score of above 4.0. While occupational hazards in order of hierarchy such as; forklift accident, holes in flooring, unsafe safety harnesses, compressed gas accidents and accidents caused by fire accidents are rarely experienced by the construction professionals. It can be deduced from this findings that the construction industry is a risky industry to work in judging from the number of hazards that the workers are exposed. These findings also coincide with the work done by Idoro (2008) and Agbede et al. (2015).

Challenges in Ensuring the Safety of Construction Workers on the Construction Sites

Exploratory factor analysis was used to examine the challenges confronting the site manager or safety personnel in ensuring the safety of construction workers on construction sites. Twenty (20) challenges identified from the literature were explored using CPA - Component Principal Analysis otherwise called Factor Analysis. In the analysis, the KMO and Bartlett's test of sphericity shows good factorability features as shown in Table 3 The Bartlett's test of sphericity gave a chi-square value of 1752.874 at 780 degrees of freedom, significant at 5% confidence

level. This, therefore, suggests correlation among the chosen factors (challenges in ensuring the safety of construction workers) and supportive criterion for factorability.

Table 3: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.69
Bartlett's Test of Sphericity:	
Approx. Chi-square	1752.874
Degree of freedom	780
Significant level	0.000

CPA indicated 3 components (out of 20 possible components) with an eigenvalue of at least 1 as shown in Table 4. The first components have an eigenvalue of 15.374 while the third component has 2.278; these represent the variation each of the linear components can explain.

The percentage of variance explained by each of these components is given in the third column while their cumulative is in the fourth column. The first component explained the highest variation (38.435%) while the last explained 5.696%. Altogether, the variables explain 51.239% variation by their linear components.

Table 4: Total Variance Explained before Rotation

Component	Initial Eigenvalues		Cumulative Percentage of Variance
	Total	Percent of Variance	
1	15.374	38.435	38.435
2	2.843	7.108	45.543
3	2.278	5.696	51.239

By varimax rotation method, twenty factors (20) factors loaded differently on 3 components which form the basis for significant challenges encountered in the ensuring safety of construction workers as reported in Figure 1.

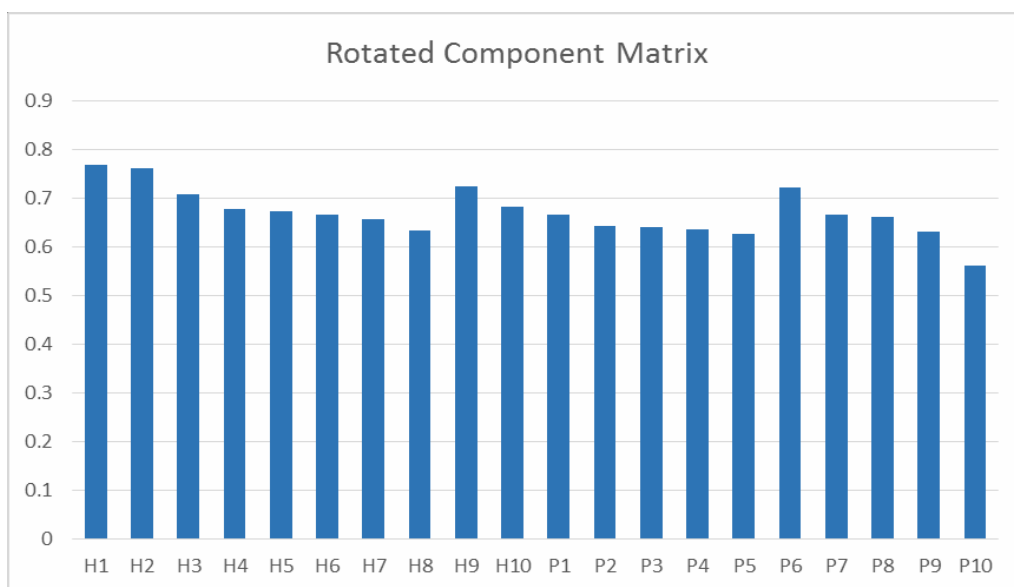


Figure 1: Rotated Component Matrix

Keys: H1 - Shortage of protective equipment, H2 - Wrong use of protective equipment, H3 - Absence of prescribed health and safety regulations for the construction industry, H4 - Low priority given to safety of construction workers by contractors, H5 - Negligence of health and safety department, H6 - Absence of prescribed health and safety regulations for the construction industry, H7 - Perceiving health and safety as luxury, H8 - Poor funding, H9 - Construction workers low awareness to health and safety requirements, H10 - Contractor low awareness to health and safety requirements, P1 - Use of hazardous materials on construction site, P2 - Poor communication between the safety personnel and construction workers, P3 - Theft of safety equipment's, P4 - Underpayment of the safety personnel, P5 - Failure to see safety practices as an integral part of project success, P6 - Low compliance to health and regulations by the construction workers, P7 - Failure to include the safety personnel into the design of the building, P8 - Construction paying more concern to their work target than safety requirements, P9 - Failure to report accident to appropriate authority, P10 - Poor enforcement of health and safety regulations.

H1- Absent of protective equipment, H9- low awareness to occupational health and safety by construction professionals, P6- low compliance to health and safety. These are the three categories of factors extracted from the CPA which significantly hinder the health and safety of construction professionals. It shows that low awareness to occupational health and safety and poor attitude of construction workers to their health and safety hinder the growth of occupational health and safety within the construction industry. Providing adequate protective equipment, increasing of awareness occupational health and safety by construction professionals and high compliance to health and safety regulations will reduce the occupational hazards experienced within the construction industry.

CONCLUSIONS

The construction industry functions as a pillar for the Nigeria economy as it assists in boosting the economic performance through the creation of employment opportunity, housing delivery, provision of infrastructure and many others. The activities responsible for the construction industry contribution to the economy requires the exertion of body and mind coupled with an element of skill to work on construction sites. This therefore makes the construction worker significant for the construction industry performance. Unfortunately, the study revealed that the construction worker is liable to numerous health hazards as the Nigerian construction industry pose numerous occupational health hazards to the construction workers.

The study concludes that health hazards faced confronting construction workers are due to low awareness to occupational health and safety regulations and poor attitude of construction workers to the use of various protective equipment's. The study recommends that safety personnel should embrace the use of innovative ideas like radio frequency identification for effective monitoring and involve construction workers when drafting the health and safety policies. Also, the Government should set up a health and safety agency for the construction industry towards ensuring proper monitoring and safety inspections with punishment in the form of fines, stop-work, closure of construction sites. It is very important that further studies on the eradication of hazard from the source must be looked in future research into in order to minimise the rate of occupational accident and work-related illnesses. The study was limited to Lagos because of the numerous ongoing construction works which serve as a point of attraction to numerous professionals.

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MORE PROACTIVE FACILITY MANAGEMENT ROLE FOR RESILIENCE AT THE WORKPLACE

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The article analyses the influence of the economic crisis on the occupational health and discusses the need for more proactive role of facility management (FM) to improve the mental health at the workplace. During the recent economic crisis period, economic ‘factor of production’ had number of effects on the workplace, such as: job insecurity (JI), work intensity, temporary uninsured work, violence and harassment, absenteeism and presentism due to occupational stress. Economic downturn caused a prolonged increase in suicide mortality. The present research focuses on the literature review analysis from the perspective of JI, which is especially exposed in the time of economic crisis and is associated with many diseases connected with depression, heart disease and suicidal risks. The focus of research is to explore ‘the role of FM to mitigate the risk of mental health diseases’ in connection of JI. From that perspective, the paper evaluates the outcomes of different quantitative studies during the period of years of economic crisis. Results show, that different workspace factors have an impact on the satisfaction of employees and consequently on their health, and that facility management can play a positive role. The paper covers only the findings in the time of economic crisis in Europe from 2008-2017. The research covers a growing need for the focus on happiness and well-being issues.

Keywords: Economic crisis, Occupational health, Workplace, Facility management, Resilience

INTRODUCTION

Research on occupational health promotion, job stress, high performance workplaces, strategic human resources management and leadership styles congregate around the importance of supporting employees to be effective in their jobs in ways that promote their health. On the contrary, terminator management is associated with increased level of anger, frustration, lack of motivation and interest and therefore higher incidence of mental and health problems. As the result of globalisation, deregulation of labour markets and increasing competition as well as global financial crisis, many European countries suffered from significant labour market changes. The effects are higher unemployment rates and labour market conditions, which are related to higher fear of losing job, higher experience of stress, and lower job satisfaction. They create the sense of JI, undermine the confidence in the company and negatively influence attitudes towards the job and organisation (Sverke et al., 2002), reduce productivity and increase economic costs for the firms, employees and society. Virtanen et al. (2013) evidenced that JI relates to outcomes via four overarching mediating mechanisms: stress-related and social exchange-related mechanisms, job preservation motivation and proactive coping. JI is

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seen as an especially harmful stressor that affects well-being at the workplace, as this stressor includes uncertainty and uncontrollability. It is difficult for the individual to react adequately to the stressor with the appropriate coping strategy, which in turn leads to feelings of anxiety and lower well-being (Sverke et al., 2002). According to Schreurs et al. (2010) the negative outcomes of JI could be explained with the psychological contract theory, which defines a mutual obligation between an employer and an employee, perceived as an employee's loyalty in exchange with employer's security. JI is a state of no longer guaranteed security, so employee perceives it as a violation, which has consequences for the well-being and commitment of employees.

The FM focus on supporting 'people' is reflected from different FM standards. The European standard CEN 15221 defines FM as 'integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities' (CEN, 2006). International FM Association (IFMA, 2003) defines FM as 'a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology'. ISO 41011:2017 FM-Vocabulary defines FM as 'function, which integrate people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business'. Based on this, a new standard, ISO/FIDIS 41001:2018 FM-Management-Requirements, gives an updated definition: 'FM integrates multiple disciplines to have an influence on the efficiency, productivity and economies of societies, communities and organizations as well as the manner in which individuals interact with the built environment. FM affects the health, well-being and quality of life of the world's societies and population through services, manages and delivers.' Many researches in the field of FM discuss 'people' from the perspective of increasing job satisfaction through the wellness of their workplace environment or well-being (Ljungblad et al., 2014); positive well-being as a result from a set of indicators, characterizing the context in which work is performed, among others also physical working conditions and job security (Herzberg et al., 2011); the built environment as an influential factor on behaviour (change) and cognitive processes (Cradock et al., 2013); the physical interventions to stimulate healthy behaviour (Burney et al., 2016); the influence of happiness on well-being (Johnston et al., 2013), and similar.

The main focus of the paper is to explore the possibilities to stimulate healthy environment as an opportunity for mitigating the effects of people needing care through the changing circumstances, as mentioned by Beard et al. (2016). For that, a literature review is prepared from two topics 'JI and mental health' to research the consequences of the economic crises and 'happiness' as an orientation for boosting employees in difficult time of changes. From JI problems, it is seen that not only employees who lose the job have mental problems, but also the others who are still employed are scared and paralysed. The happiness theory is seen more from the perspective to encourage an implementation of necessary interventions targeting both, the traditional psychosocial environment and the organizational efficiency to achieve decreasing employee stress and to enhance mental well-being, in accordance with Bhui et al. (2016). Based on that, the main research question is 'if and how can FM help to support the employees in the time of JI to avoid the mental health problems'.

RESEARCH

Method

The method is a literature review focused on original research that examines the effect of economic crisis on health behaviour. This review gives an overview of mostly empirical evidence available and aims to (a) examine the evidence arising from the economic crisis, especially focused on JI and (b) examine the mechanisms in 'happiness' theory to learn how to increase the positive emotions in organizational environment.

The literature search was conducted using the Scopus database, Google scholar and a hand search (snowball method). Search terms in both databases were combinations of the following key words: 'economic crisis', 'mental health', 'facility management', 'people orientation', 'job insecurity', 'happiness' and keywords. These search terms aim to give a general overview of the field. The articles from economic crises topic were mostly focused on the problem of the last economic crisis in Europe. Mostly peer-reviewed papers were included into literature review, but also some additional internet resources are added.

Job insecurity and mental health

Catalano et al. (2009), using a labour market model, hypothesised that tolerance for behavioural and physical deviance may be reduced in times of an economic crisis following anxiety of JI. Among a series of coping mechanisms for the work-related stressors are alcohol consumption and substance misuse and even suicide (Dee, 2001). In an economic crisis, the impact on mortality and morbidity is exacerbated where people have easy access to unhealthy coping mechanisms (Ng et al., 2013).

In a study in 16 EU countries about the influence of JI on health, JI was associated with an increased risk of poor health in most of the countries included in the analysis. The association between JI and health did not differ significantly by age, sex, education, and marital status (Laszlo et al., 2009). A high proportion of the working European population aged 45–70 years perceive their jobs as insecure; the percentage of individuals within the sample of their countries reporting to have an insecure job ranged from 14.2% in Spain to 41.7% in Poland. The negative impact of the financial crisis on Spanish employees' perceived level of work flexibility, autonomy, stress and monotony is shown on work-balance (Gregory et al., 2013). In terms of human experience, Grau reported 150,000 families affected by the misery of the economic crisis: the pain of being fired, the financial anxiety at the end of the month, or the misery of losing a home (the period from 2008-2011). It is seen that Spanish employees reported very high levels of stress and monotony, up to half per cent (49.9) of the Spanish working in 2010. The financial crisis in Greece had number of effects on the workplace (Boustras, 2015), such as: JI and work intensity, increase in temporary uninsured work, violence and harassment, and absenteeism and presentism due to occupational stress. Drydak (2015) showed that self-reported health and mental health were negatively affected by unemployment during the 2008-2013 period of strong financial downturn.

Reichert and Tauchmann (2017) analysed the link between workforce reduction, subjective JI and mental health. They found that staff reductions affected the psychological health of employees and their subjective JI. In quantitative terms, it showed that individuals who experienced company-level job cuts were about 10 per cent more likely to be concerned about

their jobs. They also found that staff reductions have virtually no effect on mental health for individuals who regard finding a new job as fairly easy, while those who are pessimistic about that are most adversely affected. It shows that fear of a job loss is likely to adversely affect mental health and life satisfaction. They have also shown that company-level workforce reduction exerted detrimental effects on the mental health of employees who remain working in the respective firm and that a positive and statistically significant relationship between workforce reductions and subjective JI has been shown.

An Italian study by Fiori et al. (2016) revealed the results that employment insecurity is associated with poorer mental health and that the risks was higher in 2013 than in 2015. The study has concentrated on the relationship between JI and mental health. The sample consisted of 26,972 healthy active individuals in 2005 and 20,432 in 2013, among the young adult population in Italy. The study showed that within the youth labour force, permanent employees have better psychological health than individuals in temporary or non-standard working arrangements, or in unemployment spells. They also stated that the mental health deterioration of unemployed people was especially acute among Italians in 2013, as the economic downturn had lasted about five years, and many of them have used their personal and family savings. At the same time, employers have more choice, thus, individuals in poor health were forced to accept a less secure, poorly paid job. Another Italian study by Giorgi et al. (2015) examined the role of fear of the economic crisis and perceptions of low employability in relation to psychological distress. They found that experiencing fear of the economic crisis can be considered an important source of dissatisfaction because workers may perceive an organizational negative situation in which there is a high risk of losing their jobs and their associated benefits, and that the non-employability dimension had a higher impact on psychological distress. The economic crisis can be perceived by the individual as threatening and therefore tends to be accompanied by negative emotions such as anxiety or fear. The analyses revealed that both perceived JI and unemployment constitute significant risks of increased depressive symptoms in prospective observational studies.

After the economic crisis hit the global capitalist economy in 2008, the Slovene economy experienced a decrease of exports by 16.1% in 2009 and a devastating decline in economic growth. The debt crisis that followed was a logical outcome of the recession and the crisis rooted in the corporate sector. Unemployment rates were 4.4% in 2008 (year of the crisis) and rose to 7.2% (2010) and 8.8% (2012). In a study in 2009 (1592 Slovenian employees), data about perceived impact of the economic crisis, several socio-demographic, socioeconomic and health parameters were collected. Depressive and anxiety scores were significantly increased among 46.6% employees being affected by the economic crisis. The level of depressive symptoms was significantly associated with perceived impact by the crisis, recent sick leaves, reported injuries sustained at work, benzodiazepine and analgesic use, the lack of emotional support, and trust in crisis telephone lines. The level of anxiety symptoms yielded the robust association with the level of depression symptoms, reported injuries sustained on the way to work and education (Avguštin et al., 2011). This creates a new pathology - health problems relate to the reality of keeping and getting the jobs; health indicators show that the psychological problems are growing, consequences of stress are stronger, and absenteeism and presentism of employees are bigger. In another recent study (Jimeenez et al., 2017), the samples of 251 Slovene and 219 Austrian workers were analysed. The data indicated that JI is related to higher stress and intention to quit as well as to lower resources/recovery at the workplace.

Stress is an important mediator in the relationship between resources/recovery and job satisfaction as well as intention to quit. Margan and Dodić (2015) conducted a research with the aim to establish how indicators of worker's health status influences the employer's decision-making on which workers to retain or dismiss during personnel restructuring in the enterprise. The results show that the observed indicators of workers' health, long-time sick leave and disability category exert had the greater risk for dismissal.

Facility management and happiness

Theoretical approach of happiness from the workplace perspective looks for well-being, employee's physical health, psychological health, physical safety and wealth perspectives. Researchers (Allen, 2015; Oswald et al., 2014) mentioned some motivational organizational factors, such as work enjoyment, -enrichment, -relationships, -life balance, -variety, -teams, -recognition, -reward, -meaningfulness, -engagement, -equity, workplace leadership and -community. The systematic research on physical environment couldn't be found. The researchers mentioned various way to achieve happiness, from providing nicer offices or entertainment to securing a good pension scheme, higher wages and other benefits (Allen, 2015); or to random acts of workplace happiness, hire happy people, stop negative behaviour, celebrate success and mistakes (Kjerulf, 2016). The research about workplace happiness (Andrew, 2011; Diener, 2000) shows that happiness is an entirely subjective feeling of well-being experienced by the person, characterised by the presence of positive emotions and the absence of negative emotions. The positive characteristic of orientation to happiness that proposes different pathways to happiness may contribute to work-related well-being (Johnston et al., 2013).

Interventions that draw individuals' attention to pleasurable, meaningful or engaging aspects of their life, had the potential for increasing well-being (Giannopoulos and Vella-Brodrick, 2011, by Johnston et al., 2013). Allen (2015) suggested four key areas to focus on: autonomy (feeling of control), relationships (liking colleagues and supportive and friendly environment), progress (against goals they care about), and meaning (feeling work has a purpose). Sharifirad (2013) states that employee wellbeing attracts much attention of researchers, for the sake of happier and more productive employees. The statistic of productivity of happier people is amazing. It is found that happier people are both healthier and more productive (De Neve and Oswald, 2012). The University of Warwick research shows that happiness treatments improve productivity by approximately 10%-12% (Oswald et al., 2014). Anchor (2010) says when we are positive, our brains become more engaged, creative, motivated, energetic, resilient, and productive at work says and states that happy companies increase sale by 37%, productivity by 31% and accuracy of tasks by 19%.

Regarding FM perspective, Larssen (2011) argue that in order to allow for elaborating a more professional and strategic facility management, it is necessary to develop a new understanding of new, more active FM role with the emphasis on the effects on the organization of core activities and FM contribution to added value. Through the years, the focus on added value was studied on theoretical and practical level (Jensen et al., 2012; Coenen et al., 2012; Sarasoja et al., 2012; Lindholm, 2008), so it wasn't strange that new standards added the definition that 'FM affects the health, well-being and quality of life' (ISO/FIDIS 41001:2018).

Bjørberg et al. (2016) went even further. They found that it is very important to focus on

workplace happiness with optimization of building design in a way to enable the value creation for the end-user throughout building's lifetime. Beside added value approach, they emphasised the identification of needs and changes in existing building portfolio, adaptability approach, getting involved in early phase planning and active dialogue. Boge et al. (2017) were more concrete regarding office space. They were interested in offices and services that facilitate happy knowledge workers. On the number of 1670 respondents of knowledge workers, they concluded that the most important factors are 'common areas', 'freedom of choice' and 'office leisure'.

Cloutier et al. (2014) oriented their research on community engagement for both improvement of the physical environment and increasing happiness, so they presented Sustainable Neighbourhoods for Happiness Index. The results of critically observing the neighbourhood's state and implementing system-thinking and analysis for the best improvements, allowed communities to improve the overall happiness of residents through a shift toward sustainability, such as: walkability, orientation, use of native vegetation, green space connectivity/biodiversity, access to nature, and measures of social capital. An interesting research from Chuluun and Graham (2016) showed that average local happiness (happiness inequality) is positively (negatively) correlated with both R&D intensity and firm investment. Firms in happier places, tend to invest more than firms in less happy places, and it was found that younger firms' investment behaviour more strongly correlate with local happiness levels.

CONCLUSIONS AND RECCOMENDATION

Job insecurity has become an increasing problem since the global economic crisis and as labour market has become more flexible. Based on the literature review, we suggest that JI is relevant source of mental health problems for a particularly vulnerable group of the population, thus the special protection should be implemented through different policies to prevent psychological health problems among vulnerable employees.

From the literature review it is also seen that the problem affects both groups, people who are unemployed and the one who are in the situation of 'uncertainty'. To get the last group of employees more productive, it is found that orientation to happiness may contribute to work-related well-being and organizational success.

One of the problem with findings from literature is the diverse nature of happiness theory, physical environments, health behaviour and FM. Here, we see that core-business organization and FM should work and communicate closely, both with the aim to thoroughly engage the employees in the organizational changes, to move from declining situation toward increasing. Using the concept of FM, as a professional supporting organization, is important from the FM 'people' perspective of satisfaction, and the one which can make physical interventions to healthy environment. From the literature findings, we can conclude with some main statements that will contribute to value creation and happiness on the strategy, planning, design and construction phase. Besides the quality of indoor environment, also other indicators are important, such as freedom of choice, adaptability, common areas, office leisure, maintenance, and involvement in the design phase. More qualitative research is needed in order to find mechanisms to have an impact on the design and implementation of physical interventions in real life, and to research its influence on health behaviour.

This paper shows that some central areas of FM competences should enhance in the context to

contribute to happiness. A facility manager should understand the needs for today and for the future. Furthermore to regularly measure user satisfaction, to establish constructive dialog with users as a base for improvements. In order to sustain user satisfaction over time, the premises might have to be developed and transformed in accordance with the changing demands. As such, future research and practice should examine and explore the possible effect of FM contributions to job security.

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CONSTRUCTION SAFETY TRAINING METHODS AND EFFECTIVENESS FOR NON-NATIVE WORKERS

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Safety training in the construction industry is recognized as a needed step before entering construction sites and performing construction activities. As one of the most important industries to the US economy, the construction industry hires a large number of non-English speaking workers. Construction injury and fatality incidents involve non-English speaking workers at a higher rate than native workers. Ineffective safety training is considered one of the major causes of injuries. To determine the influence of different construction safety training methods and their effectiveness for non-native workers, the researchers reviewed current practices of several popular construction safety training methods, and analyzed the effectiveness of each method considering the barriers for non-English speaking workers. To achieve this goal, the researchers used statistical analyses of existing data, and conducted surveys and collected opinions from non-English speaking workers and from managers of companies that have hired non-native workers within the United States. The research revealed a list of the most effective safety training methods for non-native workers based on the perspective of personnel within the US construction industry.

Keywords: Construction safety, Non-native workers, Training effectiveness, Kirkpatrick model

INTRODUCTION

In the United States, according to the Occupational Safety and Health Administration (OSHA) requirements, all employers must provide training to workers who face hazards on the job (OSHA 2018). Safety training plays an important role in the construction industry to help workers build their abilities in hazard recognition and risk perception. Haslam et al. (2005) found that poor safety training practices can cause negative attitudes among workers with respect to safety issues. More specifically, hazard recognition performance can be impacted by different safety training methods, which in turn can affect project-level safety perception (Namian, et al. 2016).

As a large immigrant country, the United States has a high number of non-native born populations, including a large percentage of non-English speaking immigrants. Those foreign-born workers are distributed in every industry and are performing necessary work. As one of the most important industries to the country's economy, the construction industry hires many non-English speaking workers. According to the Bureau of Labor Statistics (2018), of the approximately 10.7 million employees in the US construction industry, 6.1% are black or African American, 1.9% are Asian, and 29.8% are Hispanic or Latino. Records show that construction injury and fatality incidents involve non-English speaking workers at a higher rate than native workers (Pransky, et al. 2002).

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Inappropriate and insufficient safety training is regarded as one of the potential issues that cause higher incident rates for non-native workers than for native workers (Cunningham, et al. 2017). Studies of the effectiveness of construction safety training have been conducted for decades, however, training specifically for immigrant workers has been emphasized only in recent years. The purpose of the study presented in this paper is to determine if current safety training methods are preferable and understandable for immigrant workers whose first language is not English, and to identify the most effective methods for non-native construction workers to improve their safety performance. In this paper, the target group of non-native workers mainly refers to those workers in the construction industry who were not born in the US, or who have cultural differences or low English proficiency.

LITERATURE REVIEW

Government statistics (BLS 2017) show that injuries to foreign-born workers make up about one-fifth of the total fatal work injuries. Thirty-seven percent of these workers were born in Mexico, followed by 19% from Asian countries. Furthermore, the same report shows that Asian, Hispanic, and other non-native workers incurred 160 fatal injuries in 2016, up from 114 in 2015, which was the highest percentage increase (40%) among any race or ethnic origin (BLS 2017). All of these reports and statistics indicate that the safety of non-native workers is of great concern.

Because of the culture differences and language barriers, non-native-English speaking workers already find themselves at a disadvantage in many jobsite communications. Lacking proper training and scarcity of culturally usable training materials have become major obstacles in such situations (Evia 2011). Based on a review of current practices regarding safety training, the formats of safety training can be organized as follows: written manual, video, on-line interactive training module, short guideline and tip sheet, and in-person training (Gambatese and Liu 2018).

A training evaluation model was introduced by Donald Kirkpatrick in 1970 to evaluate the effectiveness of safety training methods. The Kirkpatrick Model has served as the primary organizing design for training evaluations in for-profit organizations for over 30 years. Survey results indicate approximately 87% of Human Resource Development (HRD) executives attach some level of importance to evaluation and 67% use the Kirkpatrick Model in some fashion (Farjad 2012). The Kirkpatrick Model incorporates four steps to determine if a particular safety training is effective or not. These steps can be defined as follows: Step 1-Reaction; Step 2-Learning; Step 3-Behavior; and Step 4-Results. The four steps represent specific questions based on trainees' and trainers' perspectives, and on an overall view of the entire project or training program.

METHODOLOGY

To investigate the influence of different construction safety training methods and their effectiveness for non-native workers, the researchers utilized an industry survey. The researchers first identified through a literature review several commonly-known and used training methods and formats that might fulfill the needs of non-native construction workers in safety training. Considering the condition of English not being their first language, the methods are identified as: 1) Training manual in English; 2) Training manual translated into workers' language; 3) Training video in English; 4) Training video translated into workers' language; 5) In-person training in English; 6) Online training such as OSHA 10-hour training; 7) Hands on training (Gambatese and Liu 2018, OSHA 2018, Cunningham et al. 2017).

Survey questions were designed based on the Kirkpatrick Model to evaluate the effectiveness of the training. Figure 1 indicates the four steps of training evaluation and related evaluation questions that could apply to construction safety training (Kirkpatrick and Craig 1970). As show in Figure 1, the effectiveness of construction training requires analysis in four categories: reaction, learning, behavior and results. Feedback on each of the four levels (steps) from all training-relevant parties was desired to perform a comprehensive evaluation. The evaluation begins at Level 1 (Reaction), and then, as time and budget allow, should move sequentially to upper levels (Kirkpatrick 1998).

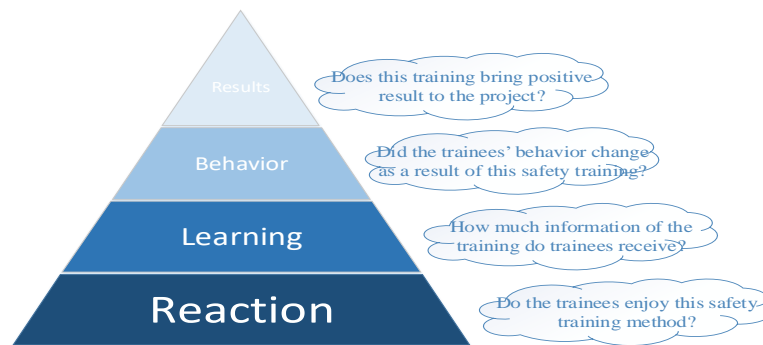


Figure 2: Kirkpatrick's' four-step model of training evaluation. (Revised from Kirkpatrick and Craig, *Evaluation of training* 1970)

The survey for the present study included three parts: demographic information, basic training information, and personal perspectives. In the demographic information part, basic questions such as the participant's company size, position, and working experiences were asked. Basic training information questions were included to collect information regarding the companies' current training methods and policy for non-native workers. Personal perspective questions mainly focused on collecting personal points of view related to all four levels of the evaluation model using a 5-point Likert-type scale, as suggested by Kirkpatrick (1998). Statistical methods used to test Likert-type scales are the Kruskal-Wallis test and Mann-Whitney test. The Kruskal-Wallis test, also known as one-way ANOVA on ranks, is a non-parametric method and does not assume a normal distribution (McDonald, Kruskal–Wallis test 2015). This test was used to analyze the discrete values received from the 5-point evaluation scale. The Mann-Whitney test (also known as the Wilcoxon test) was then performed to determine which two groups are different in the mean ranks.

The survey was distributed to Associated General Contractors (AGC) members with a total sample size of 1623. The online survey system Qualtrics was used to distribute the survey. The Qualtrics system provides not only a survey distribution service, but also a panel service that contacts participants directly and obtains responses on behalf of researchers. The researchers considered the response rate from AGC members to decide whether the additional request from the Qualtrics panel service would be necessary.

It should be noted that, while surveys may incorporate personal bias, the use of a survey is common for such research. In addition, the sample size is critical to obtaining statistically significant results. As part of the analysis of the responses, the researchers made efforts to ensure quality data. Specifically, those responses that did not meet specified criteria were discarded. In addition, the researchers utilized analyses of qualitative data from answers to open-ended questions provided by the respondents. Further details of these processes are provided in the Results section below.

RESULTS

Demographics

The response rate from the AGC contact list was low (~1.5%). Therefore, the researchers utilized the AGC responses to pilot test the survey. The responses from the AGC contractors were reviewed to gain insight into issues that may have led to the low response rate, and the survey questions were modified as needed. The researchers then conducted a second round of the survey through the Qualtrics panel service. The targeted participants were construction industry personnel at the worker and above levels (e.g., worker, superintendent, project manager, and president levels) located throughout the US. The participants might be non-native worker colleagues, managers, or non-native workers themselves who work on construction sites, and are assumed to know non-native workers well. While initial calculations revealed that a large sample size would be needed for a confidence interval of at least 95%, given resource constraints (the cost of obtaining responses through the Qualtrics panel service) and to ensure a sufficient number of responses for a relatively high level of confidence in the statistical analyses, a total of 80 responses were requested. To ensure valid responses, two quality control measures were used: time to complete the survey and “straight lined” marked choices. From the pilot study, the median duration of all completed responses was approximately five minutes. Considering response quality, any fast responses finishing the survey in less than two minutes were regarded as low-quality/random-choice responses. As for the second measure, the straight lined responses (e.g., choose “A” for all questions, or choose the same value in the 5-point scale questions) are not reasonable or useful for data analysis, so they were considered as invalid responses. As a result, a total of 82 high quality responses were received from Qualtrics.

All of the participants work for companies in the US that hire non-native workers. Within the 82 responses, 48% were from participants who work in small-size companies (less than 50 employees), and approximately 12% of the respondents work in a large company with more than 500 employees. More than half of the participants are in upper level management positions, and approximately 74% of the respondents have more than 5 years of work experience in construction. Regarding the language background of non-native workers, approximately 85% of the participants’ companies have workers who speak Spanish, 5% who speak Filipino, and 2% have Chinese workers. Accordingly, 75 out of the 82 participants said that their companies provide safety training to non-native workers, and 72 out of those 75 indicated that non-native workers receive the same safety training as the native workers. With respect to training methods, most companies provide in-person training (66%) and hands-on training (63%), as illustrated in Figure 2.

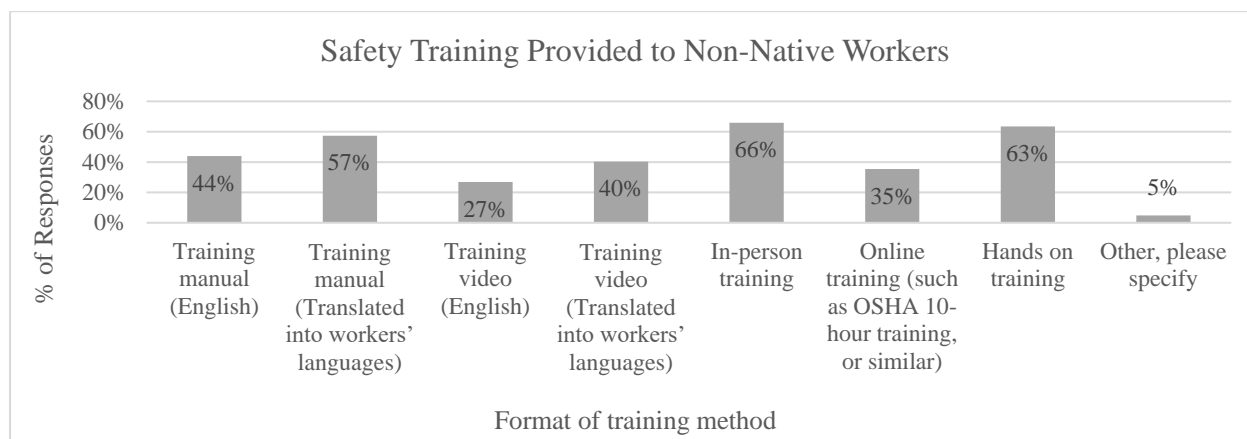


Figure 3: Training methods that company provides to non-native workers

Application of Kirkpatrick's Model of Evaluation

Based on Figure 1, the survey includes questions aimed at the four-level model of evaluation. Participants were invited to evaluate the preference and level of comprehension of all identified training methods using a scale of 1 to 5 for the first two levels of the model, Reaction and Learning. For Level 1 (Reaction), the question "Which of the following training methods do you think non-native workers would prefer?" was asked. The rating scale was defined from 1-Not suggested to 5-Preferred. The resulting mean rating for each training method is listed in Table 1. The results show that hands-on training (mean = 4.68) is the most preferable training method, and English-version video (3.45) is the method that non-native workers prefer the least.

Table 1: Rating at "Reaction" level of Kirkpatrick's Model for all training methods (1 = Not suggested to 5 = Preferred)

	Manual (Eng.)	Manual (Transl.)	Video (Eng.)	Video (Transl.)	In-person (Eng.)	Online Training	Hands-on Training
Mean rating	3.55	4.16	3.45	4.15	3.79	3.83	4.68

To assess the second level (Learning), the questionnaire asked "How much of the training material content do you think the non-native workers could understand?" A rating scale from "1-Not understandable", "3-Moderate understand (50%)", to "5-Fully understandable" was used. The results with respect to mean ratings (see Table 2) indicate that translated training video (4.59) has the highest knowledge transferrable rate, and English version manual (3.35) may not be very effective for non-native workers to receive training knowledge.

Table 2: Rating at "Learning" level of Kirkpatrick's Model for all training methods (1 = Not understandable to 5 = Fully understandable)

	Manual (Eng.)	Manual (Transl.)	Video (Eng.)	Video (Transl.)	In-person (Eng.)	Online Training	Hands-on Training
Mean Rating	3.35	4.55	3.38	4.59	3.68	3.59	4.56

The third level (Behavior) indicates whether workers' behaviors change after the safety training is provided. In response to the question "Do you think the workers' behavior changes as a result of training? (1 = behavior is worse to 5 = improves a lot)," a mean rating of 4.16 was received from the survey responses, demonstrating that most non-native workers' behaviors improved after the safety training. The top level of the Kirkpatrick Model, "Results", reflects whether the

change in the workers' behaviors has brought positive return on investment. The following question was asked: "Do you think the non-native workers' behaviors provide a positive return on investment?" The researchers defined a rating scale from -2 to 2 as follows: "-2-Negative", "0-Neither negative nor positive", and "2-Positive". The results show a mean rating of 1.48, which represents a positive return on investment. Participants perceive that the safety training is beneficial to the companies.

Lastly, the participants shared their perspectives on safety training for non-native workers. Using a keyword analysis of the open-ended responses, the most frequently used keyword was "comprehension". Comprehension could be enhanced by improving workers' English, providing more materials in their languages, and using bilingual training resources. When asked about concerns in selecting training methods, 72% of the respondents set "effectiveness of training" as the first priority, which was rated much higher than "return on investment" and "training duration".

DATA ANALYSIS

To analyze the effectiveness of all training methods, the researchers conducted further analysis of the responses related to the first two levels of training evaluation (Reaction and Learning). It is not convincing to use only the mean rating to determine whether the method is effective or not, given the fact that some mean ratings were quite close to each other. The Kruskal-Wallis, Wilcoxon, and Fishers' exact tests were used to examine if there is statistical evidence that one training mode is superior to another, and if a relationship between the first and the second evaluation levels exists.

In the analysis for Level 1 (Reaction) of the Kirkpatrick Model, the Kruskal-Wallis test was utilized to determine if the sample originated from the same distribution. The null hypothesis is that the mean ranks of all groups are the same. In this case, the identified groups refer to different training methods. After performing the test, it was concluded that at least one mean rank of one group is different from the mean rank of at least one other group (p -value $< 2.2e-16$). The null hypothesis for the Mann-Whitney test is that the number of differences in each identical group are equal. The results are presented in Table 3. In conjunction with the mean ratings (Table 1), "Hands on training" was shown to be the most preferred training method (p -values < 0.01). However, the translated manual and training videos were both viewed as the second most preferred methods, as there was no statistical evidence showing the two groups are different (p -value = 0.652). Moreover, videos, manual, and in-person training in English were rated to be the least favorite methods.

Table 3: Mann-Whitney test for “Reaction” level comparison between two groups

P-Value	Manual (Eng.)	Manual (Trans.)	Video (Eng.)	Video (Trans.)	In-person (Eng.)	Online training	Hands on training
Manual (Eng.)	-	< 0.01	0.278	< 0.01	0.098	0.051	< 0.01
Manual (Transl.)	-	-	< 0.01	0.652	0.018	< 0.01	< 0.01
Video (Eng.)	-	-	-	< 0.01	0.018	< 0.01	< 0.01
Video (Transl.)	-	-	-	-	0.019	0.017	< 0.01
In-person (Eng.)	-	-	-	-	-	0.782	< 0.01
Online Training	-	-	-	-	-	-	< 0.01
Hands on training	-	-	-	-	-	-	-

The same analysis was conducted to test the extent of knowledge transfer (Level 2: Learning) of each identified training method. The results of the Kruskal-Wallis test indicate that at least one mean rank of each group is different than that of at least one other group (p-value <0.01). Table 4 shows the results from the Mann-Whitney tests to determine which two groups were identical. From the results, it can be seen that the mean rating from Table 2 for “Learning” level evaluation does not provide strong evidence to demonstrate better training methods for non-native workers on receiving safety knowledge.

Table 4: Mann-Whitney test for “Learning” level comparison between each two groups

P-Value	Manual (Eng.)	Manual (Trans.)	Video (Eng.)	Video (Trans.)	In-person (Eng.)	Online training	Hands on training
Manual (Eng.)	-	< 0.01	0.561	< 0.01	< 0.01	0.094	< 0.01
Manual (Transl.)	-	-	< 0.01	0.488	< 0.01	< 0.01	0.955
Video (Eng.)	-	-	-	< 0.01	< 0.01	0.114	< 0.01
Video (Transl.)	-	-	-	-	< 0.01	< 0.01	0.890
In-person (Eng.)	-	-	-	-	-	0.480	< 0.01
Online Training	-	-	-	-	-	-	< 0.01
Hands on training	-	-	-	-	-	-	-

Lastly, the researchers tested if Level 1 (Reaction) and Level 2 (Learning) of the Kirkpatrick evaluation model are independent or related. The purpose of this test was to answer the research question “For non-native workers, if they like a training method more than others, would they be able to receive more information from this training method rather than other training methods?” Paired Fisher’s exact tests were performed to check the independency. Fisher’s exact test of independence is used when there are two nominal variables and the researcher wants to determine whether the proportions of one variable are different depending on the value of the other variable (McDonald, 2015). The test assumes that the relative proportions of one variable are independent of the second variable. The test results indicate that Level 1 and Level 2 evaluations are not independent for all training methods (p-value <0.01).

LIMITATIONS

While the study methodology selected was suitable for the purpose and scope of the study (Creswell 2009), it did result in some limitations. One of the limitations in this study is that the researchers were unable to identify whether the participants had received the safety training. The first two levels of the Kirkpatrick Model (Reaction and Learning) require feedback from the trainees or the workers who actually received safety training. However, the survey responses collected were mainly from management personnel in the company and, as a result, their perspectives might be biased. Another limitation is that the responses to the upper-level evaluation questions are based on the participants' perspectives; the responses will inevitably be subjective with participant bias and the small sample size.

CONCLUSIONS AND RECOMMENDATIONS

In the Level 1 (Reaction) evaluation of the Kirkpatrick model, hands-on training is the most accepted training method for non-native workers. English version videos are viewed as the least favorable training method. However, there is not enough evidence to say that English version videos are less accepted by non-native workers than in-person training and English version training manuals.

For Level 2 (Learning) of the Kirkpatrick model, combining the mean value ranking and the Mann-Whitney test result, there is strong evidence that non-native workers are able to receive more information from translated training videos rather than English version training manuals, videos, and in-person training. There is no evidence indicating that non-native workers are able to receive more information from translated training videos compared to translated manuals and hands-on training, even though translated training videos have the highest mean value in Level 2.

Regularly providing construction safety training is important for workers before entering the construction site. For non-native (low-English proficiency) workers, highly-effective training methods are more helpful for strengthening their ability to work safety. Just like the suggestions collected from the survey participants, using comprehensive and bilingual training materials to help them better understand the training content makes the training easier and more effective.

Further study is recommended that focuses on long term evaluation of the safety training methods, including administering post-training surveys, conducting follow-up needs assessment, and offering ongoing, sequenced training and coaching over a period of time. Future evaluations could be conducted with a larger sample size and using empirical data. Additionally, while the four-level diagram of the Kirkpatrick Model is usually drawn in the shape of a triangle, it is not known why the model is depicted in this way. Future research could explore whether there is some relationship between each level. For example, for the first level "Reaction", if the trainee chose "1 - not suggested", does that mean he or she is also not willing to gain any information or safety knowledge from the next level? Further research could focus on this question to determine the possible relationships between the levels and confirm the triangular shape of Kirkpatrick's' model.

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ACTOR-LED, IMMERSIVE INDUCTIONS

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Inductions are ubiquitous in construction and workers on most projects in most countries of the world experience them whenever they move to a new project, which may be very frequently. There is evidence that typical inductions have become ineffectual, partly due to workers thinking that they have ‘heard it all before’. EPIC (Employers Project Induction Centre) is one of the most striking examples of where major London infrastructure project, Tideway, has tried to do something ‘transformational’ in relation to occupational safety and health (OSH). EPIC is a full-day event in which actors take participants through – and engage them in – a ‘real life’ scenario involving an incident on a construction site. Participants have an opportunity to discuss and influence the outcomes of the scenario being acted out in front of them in a purpose-built facility. This paper briefly presents the problems with traditional inductions. It describes the EPIC programme and the research work that reviewed the practice and evaluated its effectiveness. This work is part of a seven-year longitudinal study of how strategy becomes practice funded jointly by the Institution of Occupational Safety and Health (IOSH) and Tideway.

Keywords: Induction, Training, Major projects, Culture, Innovation.

INTRODUCTION

Inductions are part of everyday life in the UK construction industry but, despite their prevalence, surprisingly little research has been conducted into their effectiveness or their impact on health and safety outcomes. One of the few studies to shed light on induction practices in construction was by Pink et al. (2010), who reported on the findings of an ethnographic study of inductions on construction sites around the UK. The authors found problems that will be familiar to anyone who has been through a site induction, including:

- Low levels of engagement from trainers and workers;
- Poor communication of complex health and safety information;
- Failure to establish whether learning outcomes had been achieved; and
- A lack of open discussion of risks and hazards.

Pink et al. (2010) concluded that the requirements of training and briefing were being conflated, and that these functions should be separated.

Recognising the problems inherent in conventional site inductions, some clients and contractors in the UK have tried different approaches to briefing and inducting construction workers. This paper reports on the preliminary evaluation of an actor-based, immersive induction programme that is being used on a major infrastructure project in the UK. The context

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was the vision of the project client to be transformational by combining a number of existing approaches, including behavioural health and safety, but applying them in novel ways and ‘raising the bar’ in terms of performance and outcomes.

This paper begins by reviewing the literature on actor-based training and inductions, which is followed by details of the authors’ evaluation methodology. The findings of the evaluation are then discussed. The paper concludes by discussing the effectiveness of the induction programme, lessons for the broader construction industry and the challenges involved in establishing the links between such programmes and health and safety outcomes. The EPIC intervention has been discussed previously, targeting an industry audience (Pinder et al., 2017).

CONTEXT

Worker inductions have become ubiquitous on all but the smallest UK projects and are now common practice across the world, at least on larger projects. One significant problem is that much of the content of the various inductions on different sites is identical, such that the mainly itinerant frontline workers have ‘heard it all before’ and often the content is delivered by junior staff members with little training using old-fashioned ‘chalk and talk’ techniques (Pink et al., 2010).

The use of actors in training and inductions is still relatively novel in the construction industry in the UK and probably beyond, however actor-based training has been used for several decades in other fields, most notably in healthcare and social work as part of scenario-based training. For instance, actors have been employed to simulate patients in clinical consultation coaching (Wilson, 2000), to play the part of anaesthetists in the training of surgical teams (Kassab et al., 2010) and to role play in child protection training (Lexton et al., 2005). Most of the published research on the use of actors in training and inductions has taken place in these fields and, therefore it is that body of literature that is introduced here.

Discussing the use of actors in vocational training, Finn (2014) argued that “*The vast majority of teaching and training in education and work continues to be conventional, narrow and highly prescribed – not experiential*” (p. 109). He suggested that this is because training tends to be designed around the needs of organisations, rather than the needs of individuals and that an effective learning experience should be learner-centric and encourage active participation, exploration and reflection.

Role play has long been used as a method for creating more experiential training experiences and usually involves learners assuming different characters. However, role play involving non-actors (i.e. learners) tends to be less realistic or authentic (Wilson, 2000; Finn, 2014), can be stressful for the people taking part (Petracchi, 1999) and, in some cases, can simply be impractical. For instance, Nestel et al. (2008) justify the use of actors because of the difficulties of recruiting clinicians to take part in fully-equipped simulated operating theatres, because clinicians are a scarce resource.

Authenticity is by far the most widely cited advantage of actor-based training because trained actors have the skills and confidence to portray roles realistically and improvise when required (Bell et al., 2014). This can make for a much more immersive and interactive learning experience (Keltner et al., 2011). For example, in her study on using actors in social work simulations, Petracchi (1999, p. 67) found that “*Social work students began to conceptualize and to “feel” how a social worker would react in a given situation rather than simply imagining*

the actions that would take place.”

At the same time as providing greater realism, actor-based training can also provide a “safe environment” for people to learn in (Bell et al., 2014). Actors can portray roles in ways that are sensitive and non-threatening (Finn, 2014; Lexton et al., 2005), a particularly important issue when discussing topics that are emotive, such as child protection and mental health. Actor-based training can also make for a more consistent learning experience, because actors can play the same role again and again, whilst adapting their responses to a particular group of learners (Petracchi, 1999).

However, actor-based learning also has some disadvantages including the difficulty and time required to set-up such training (Kelnter, 2011), and the cost of employing and training actors (Bell et al., 2014). Lexton et al. (2005) found that using actors in child protection training doubled the cost of running a course. There is also a risk that using actors in simulated training may perpetuate stereotypes or appear patronising to experienced professionals (Lexton et al., 2005). More experienced professionals may find the acting less realistic than their less experienced peers, which may impact on their learning experience (Nestel et al., 2008).

For practical and ethical reasons, most of the studies cited above have evaluated the effectiveness of actor-based training programmes by asking participants to rate their own learning experience, either through interviews and/or questionnaire surveys, along with observations of the training. These methods of evaluation can provide some insights into the efficacy of actor-based training, but they cannot show what impact such training has on subsequent working practices, or whether the same outcomes would have been achieved through more conventional training methods.

METHODOLOGY

The content of this paper has been taken from the emerging findings of the longitudinal research on Tideway. This longitudinal methodology is summarised as follows and a fuller discussion can be found in Fuller et al. (forthcoming). The challenges of setting up a longitudinal study were presented at the 2017 cib W099 conference in Cape Town and an associated journal paper (Fuller et al., 2017).

Longitudinal methodology is not routinely used, often due to the time and cost involved (Bryman, 2012). Longitudinal studies provide richer data and tend to be used where there is a high level of social interaction (Hale, 2014). Longitudinal research has some distinct advantages over cross-sectional studies (Miller and Friesen, 1982) in particular for collecting “data from numerous organizations in an economical fashion” (Miller and Friesen, 1982, p. 1013). The authors are not aware of any previous longitudinal studies on occupational safety and health (OSH) in construction.

Cross-sectional methods can only take ‘snap-shots’ at a particular time which are then extrapolated backwards and forwards, outside of the timeframe of the data collection (Yin, 2003, p. 159). This method relies heavily on the historical recollections of interviewees and on data derived from lagging indicators. However, longitudinal studies need experienced researchers who can ‘fit in’ to organisations, have a greater rate of data collection, and be more adaptable to deal with changes to their area of study as they emerge over time. They also require more commitment from industry collaborators to provide good access over sustained periods.

In this seven-year study the authors are tracing a number of specific interventions, such as the Employers Project Induction Centre (EPIC), over the length of the project. This is providing rich pictures of how the interventions move from strategy to practice and how they mutate over time, responding to happenings and changing circumstances – this is similar to tagging a suitcase on a transatlantic plane, where the primary interest is on the whereabouts and condition of the case itself. But, tracing these interventions over time is also providing insights on cross-cutting issues such as decision-making, organisational rhetoric and worker engagement – this is analogous to tagging a migrating bird, where the particular bird is used to learn more about the habits of the species and the influence of other factors, such as global warming, changing habitats etc.

The findings for this paper draw from the broader findings of the overall study. The following steps more specifically relate to EPIC:

- Each member of the research team attended and experienced EPIC first-hand as ‘normal’ delegates. Each member attended on a different day to experience the actors playing different roles and responding to different cohorts of attendees
- The research team members reviewed their experiences individually and then as a group providing direct feedback to Tideway as part of the periodic review of EPIC
- Analysis of exit feedback collected from 530 EPIC participants over a three-month period
- Online survey of mainly office-based staff working on the project (224 responses)
- Focus groups with frontline workers at two of the main drive sites
- Interviews with a wide variety of people working on Tideway, including senior managers.

FINDINGS, ANALYSIS AND DISCUSSION

At a very early developmental stage in the Tideway project the authors had been appointed as OSH advisors and had proposed an immersive, interactive induction. This was then developed with the actor-based training organisation Active Training Team (ATT). Tideway and ATT built upon previous immersive, behaviour-based OSH training programmes (such as a one-off initiative on Crossrail) and developed a full-day event in which actors engage delegates in a ‘real life’ scenario involving a fatal incident on a construction site. Participants have an opportunity to discuss and influence the outcomes of the scenario being acted out in front of them in a purpose-built facility.

EPIC is the second of several steps in Tideway’s onboarding process. Before attending EPIC, everyone attends the Central Onboarding Facility which deals with security, drugs & alcohol testing, critical health examinations and an OSH communications assessment. Following EPIC, and still before they start work on site, all site-based people attend a site induction, which are in reality orientations, held by the main works contractors. Everyone who works on Tideway must attend EPIC, whatever their role and the duration of their work on the project. This has created some tensions regarding very short-term workers or delivery drivers etc.

The objectives of EPIC, stated by Tideway, are:

- For people to leave the session having had a ‘visceral experience’ that instils an intelligent and respectful wariness of the dangers of the workplace;
- To gain buy-in to the fact that, regardless of role or function, OSH is everyone’s equal responsibility;

- To engage everyone in understanding that people at all levels should expect to challenge and be challenged over OSH issues.

Therefore, EPIC was designed to be experiential, challenging and different to the typical OSH training programmes and project inductions normally used in construction. Figure 1 shows delegates suggesting changes to the actors in an effort to disrupt the chain of events that lead up to the accident.



Figure 1: Delegates suggesting changes to the actors to try to change the outcome

EPIC commenced on May 8th 2015 and up until the end of January 2018, 11,253 people had completed the day's event.

79% of the survey respondents agreed that EPIC was 'excellent'. When asked 'why?' there were a variety of responses including:

"This reflects real life. Unless you have been exposed to [the] consequence of a work accident you are not prepared for the aftermath. This should help people understand the wider issues of safety and should help avoid incidents that lead to the consequence and subsequent enquiry."

People made a point of describing EPIC as feeling 'different' and 'innovative' and said that they found the day informative and thought-provoking, with a clear and powerful message. One person commented that:

"I had never experienced anything like it before. I loved the fact that it was interactive and emotional. It actually meant something. I came away feeling as though I could challenge a construction site worker should I feel the need to."

78% of survey respondents ticked a box that stated that attending EPIC had made them more confident to stop any unsafe work that they saw. 72% also claimed that EPIC had improved their understanding of the project and made them feel part of Tideway.

Analysis of exit feedback forms from EPIC participants revealed that people found the day interactive (n=200), well delivered (n=114), engaging (n=83) and informative (n=73). When asked an open question on what they would take away from the day, the three most common responses were:

- Personal responsibility for safety (n=90)
- Communication skills (n=82)
- The importance of safety (n=73)

Negative comments about EPIC tended to focus on the emotional nature of the day, which a few people found to be too stressful, and the behavioural theory in the afternoon session, which

some people thought was not relevant and felt that it made the day unnecessarily long. The afternoon session was also delivered in a more traditional manner.

The EPIC programme included a motivational ‘slot’ by a member of the Tideway senior leadership (Figure 2). However, the focus groups and interviews suggested that this input, along with other aspects of EPIC had sometimes generated unrealistically high expectations amongst some workers regarding issues such as personal protective equipment (PPE) and welfare facilities on site, particularly during the early stages of the project. In other words, in the early days it was felt that the reality did not always ‘live up’ to the claims made on the day. Some also questioned whether EPIC has actually changed how workers behave on site, so a key challenge for Tideway moving forward will be how to reinforce the message from EPIC once people begin working on site. Tideway are currently planning direct follow-ups to EPIC, building on the actor-led approach but delivered in the workplace rather than at a central facility.



Figure 2: Senior management input, demonstrating commitment to the vision

Limitations and further work

It is acknowledged that this study was carried out at the early stage of the EPIC delivery and the content has been adjusted somewhat, partly in response to feedback from the research team. Furthermore, many of the early attendees were actually office workers who may not have experienced an accident before and are less familiar with the conditions on site.

The very positive feedback may have been affected by the novelty factor, especially for the number of office workers who formed a large part of the survey sample.

The authors will continue to study the development and outcomes of EPIC as part of their longitudinal research and further insights will be published in due course. They are also planning a more thorough and subtle study to attempt to evaluate the extent to which EPIC has actually changed the behaviour and attitudes of frontline workers.

CONCLUSIONS

EPIC is proving to be an excellent example of Tideway’s ‘transformational’ approach to OSH and has been very well received. It also provides a number of important lessons for the construction industry and OSH practitioners as follows:

If you want to genuinely engage workers in meaningful conversations about OSH, you need to move beyond the use of traditional PowerPoint or video briefings and offer a more immersive and interactive experience to workers. However, this takes time, thought and commitment.

Whilst feedback from EPIC so far has been overwhelmingly positive, this may have been skewed by the large number of office-based staff who attended in the early months. It may be that, site-hardened frontline operatives may not be as impressed by simulated accidents when they have seen the ‘real thing’.

Initiatives such as EPIC are as much about making people feel valued and creating a sense of common purpose, as they are about raising awareness of OSH issues. The importance of this should not be underestimated in an industry that has traditionally been poor at valuing its largely itinerant workforce.

It is important to carefully plan the amount of theory to introduce to participants, as this can be off-putting for some people, particularly those with a relatively low level of traditional education and might be perceived as irrelevant. Behavioural theory is arguably most effective when its less overt and more embedded in the scenario being acted out.

The duration of the event needs careful consideration, particularly for people travelling long distances. It is also important to recognise that people’s concentration and attention may diminish if the day is too long.

A good understanding of English for all attendees is essential to understand the scenarios and realise the benefits of the approach. This was achieved to some extent by Tideway’s use of an OSH communications assessment as part of the onboarding process before people attended EPIC. Figure 3 shows four very nervous Eastern European workers, with limited English, about to start EPIC on the same day as one of the authors. They seemed to have ‘slipped through the language assessment net’ and really struggled with the day as a result.



Figure 3: Non-English-speaking delegates wait nervously for the start of EPIC

Tideway considered that maintaining the element of ‘surprise’ was critical to the impact of EPIC. Tideway appears to have been very successful at encouraging participants not to spoil the surprise for their colleagues – 92% of survey respondents agreed that ‘EPIC was surprising’. This conclusion will be tested as the project moves forward to times when the EPIC concept becomes more widely known and more attendees have some expectation of what will happen. Immersive sessions like EPIC will not suit everyone. A balance needs to be achieved between forewarning people of the nature of the day and spoiling the element of surprise.

Transformational programmes such EPIC can raise expectations amongst workers joining a project. It is therefore important to manage expectations and deliver on commitments, particularly when they are about being better than industry norms. It also underlines the need for a consistent experience across all the different facets of the onboarding 'journey'.

Although the notion of challenging unsafe behaviour is becoming more accepted in construction, immersive and interactive programmes can help people feel more confident in challenging colleagues. This is particularly the case for people who are less familiar with working on construction sites.

Learning through engaging the emotions is an effective tool in changing practice. This agrees with Horwath and Morrison (1999 from Lexton et al., 2005). However, care needs to be taken to manage the emotional nature of the day, which some people can find stressful.

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THE ROLE OF CONSTRUCTION HEALTH AND SAFETY (H&S) IN THE MANAGEMENT OF THE BUSINESS OF CONSTRUCTION

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Historically, construction H&S has been viewed as an operational issue, and therefore the focus of H&S interventions has been at project level. However, the impact of accidents on the share price of general contractors (GCs), and research relative to, among other, the role of H&S in marketing, indicates that construction H&S plays a holistic role in the business of construction. The purpose of the study reported on is to determine the importance of H&S in terms of managing the business of construction, and various aspects in terms of managing construction H&S. The management of a large GC were surveyed using a self-administered questionnaire. The salient findings include H&S is important in terms of, among other, managing the business of construction, managing projects, organisation strategy, owner / shareholder satisfaction, marketing of the organisation, organisation image, and reputation. The belief that ‘H&S is a strategic business issue’, and ‘H&S is an operational issue’, among other, are more than important in terms of managing construction H&S. Respondents perceive their organisation’s H&S status to be between compliant to proactive / proactive. Conclusions include that H&S is not solely an operational issue as H&S performance impacts on: overall project performance, and therefore client and design team satisfaction, and attractiveness to clients, and contractor profitability, and therefore owner / shareholder satisfaction. It is recommended that GCs view H&S as a strategic business issue, and integrate H&S into very function of the organisation.

Keywords: Business, Construction, Health and Safety

INTRODUCTION

According to the Construction Industry Development (cidb) (2009), during visits to 1415 construction sites, Department of Labour (DoL) inspectors issued 1 388 (98.1%) notices, namely 86 (6%) improvement notices, 1 015 (73%) contravention notices, and 287 (21%) prohibition notices. Furthermore, 52.5% of contractors were non-compliant. Smallwood & Lingard (2009) argue that ethical business practice includes compliance with legislation. Then, given that values embrace ethics, the existence of H&S legislation amplifies the need for the inclusion of H&S as a value. It is notable that a South African study determined that the OH&S Act and the Construction Regulations, which are H&S focused, were ranked first and third in terms of the extent to which ‘motivators’ contributed to respondents’ organisations addressing H&S (Smallwood, 2014).

Sherratt (2018) states that construction clients are keen to be associated with responsible contractors, and in the United Kingdom (UK), the Social Value Act 2012 requires public sector

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clients to consider economic, social, and environmental well-being when awarding public sector contracts. Furthermore, corporate social responsibility (CSR) is embedded in the guise of sustainability values within the construction process. The South African study referred to ranked 'business' related motivators in terms of the extent to which 'motivators' contributed to respondents' organisations addressing H&S as follows: image (2nd); professionalism (4th); reputation (5th), and H&S is an organisation value (6th) – near major to major / major extent (Smallwood, 2014). The following contributed between some extent to a near major / near major extent: H&S is a moral issue (7th); organisation H&S policy (9th); preservation of organisational integrity (13th); marketing edge / advantage (18th); resulting client satisfaction (23rd); CSR issue (24th), and client 'pressure' (35th).

Given the aforementioned, and that to date, globally, the focus of H&S research has been at project as opposed to business level, a study 'The Holistic Role of Construction H&S' was undertaken, the objectives of the study being to determine the:

- Importance of H&S in terms of various aspects related to an organisation and projects;
- Importance of aspects in terms of managing construction H&S, and
- Perceived rating of the GC's current H&S status.

REVIEW OF THE LITERATURE

Importance of the Project Parameters

Historically, research findings indicate that the traditional project parameters of cost, quality, and time, take precedence over H&S with respect to the importance of project parameters. An 'image of contractors' study conducted by Smallwood (2010) required respondents to indicate the importance of twenty-six image related aspects. The mean scores recorded between parentheses are between 1.00 and 5.00. Based upon the client related responses, quality (4.75) and remaining within budget (4.75) were ranked joint first, time performance (4.25) eighth, health (4.00) eleventh, and safety (3.75) thirteenth.

Economics of Health and Safety

Given that the cost of accidents (COA) is estimated to be between 4.3% and 5.4% of the value of completed construction, whereas the cost of implementing H&S is estimated to be between 0.5% and 3% of project costs, clearly H&S is a 'profit centre' (Smallwood, 2004). Research conducted by Ikpe, Hammond, Proverbs, and Oloke (2011) determined that the benefits of accident prevention outweigh the costs of accident prevention by a ratio of approximately 3:1 - 62% benefit gain to 38% benefit loss. These findings clearly indicate the financial component of the 'holistic role of H&S'.

In terms of synergy, a study conducted among construction project managers in South Africa (Smallwood, 1996 in cidb, 2009) determined, inter alia, that productivity (87.2%) and quality (80.8%) predominated among aspects negatively affected by inadequate H&S, followed by cost (72.3%), client perception (68.1%), environment (66%), and schedule (57.4%). This finding underscores the 'holistic role of H&S', particularly with respect to enhancing project performance, competitive advantage, marketing, and PR.

A further economics of H&S aspect is public confidence in terms of share prices. Immediately after the M1 Motorway, Johannesburg, temporary bridge collapse in South Africa on a

Wednesday afternoon in October 2015, the company's share price dropped sharply by 7.32% to R11.15, leaving it 48.37% lower than a year ago (Slabbert, 2015). Following the news of the Injaka Bridge collapse in South Africa in July 1998, the share price slipped from R15.30 to R12.50 (18.3%) (Temkin, 1998).

Marketing, Public Relations, and Image

A study conducted in South Africa by Smallwood (2005) investigated the marketing benefits of optimum H&S. The study concluded that the TQM related H&S phenomena, which contributed to the acquisition of work, or additional work, clearly indicate the indirect role and benefits of optimum H&S in construction marketing. In essence, optimum H&S does provide 'better practice' H&S general contractors with a competitive edge, and increases their attractiveness to clients. The findings of the 'image of contractors' study reported on earlier, indicated the importance of H&S, which were de-linked for the study. A study conducted in the United Kingdom by Brabazon et al. (2000) in Wright and Marsden (2002) determined that most construction sector firms surveyed view H&S performance to be important in terms of commercial success due to its impact on tendering and their reputation. Clearly, performance relative to H&S affects clients' perceptions of a contractor's image, which in turn impacts on their reputation.

RESEARCH

Research Method

The questionnaire consisted of three primary closed end questions, the first two consisting of thirty-four, and fifty-nine sub-questions respectively. The aspects for the 'Importance of H&S in terms of various aspects related to the organisation and projects' question were evolved from a previous study 'The Motivators for Addressing H&S' (Smallwood, 2014), and the aspects for the 'Importance of aspects in terms of managing construction H&S' question were evolved from a previous study 'Contributors to better practice H&S performance' (Smallwood, 2002).

The sample stratum consisted of delegates attending a national H&S conference of a major general contractor in South Africa. Two self-administered questionnaires were circulated upon commencement of the conference, one being 'The Holistic Role of Construction H&S'. Eleven responses were received and included in the analysis of the data.

Research Findings

Table 1 indicates the importance of H&S in terms of 34 aspects on a scale of 1 (not) to 5 (very), and a mean score (MS) ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint score of 3.00, which indicates that in general the respondents perceive H&S to be between important to very important in terms of the aspects.

However, when reviewing the MS ranges, 21 / 34 (61.8%) of the MSs are $> 4.20 \leq 5.00$, which indicates that H&S is between more than important to very / very important. A further 13 / 34 (38.2%) MSs are $> 3.40 \leq 4.20$ - between important to more than important / more than important.

With respect to the upper half of the MS range $> 4.20 \leq 5.00$, 9 / 21 (42.9%) aspects have MSs > 4.60 . Two are satisfaction related - client satisfaction (1st), and project manager satisfaction (8th). Legal compliance by the organisation is ranked second.

Attractiveness to clients (3rd), organisation image (4th), organisation reputation (5th), and prequalification for projects (9th) are related. Managing the business of construction (6th), and managing projects (7th) are related. These findings clearly indicate the 'holistic role of H&S'.

With respect to the lower half of the MS range $4.20 \leq 5.00$, 12 / 21 (57.1%) aspects have MSs > 4.20 . Owner / Shareholder satisfaction (10th), sustainability of the organisation (11th), profitability of projects (13th), profitability of the organisation (14th), achieving projects' goals (Quality) (16th), achieving projects' goals (Time) (17th), achieving projects' goals (Cost) (20th), and achieving projects' goals (Productivity) (22nd) are related. Marketing of the organisation (15th), attracting clients (18th), internal public relations (19th), and external public relations (22nd) are related. These findings also underscore the 'holistic and synergistic role of H&S'.

13 / 34 (38.2%) MSs fall in the MS range $3.40 \leq 4.20$ - between important to more than important / more than important. Achieving projects' goals (Developmental) (30th), managing costs on projects (25th), and achieving projects' goals (Environment) (29th) are related. Organisation strategy (23rd), organisation tactics (26th), and operational interventions (12th), are related. Worker satisfaction (24th), and designer satisfaction (27th) are related. Worker satisfaction (24th), development of human resources (31st), and maintenance of human resources (34th) are related. Attracting graduates (32nd), and attracting workers (33rd) are related. These findings indicate the 'holistic and synergistic role of H&S'.

Table 1: Importance of H&S in terms of various aspects related to the organisation and projects

Aspect	Response (%)					MS	Rank	
	Unsure	Not.....Very						
		1	2	3	4	5		
Client satisfaction	0.0	0.0	0.0	0.0	18.2	81.8	4.82	1
Legal compliance by the organisation	0.0	0.0	0.0	0.0	18.2	81.8	4.82	2
Attractiveness to clients	0.0	0.0	0.0	0.0	27.3	72.7	4.73	3
Organisation image	0.0	0.0	0.0	0.0	27.3	72.7	4.73	4
Organisation reputation	0.0	0.0	0.0	0.0	27.3	72.7	4.73	5
Managing the business of construction	0.0	0.0	0.0	0.0	36.4	63.6	4.64	6
Managing projects	0.0	0.0	0.0	0.0	36.4	63.6	4.64	7
Project manager satisfaction	0.0	0.0	0.0	0.0	36.4	63.6	4.64	8
Prequalification for projects	0.0	0.0	0.0	0.0	36.4	63.6	4.64	9
Owner / Shareholder satisfaction	0.0	0.0	0.0	0.0	45.5	54.5	4.55	10
Sustainability of the organisation	0.0	0.0	0.0	0.0	54.5	45.5	4.45	11
Profitability of projects	0.0	0.0	0.0	9.1	45.5	45.5	4.36	12
Profitability of the organisation	0.0	0.0	0.0	9.1	45.5	45.5	4.36	13
Marketing of the organisation	0.0	0.0	0.0	9.1	45.5	45.5	4.36	14
Achieving projects' goals (Quality)	0.0	0.0	0.0	9.1	45.5	45.5	4.36	15
Achieving projects' goals (Time)	0.0	0.0	0.0	18.2	27.3	54.5	4.36	16
Attracting clients	0.0	0.0	0.0	27.3	9.1	63.6	4.36	17
Internal public relations	0.0	0.0	0.0	9.1	54.5	36.4	4.27	18
Achieving projects' goals (Cost)	0.0	0.0	0.0	9.1	54.5	36.4	4.27	19
External public relations	0.0	0.0	0.0	18.2	36.4	45.5	4.27	20
Achieving projects' goals (Productivity)	0.0	0.0	0.0	18.2	36.4	45.5	4.27	21
Organisation strategy	0.0	0.0	0.0	9.1	63.6	27.3	4.18	22
Worker satisfaction	0.0	0.0	0.0	18.2	45.5	36.4	4.18	23
Managing costs on projects	0.0	0.0	0.0	18.2	45.5	36.4	4.18	24
Organisation tactics	0.0	0.0	0.0	9.1	72.7	18.2	4.09	25
Operational interventions	9.1	0.0	0.0	0.0	54.5	36.4	4.00	26
Designer satisfaction	0.0	0.0	0.0	27.3	45.5	27.3	4.00	27
Corporate social responsibility	9.1	0.0	0.0	9.1	45.5	36.4	3.91	28
Achieving projects' goals (Environment)	0.0	0.0	0.0	36.4	36.4	27.3	3.91	29
Achieving projects' goals (Developmental)	9.1	0.0	0.0	18.2	36.4	36.4	3.82	30
Development of human resources	9.1	0.0	0.0	27.3	27.3	36.4	3.73	31
Attracting graduates	0.0	0.0	27.3	9.1	27.3	36.4	3.73	32
Attracting workers	0.0	9.1	9.1	18.2	27.3	36.4	3.73	33
Maintenance of human resources	9.1	0.0	9.1	18.2	27.3	36.4	3.64	34

Table 2 indicates the importance of 58 aspects in terms of managing construction H&S on a scale of 1 (not) to 5 (very), and a MS ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint score of 3.00, which indicates that in general the respondents perceive the aspects to be between important to very important in terms of managing construction H&S.

However, when reviewing the MS ranges, 39 / 58 (67.2%) of the MSs are $> 4.20 \leq 5.00$, which indicates that the aspects are between more than important to very / very important in terms of managing construction H&S. A further 19 / 58 (32.7%) MSs are $> 3.40 \leq 4.20$ - between

important to more than important / more than important.

With respect to the upper half of the MS range $4.20 \leq 5.00$, 14 / 39 (35.9%) aspects have MSs > 4.60 . Site management (1st), management involvement (2nd), middle management (5th), management commitment (6th), management participation (7th), supervision (8th), and top management (12th), indicate the importance of management and supervision. H&S culture features prominently in terms of a vision of a ‘Fatality, injury, and disease-free work place’ (4th), the belief ‘people are our most important resource’ (9th), H&S culture (10th), core competencies e.g. values, aptitude, and integrity (13th), and respect for people (11th). Worker participation in H&S ranked third, is notable as it is one of the two pillars of an H&S programme. H&S education ranked fifteenth indicates the importance of tertiary H&S education. Furthermore, it is notable that H&S is a strategic business issue (14th), is ranked higher than H&S is an operational issue (16th), albeit it marginally.

Notable rankings within the lower half of the MS range $4.20 \leq 5.00$, which includes 24 / 39 (61.5%) aspects, are legal function (23rd), financial provision for H&S (28th), procurement function (39th), and public relations function (36th).

The remaining 19 / 58 (32.8%) MSs fall in the MS range $3.40 \leq 4.20$ - between important to more than important / more than important. Notable rankings with respect to the business of construction are financial function (47th), human resources function (48th), administration and information technology function (54th), marketing function (55th), and procurement (58th).

Table 2: Importance of aspects in terms of managing construction H&S

Aspect	Response (%)					MS	Rank	
	Unsure	Not.....Very						
		1	2	3	4			5
Site management	0.0	0.0	0.0	0.0	9.1	90.9	4.91	1
Management involvement	0.0	0.0	0.0	0.0	9.1	90.9	4.91	2
Worker participation in H&S	0.0	0.0	0.0	0.0	9.1	90.9	4.91	3
A vision of a ‘Fatality, injury, and disease-free work place’	0.0	0.0	0.0	0.0	18.2	81.8	4.82	4
Middle management	0.0	0.0	0.0	0.0	18.2	81.8	4.82	5
Management commitment	0.0	0.0	0.0	0.0	18.2	81.8	4.82	6
Management participation	0.0	0.0	0.0	0.0	18.2	81.8	4.82	7
Supervision	0.0	0.0	0.0	0.0	18.2	81.8	4.82	8
The belief ‘People are our most important resource’	0.0	0.0	0.0	0.0	27.3	72.7	4.73	9
H&S culture	0.0	0.0	0.0	0.0	27.3	72.7	4.73	10
Respect for people	0.0	0.0	0.0	0.0	36.4	63.6	4.64	11
Top management	0.0	0.0	0.0	0.0	36.4	63.6	4.64	12
Core competencies e.g. values, aptitude, and integrity	0.0	0.0	0.0	0.0	36.4	63.6	4.64	13
H&S education	0.0	0.0	0.0	0.0	36.4	63.6	4.64	14
H&S is a strategic business issue	0.0	0.0	0.0	0.0	45.5	54.5	4.55	15
H&S is an operational issue	0.0	0.0	0.0	0.0	45.5	54.5	4.55	16
Production function	0.0	0.0	0.0	0.0	45.5	54.5	4.55	17
Project H&S plans	0.0	0.0	0.0	9.1	27.3	63.6	4.55	18
Construction Management competencies (knowledge & skills):	0.0	0.0	0.0	9.1	27.3	63.6	4.55	19
Accountability for H&S	0.0	0.0	0.0	9.1	27.3	63.6	4.55	20
H&S awareness	0.0	0.0	0.0	9.1	27.3	63.6	4.55	21
Hazard identification and risk assessment during construction	0.0	0.0	0.0	18.2	9.1	72.7	4.55	22
Legal function	0.0	0.0	0.0	0.0	54.5	45.5	4.45	23
The belief ‘All accidents are preventable’	0.0	0.0	0.0	9.1	36.4	54.5	4.45	24

Aspect	Response (%)					MS	Rank	
	Unsure	Not.....Very						
		1	2	3	4			5
Construction H&S competencies	0.0	0.0	0.0	9.1	36.4	54.5	4.45	25
H&S training	0.0	0.0	0.0	9.1	36.4	54.5	4.45	26
H&S climate (optimum)	0.0	0.0	0.0	0.0	60.0	40.0	4.40	27
Financial provision for H&S	0.0	0.0	0.0	9.1	45.5	45.5	4.36	28
H&S management system (H&SMS)	0.0	0.0	0.0	18.2	27.3	54.5	4.36	29
Project H&S specifications	0.0	0.0	0.0	18.2	27.3	54.5	4.36	30
Project quality plans	0.0	0.0	0.0	18.2	27.3	54.5	4.36	31
Optimum status for H&S (= or more important than cost, quality, and time)	0.0	0.0	0.0	18.2	27.3	54.5	4.36	32
General management function	0.0	0.0	0.0	18.2	27.3	54.5	4.36	33
Quality management system (QMS)	0.0	0.0	0.0	18.2	36.4	45.5	4.27	34
The belief 'Accidents are failures of management'	0.0	0.0	0.0	18.2	36.4	45.5	4.27	35
Public relations function	0.0	0.0	0.0	18.2	36.4	45.5	4.27	36
Safe work procedures	0.0	0.0	0.0	18.2	36.4	45.5	4.27	37
H&S inspections	0.0	0.0	0.0	18.2	36.4	45.5	4.27	38
Procurement function	0.0	0.0	9.1	0.0	45.5	45.5	4.27	39
Project risk plans	0.0	0.0	0.0	18.2	45.5	36.4	4.18	40
Project close out reports that address H&S	0.0	0.0	0.0	18.2	45.5	36.4	4.18	41
Project environmental plans	0.0	0.0	0.0	27.3	27.3	45.5	4.18	42
Conditions of contract that include H&S	0.0	0.0	0.0	27.3	27.3	45.5	4.18	43
H&S method statements	0.0	0.0	0.0	27.3	27.3	45.5	4.18	44
Risk management system (RMS)	0.0	0.0	0.0	27.3	36.4	36.4	4.09	45
H&S meetings	0.0	0.0	0.0	27.3	36.4	36.4	4.09	46
Financial function	0.0	0.0	9.1	9.1	45.5	36.4	4.09	47
Human resources function	0.0	0.0	9.1	9.1	45.5	36.4	4.09	48
H&S policy	0.0	0.0	9.1	18.2	27.3	45.5	4.09	49
Zero H&S targets	0.0	9.1	0.0	18.2	18.2	54.5	4.09	50
H&S measurement	0.0	0.0	0.0	27.3	45.5	27.3	4.00	51
Environmental management system (EMS)	0.0	0.0	0.0	36.4	27.3	36.4	4.00	52
Tertiary education (all built environment) that includes construction H&S	0.0	0.0	9.1	27.3	18.2	45.5	4.00	53
Administration and information technology function	0.0	0.0	9.1	27.3	27.3	36.4	3.91	54
Marketing function	0.0	0.0	9.1	36.4	9.1	45.5	3.91	55
Generic method statements	0.0	0.0	9.1	27.3	36.4	27.3	3.82	56
Supply chain management	9.1	9.1	0.0	18.2	18.2	45.5	3.64	57
Procurement	9.1	0.0	9.1	27.3	18.2	36.4	3.55	58

Anglo American plc (2014), the giant South African mining group, includes H&S as one of four 'pillars of value'. Given Anglo American plc's improvement in H&S performance over a period of years, it was deemed appropriate to interrogate the GC's current H&S status using Anglo American plc's H&S journey model as depicted in Figure 1 below. 77.8% of respondents indicated 'proactive', and based upon the percentage responses to the five-point scale, the resultant MS of 3.67 is $> 3.40 \leq 4.20$, which indicates the status is between compliant to proactive / proactive.

Basic	Reactive	Compliant	Proactive	Resilient
Little interest in H&S – doing the minimum to get by. Exposed to significant H&S issues	Aware that H&S is an issue, but usually responding to issues. Systems are forming, but immature	H&S is a core part of doing business. Focus is on compliance with systems and processes	Starting to get ahead of the game – anticipating and preventing H&S issues	World class H&S performance – creating a process of continuous improvement / innovation
0.0%	11.1%	11.1%	77.8%	0.0%

Figure 1: Respondents' perceived rating of the GC's current H&S status

CONCLUSIONS

The importance of H&S with respect to various aspects related to the organisation and projects, leads to the conclusion that H&S is not solely an operational issue as H&S performance impacts on, inter alia: client, project manager, owner / shareholder, and designer satisfaction; attractiveness to clients; organisation image; organisation reputation; managing the business of construction; sustainability of the organisation; operational interventions; profitability of projects; profitability of the organisation; marketing of the organisation; attracting clients; corporate social responsibility; external public relations; organisation strategy, and organisation tactics.

The importance of aspects with respect to managing construction H&S further indicates the 'holistic role of H&S in construction', or rather the importance of managing H&S at the business, as opposed to solely at the operational level - middle management; top management; management involvement; management participation; management commitment; a vision of a 'fatality, injury, and disease-free work place'; the belief 'people are our most important resource'; H&S culture; H&S is a strategic business issue; legal function; financial provision for H&S; procurement function; public relations function; human resources function; financial function; administration and information technology function; marketing function, and procurement.

RECOMMENDATIONS

It is recommended that GCs view H&S as a strategic business issue, and integrate H&S into every function of the organisation. H&S should be afforded status at least equal to that afforded the traditional project parameters such as cost, quality, and time. Following this, all levels of management should be held accountable for H&S, which includes being measured relative to their H&S responsibilities. Given the importance of H&S with respect to the business of construction and projects, H&S should be the first item on the agenda of all meetings, and included in organisation reports such as CSR, annual, and project 'close-out'. The COA and the cost of prevention should be determined for all projects. With respect to H&S measurement, the focus should be on upstream as opposed to downstream measurement. This will complement management commitment, and enable a proactive review of the resourcing of H&S.

A multi-faceted approach based upon the holistic role of H&S with respect to overall

performance and the reasons for addressing it, should be adopted when promoting H&S. This applies to the DoL Inspectorate, employer associations, employee associations, construction managers, and H&S practitioners and consultants. Obviously, legislation should be cited and referred to when promoting H&S, however, the moral rationale for addressing H&S should feature prominently in tandem with the upholding of reputation and image, and consequent marketing benefits. Then, the synergistic benefits of H&S should always be cited.

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ASSESSING LANGUAGE COMPETENCY: CASE STUDY FROM A MAJOR INFRASTRUCTURE PROJECT

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Research shows the importance of effective communication in improving occupational safety and health (OSH). Workers whose first language is not English, along with traditionally low literacy levels in construction, increases the challenges for effective communication. Accident causality is complex, but there are many claims of links between poor communication or lack of understanding and accidents or incidents. To date, other projects have tried to address the communication challenge, for example through pictures, buddying or interpreters. Tideway, the client of a major infrastructure project in London UK, decided that a basic level of English was required to work on the project. Loughborough and Glasgow Caledonian Universities developed an OSH tutorial and assessment of English, in the Tideway context. This paper briefly presents the problems with using traditional interventions to address language difficulties. It describes the development of the Tideway Health, Safety and Wellbeing (HSW) communications tutorial and the research work that reviewed the practice and began to evaluate its effectiveness. This study of the communications intervention is part of a seven-year longitudinal study of how OSH management strategy becomes practice in the field on a mega project, funded by the Institution of Occupational Safety and Health (IOSH) and Tideway.

Keywords: Communication, Training, Assessment, Migrant workers.

INTRODUCTION

This paper forms one of the outputs from IOSH-funded research on London's Tideway project and forms part of their legacy to London and the broader society, including the construction industry. Tideway is a major tunnelling project, constructing 24km of tunnel following the line of the River Thames in central London. The primary purpose of the project is to reduce sewage overflows into the River Thames, delivering the core benefit of improved water quality. Tideway decided that a basic level of English for Health, Safety and Wellbeing (HSW) purposes was required to work on the project.

The descriptive case-study paper explains the development of the Tideway HSW communications tutorial developed by the authors and the research work that reviewed the practice and evaluated its effectiveness. More information on this intervention, focussed on an industry audience, is available (Gibb et al., 2017; Anon, 2017).

CONTEXT

Brace et al. (2009) investigated the causes of fatal accidents involving foreign and migrant workers in the UK. Of the 25 migrant fatalities in that study, 16 were identified as meeting

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vulnerable status. The investigation concluded that in seven cases language skill was a contributory factor. Of the nine migrant workers judged not to be vulnerable, only five were assessed as having good or fluent English (Walters and Bolt, 2009).

Many others have also identified language as a key contributory factor to vulnerability in the workplace, as well as to ineffective integration. Boden and Rees (2009) conducted an extensive literature review on migrant workers risk of workplace injury and found that the language barrier was a significant risk to migrant workers, particularly when new to their environment. Bust et al. (2008) found that foreign operatives were often grouped together based on language, and that in one case mixing with the indigenous workforce led to friction. Anecdotal evidence suggests that migrant workers are at greater risk of workplace injury and illness due to language barriers, as well as the temporary nature of their employment, poor work conditions, working longer hours, and cultural background (Boden and Rees, 2009). Many trade unions also believe this to be the case (Trade Union Congress, 2007). Despite the axiomatic view, there is no statistical evidence to suggest that migrant workers are at increased risk, although it is known that they often find employment in high risk industries.

With such a diverse range of workers found in the construction industry, there is likewise a requirement for several diverse types of communication strategies. Translated documents, interpreters, English language classes, and visual signage have all been employed by those responsible for safety on site. Translated documents and interpreters, whether internal or external, suffer from problems of accuracy. Translated documents, on the surface, may appear to be the ideal solution; however, information is often inaccurate, out of context, or too literally translated (Lewsley, 2010). Similar difficulties arise when using interpreters. This method suffers from drawbacks such as omission, error, delay, filtering, and approximation; all of which present obstacles to successful and complete transfer of information. Experiments conducted in the task of interpreting concluded that anything from 15% (Gerver, 1976 cited in Banks, 1991) to 40% (Loosemore and Lee, 2002) of information could be completely lost. This level of omission could cause serious misinterpretation, which on a construction site could be hazardous. The general practice on site is that a bilingual site operative will be used as a translator. However, the nominated person is rarely given any direction or formal training, meaning that misinterpretation could still arise. Loosemore and Lee (2002), in their investigation of the management problems associated with a multicultural workforce, ascertained that using a bilingual translator could also create tensions in instances where the nominated person holds no authority within the group. Moreover, in order for this method to work in practice, operatives need to be grouped together in the same location based on language, which in turn generates issues associated with poor integration. Improving English proficiency through language lessons is encouraged by many, including the HSE (2011) in their advice for employers, and Sopp (2008) in his article outlining the risks and controls involved in managing a multilingual workforce. Despite the benefits, this is not often witnessed, particularly out with large companies, as it is costly, time consuming, and too general in nature. Even when offered, uptake is often low because of the commitment required outside of work (Mulholland, 2011).

Communication theory

Communication theory, generally, is framed around the basic sender-receiver model. However, just as there are many different definitions of communication, there are different models, as

expressed by Berlo (1960), “Theories differ partly in terminology, partly in the addition or subtraction of one or two elements, and partly in the point of view of the discipline from which they emerge”. Communication theory has shown a progressive change from linear process models (Shannon and Weaver, 1949) to circular feedback models (Schramm, 1973) and transaction models (Barnlund, 1962). Nevertheless, the basic philosophy remains: for communication to be successful, the intention of the sender and interpretation by the receiver must be comparable. This is important to appreciate as there are many participant variables, such as culture, experience, and language, which may limit the “common ground” on which to build successful communication, thus making day to day communication and site training difficult to manage. It is acknowledged that language and culture are closely linked (Lingard, 2013), however, cultural aspects were not specifically addressed in this intervention.

METHODOLOGY

The content of this paper has been taken from the emerging findings of longitudinal research on Tideway. This longitudinal methodology is explained in Fuller et al. (forthcoming). The challenges of setting up a longitudinal study were presented at the 2017 cib W099 conference in Cape Town and an associated journal paper (Fuller et al., 2017). This longitudinal perspective is providing rich pictures of interventions moving from strategy to practice and mutating over time, responding to happenings and changing circumstances.

The wider seven-year study is tracing key interventions from Tideway and their main works contractors (MWCs) over the duration of the project. Evaluating interventions is a recognised academic skill, particularly in health or social care (Glasgow et al., 2001). Hawe et al. (2009) argue the benefits of considering an intervention or series of interventions, in the context of an overall system. In this case, the overall system is Tideway’s transformational approach to HSW and their emphasis on the RightWay strategy: doing things the right way.

However, this paper focusses on an initial cross-sectional qualitative evaluation of the HSW communications assessment intervention, covering its early development and deployment.

FINDINGS

The intervention

The assumption was that better communication will improve HSW performance. Tideway wanted to move away from the standard practice in the industry with regard to English language challenges. They decided that a basic level of English was required to work on the project. The authors were commissioned to develop what is thought to be a world first: an OSH tutorial and assessment of English, covering tunnelling, building, marine and office health and safety. The CEFR¹ language standards that were chosen with a basic level for all employees and enhanced for supervisors, managers and technical staff.

The original tutorial focused on ‘reception’, was customised to suit different job roles and was only to be taken by people involved on site, because the approach used site-based scenarios that the individuals could relate to. The style was restricted to straight-forward, multiple choice, IT-based approach to suit the available platform.

All the questions had responses explaining why that particular aspect of communication was important, both for English and non-English native speakers. Previous research on migrant

¹ CEFR: *Common European Framework of Reference for Languages: Learning, Teaching, Assessment.*

workers found supervisors with strong regional accents posed a significant communication challenge (e.g. Gibb et al., 2007). Therefore, voice-overs in regional accents were incorporated into the test to reflect the challenges of a real-world environment.

Certain questions required an understanding of some technical terms, acronyms or typical UK site vocabulary, based on the argument that people need to understand key terms to be able to work safely. However, having run the assessment for several months, Tideway decided to simplify the tutorial, focussing more on assessment and having one set of 30 generic multi-choice questions suitable for everyone on the project, irrespective of their role. The questions requiring more technical vocabulary, acronyms and colloquial expressions were also removed. The recordings of the accent questions were made more understandable and responses were included in the overall score. Questions requiring some understanding of typical non-English phrases were replaced by scenarios using non-English speakers' accents to complement the regional accents questions.

This resulted in the following sections:

- Watch, listen and understand – *based on an introductory film*
- Read and understand – *based on text on the Tideway HSW mission statement*
- Observe and understand – *'don't walk by'*
- See and understand – *sign recognition*
- Listen and understand – *regional and non-English accents*

Tideway also trialled a graded response approach with those having between six and nine incorrect answers having a follow-up face-to-face interview to determine the appropriate response and also to evaluate interaction and production of language. This would provide a more effective management of the communications challenges faced.

Between October 2016 and April 2018 7526 people completed the Communications Assessment and 221 (~3%) failed.

Evaluation

A full evaluation has not been completed to date as this will form part of the longitudinal study. To date the authors have not been able to assess whether the tutorial has improved communication or whether such improvement would result in workers being less vulnerable. Notwithstanding, the authors were keen to disseminate lessons learned to date to the international research community.

There is no space in this paper to describe the detailed findings of the evaluation of feedback from attendees and members of the Tideway HSW team, who were not part of the initial briefing team for the assessment. Rather, a number of key aspects have been identified and are discussed as question prompts for those considering such an intervention in the future.

DISCUSSION

Is the intervention a tutorial to challenge and improve communication skills with an attached assessment, or is it a language competence test?

Pedagogically, there is a significant difference between a tutorial with formative feedback and an assessment with summative outcomes. The authors argue that a formative approach is more appropriate as then the tutorial can challenge the status quo and encourage people to think more broadly about, in this case, communication. Whereas, a summative assessment needs to be seen as fair and transparent. Including challenging questions that create difficulties for native English speakers are more likely to improve communication than straight-forward questions

that are only really challenging those for whom English is not their native language.

An example of this is the issue of regional accents. The assessment includes a section where the tutee listens to an instruction which is shouted in a strong regional accent. They then have to choose the appropriate response from a list of options. Initially the regional accents were almost indecipherable – this was because, when people are stressed or panicking, they tend to shout louder but often with a stronger accent. This exercise was trying to challenge English speakers with strong regional accents themselves to realise that other people might have difficulties in understanding them. However, in the end, these had to be toned down due to the test not appearing to be ‘fair’. Another approach was to record similar phrases but using non-UK accents, with the same end-goal, to emphasise that someone’s accent was an important part of them being understood.

A third question type in this area was to record a number of words such as ‘duck!’ ‘watch out!’ in non-English languages that may be encountered on the project. The purpose here was to encourage UK supervisors to learn at least some key words from their workers’ languages as, under pressure, people tend to shout in their native language.

Are employers and stakeholders comfortable with the potential equal opportunities challenge regarding language competence?

The employment context in the UK is very much one of equal opportunities. Furthermore, with the UK still currently inside the European Union, there are laws to prevent hindering freedom of movement across the EU, which include the right to employment in any EU country. Whether it is actually the case or not, many employers in sectors like construction have shied away from requiring a particular level of English language ability for prospective employees. In the past this has meant that other major projects have relied on other methods of addressing the risks associated with poor language skills, such as using translators, buddying with English speakers, pictorial signs and instructions and so forth. The issue of equal opportunities was raised in the early discussions with Tideway but, having consulted their lawyers, they argued that their requirement to have at least a basic level of English was a health and safety matter and so they continued with the development of the assessment.

Does everyone have to take the assessment, e.g. English / non-English, site-based / office-based / short-term / visitors, and how can it be made relevant to such a large range of competence levels and roles?

The mandatory nature and reach of the assessment was a high priority for Tideway, in a similar way to everyone being required to do a one-day actor-led induction. This ensured that everyone was being treated the same but it also created very significant challenges for the setting of appropriate questions, especially as they were used as a summative assessment tool enabling access to the project. The authors’ opinion is that this requirement has significantly affected the effectiveness of the intervention. Just taking the native language issue against the requirement to assess the frontline workers against the basic CEFR language level means that the language and sentence structure has to be much simpler than would be the case for an assessment of people who were native speakers.

Whether to have one set of questions generic enough to be understood by all, or to customise questions to suit different job roles?

However, a greater challenge was the different roles that individuals were employed to fulfil. Language comprehension needs to be context relevant and therefore one could expect and require understanding of certain key terms or phrases that would be commonly in use for a particular job type. The reality is that not everyone who works in construction can easily

understand words and phrases that are commonly used. A UK construction example might be checking to see if a worker could understand the sentence: “Go ask the chippy¹ where he has put the keys to the MEWP²” or “Make sure the sparks³ don’t mess with the acrows⁴”. However, when these types of sentences were presented to native English-speaking office workers they did not understand them – which is not surprising.

By requiring the use of the same generic question set across all job contexts meant that important, safety critical terminology could not be adequately assessed.

Furthermore, the authors consider that effective verbal communication is of crucial importance for the health and safety of workers in a site context. If they are asked to make sure that they use a MEWP for that task but they don’t know what a MEWP is, they may also not feel brave enough to admit that they don’t know and hence try to work at height in a less safe manner. However, office workers are likely to be less at risk if they don’t understand such technical or colloquial terms which may also be used less frequently in an office environment anyway.

Is there a required vocabulary of key terms?

Following on from the previous point, the authors have developed a lexicon of key words and phrases for different types of construction contexts. This consists of nearly 400 words and phrases and, in itself, constitutes an invaluable database for future research.

What is the pass mark and what will happen to those who do not pass?

The pass mark for any assessment is a nebulous concept. Most UK universities stipulate that to gain credit in a degree exam, the student must score at least 40% - but why shouldn’t that be 50% or 90%. Would a patient feel confident awaiting an operation knowing that the surgeon only got 41% in her undergraduate degree? In dealing with a new type of assessment, the pass mark is initially somewhat arbitrary. Depending on the context, it may be considered unfair to ‘fail’ people who actually have more than adequate language skills but maybe panic when faced with a screen-based test. However, it is certainly undesirable to pass people whose language skills really are not sufficient.

The proposal here was to have a number of bands of marks (Table 1) facilitating a graduated response. However, for the initial assessment a straight forward pass-fail mark was chosen.

Those who did not pass were not permitted to work on the project. However, as most workers were already employed by contractors or sub-contractors, this did not mean that they lost their jobs, but often they were moved to a different project site.

¹ *Chippy* – Colloquial name for a carpenter/joiner

² *MEWP* – Mobile Elevated Work Platform, colloquially called a cherry-picker or scissor-lift

³ *Sparks (or Sparky)* – Colloquial name for an electrician

⁴ *Acrow* – Ubiquitous trade name of an adjustable steel prop for falsework or trench propping

Table 1: Proposed pass mark bands (assuming 30 questions)

	No. correct	%	Boundary	Response
A	29	96.7%	90-100%	Excellent result – well done
	...down to...			Very good result – well done
B	27	90.0%	83-89%	Good overall result, but advised to work to continue to improve HSW communication skills
	26	86.7%		
C	25	83.3%	67-82%	Individual needs to work on their HSW communication skills – Employer should be asked to propose risk mitigation actions to address the communication challenges
	24	80.0%		
D	21	70.0%	<67%	Worker’s HSSE communication skills are currently not good enough – employer to review, agree extra language & orientation training – re-test allowed after a defined period.
D	20 or less	66.7%	<67%	

‘Reception’ (i.e. comprehension) can be assessed with a computer-based test, but interaction and production require more of a face-to-face engagement.

One of the further proposals was to have a follow-up evaluation to cover this, basically by arranging a face to face discussion with a suitably trained individual who would be able to assess the individual’s language production and interaction skills. The plan was to use this additional step for those who scored in the ‘C’ category (Table 1).

How to make sure the exercise does not feel just like a repeat of the safety passport test.

In many countries around the world, construction workers are required to ‘demonstrate competence’ by obtaining a work ‘passport’ – often this is based largely or wholly on health and safety but may also include trade-specific skills. In the UK a common scheme is CSCS (Construction Skills Certification Scheme). Because workers will have previously taken the tests to get their CSCS card, Tideway were keen that the HSW Comms assessment did not ‘feel’ like a repeat of the CSCS test as this tutorial is focussing on the understanding of key words and phrases rather than specific HSW knowledge or competence. Therefore, the challenge is to devise a test for basic ‘comprehension’ rather than extensive technical ‘knowledge’.

CONCLUSIONS

Communication plays an important role in creating a safe and healthy construction site. Workers whose native language is different to the main project language is a reality across the globe. This factor increases the risk of accidents and triggers for ill-health conditions. Employers and project managers have employed many different methods to address the challenge of language skills. Driven by a desire to stimulate transformational safety and health, Tideway has chosen to set a level of English language understanding and competence such that they have developed an assessment intervention seeking to test all personnel before they start working on the project. As with any innovation, there have been teething problems, but the intervention has certainly raised the profile of communication across Tideway and the problems are now being addressed.

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COUNTRY CONTEXT-BASED OPPORTUNITIES FOR IMPROVING HEALTH AND SAFETY

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Using Nigeria as a case study, this study examines the Social, Political, Economic, Cultural and Religious (SPECR) contexts of developing countries towards unearthing and discussing the opportunities for improving Health and Safety (H&S). Previous research demonstrates the imperativeness of understanding the SPECR contexts of developing countries and the implications of practices, policies and laws that are not underpinned or based on a good understanding of the contexts. However, this has received little attention and the contexts-based opportunities for improving H&S remain unexamined. Through a critical review of literature, it was found that the contexts-based opportunities for improving H&S centre around social media platforms, unexplored potentials and undeveloped fields, the quest of Nigerians to embrace change, religion which teaches morals, community leadership where the leaders are able to command respect, the collectivist cultural dimension which emphasises affection, kinship and power relationship. While issues such as the sensitive nature of religion pose challenges, the study highlights SPECR characteristics, such as the collectivist cultural dimension, that policymakers and contractors should consider in developing policies and strategies towards improving H&S. Nevertheless, as the study is a theoretical piece of work, further empirical evidence on the subject is recommended.

Keywords: Culture, Developing countries, Health and Safety, Political, Social media.

INTRODUCTION

Many developing countries such as Nigeria adopt policies, standards, and methodologies from developed countries and this is profound in Health and Safety (H&S). For example, in Nigeria most of the H&S regulations or Acts originated from Britain or America (Idoro, 2011). The current Factories Act of 2004 has been adopted from the UK Factories Act of 1961 (Idoro, 2011). Nigerian contractors adopt and implement H&S regulations from Britain, for example, the Management of Health and Safety at Work Regulations 1999 and the Construction Design and Management (CDM) Regulations 2007 or 2015 (Idoro, 2011; Umeokafor, 2017).

In adopting and implementing these policies, standards and methodologies, little attention in terms of H&S, is paid to the contextual environments of the countries where they are implemented (Kheni et al., 2010; Umeokafor and Windapo, 2016). By implication, they are

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developed in the contexts of the countries of origin. Consequently, in Nigeria, just like many developing countries, some adopted H&S policies and regulations are irrelevant and impracticable (Aniekwu, 2007), unenforceable by the H&S regulator, and compliance is at the discretion of the adopters (Idoro, 2011). One example of adopted but impracticable regulatory requirements is the client's duties in the CDM Regulations 2015 where, among many, the client 'must provide pre-construction information as soon as is practicable to every designer and contractor appointed, or being considered for appointment, to the project'. In countries where such regulations are unenforceable, clients are not obliged to comply. Hence, when designers and contractors engage in H&S, they are likely to lack adequate pre-construction information. This is where the H&S record of the Nigerian construction industry is very poor (Agbede et al., 2016; Windapo and Jegede, 2013). In particular, although Agbede et al. (2016) report on South West of Nigeria including Lagos state, only 15% of their 115 respondents claim that safety training has been provided to their managers/supervisors and only 13% review and update risk assessment. While Lagos state is noted as 'the major hub of construction activities in Nigeria' (Babatunde et al., 2010: 3), the finding is indicative at best and a little representation of reality at worst. Analogously, the findings of an older study, Idoro (2011: 168), indicate that in 2006, the best accident per worker rate was 2 accidents per 100 workers and the best 'injury per worker rate for that year was 5 injuries per 100 workers'.

According to authors (Kheni et al., 2010; Umeokafor, 2015), the solution to the H&S issues in developing countries lies in understanding and integrating the contexts of developing countries in H&S matters. This includes the structure, challenges and opportunities there in.

Integrating the social, political, economic, cultural and religious (SPECR) contexts in H&S has received little attention. For example, Umeokafor (2015) assesses the contextual influence on H&S practices, while Umeokafor and Windapo (2016) developed a tool, which integrates the management of contextual factors into H&S management in project life cycle. Furber et al. (2012) examine the socio-cultural motivators of community members to engage in hazardous construction activities. Other studies include Kheni (2008) and Kheni et al. (2010). However, the SPECR contexts-based opportunities for improving H&S remains unexamined.

In addressing the gap in knowledge, using Nigeria as a case study, the current study critically examines the SPECR contexts of a developing country towards unearthing, critically analysing and discussing the opportunities for improving H&S. This will offer optimism and encourage efforts at improving H&S, advance the understanding of the SPECR contexts of Nigeria including the potentials therein and its contributions to H&S, and draw attention to overlooked characteristics of the SPECR contexts of Nigeria. Academics, contractors, policymakers and community leaders with interest in H&S are likely to find it beneficial. For internal validity purposes, the current study is based on the SPECR context and Nigeria.

NIGERIA IN CONTEXT

Nigeria is on the western coast of Africa with a landmass of about 923, 768 sq. KM, six geopolitical zones (GZs)—North West, North East, North Central, South East, South South, and South West—; a population of about 190 million and about 500 ethnic groups. The main ethnic groups are Hausa (25.1%), Fulani (3.9%), Yoruba (21%), Igbo (18%), Ijaw (10%), Kanuri (4%), Ibibio (3.5%), Tiv (2.5%), and other groups are 12% (Worldatlas 2018). While the official language is English and Pidgin English is very common and widely spoken, there

are multiple languages, but Hausa, Igbo and Yoruba are the main ones. While the exact distribution of religion is uncertain, according to Pew Forum (2010), as at 2009, of the population, 52% are Muslims, 46% are Christians, and the remaining 2% belong to other religions or none. This diversity explains the multiple cultures, beliefs, perceptions, attitudes and interests. Since 1999, Nigeria has enjoyed democracy, after a few failed attempts.

H&S in Nigeria is emerging; the oil and gas industry remains ahead of other industries in health, safety and environment (cf. Windapo and Jegede, 2013). The Federal Ministry of Labour and Employment Inspectorate Division (FMLEID) oversees (including enforcing) the current H&S laws—the Factories Act 2004. They have offices in all the states of Nigeria and the Factory inspectors enforce the law (see Umeokafor 2017 for details). However, according to Dabup (2012) and Idoro (2011), Nigeria lacks adequate H&S laws and enforcement regime; the regulatory system is dysfunctional and fragmented—one of the key barriers to H&S. For instance, the Factories Act 2004 is riddled with limitations that include not covering the construction industry hence the adoption of regulations from other countries (Idoro, 2011; Umeokafor, 2017). A review of the Act shows that it does not cover all work activities such as Display Screen Equipment and has penalties as low as 1000 Naira (£2) for serious breaches such as non-reporting of accidents (Factories Act 2014: 51.4). This is a recipe for intentional breach of the Law, as the likelihood for prosecution or a fine is low. However, it is anticipated that the Labour, Safety, Health and Welfare Bill of 2012, which awaits the presidential assent, will address a lot of these limitations. The government pays little attention to H&S; the weak legal structure that is riddled with lengthy court cases hinders the little efforts of the FMLEID (Idubor and Osiamoje, 2013).

Conversely, there are efforts to improve H&S in Nigeria such as the voluntary adoption of H&S regulations from other countries by contractors (Idoro, 2011), the contribution of social actors, the growing literature on H&S, and the recently formed informal Nigerian branches of Institution of Occupational Safety and Health (IOSH).

METHODOLOGY

The research adopted a critical systematic review of academic literature to explore the SPECR contexts-based opportunities for improving H&S in Nigeria. The literature search of keywords relevant on databases, EBSCOHost and Emeralds, showed 1760 papers of which many appeared more than once. The keywords are not limited to: ‘context’ and ‘health and safety’ and ‘Nigeria’; ‘Economic’, AND ‘health and safety’ AND Nigeria’; ‘Culture’, AND ‘health and safety’ AND Nigeria’; ‘Political’ OR ‘politics’ AND ‘Nigeria’; Religion’ AND ‘Nigeria’. Then, CIB W099 proceedings from 2010–2017 were also searched, producing two papers. In both cases, the titles and where possible the keywords were scrutinized for relevant papers. This produced 38 papers that the abstracts and conclusions were further scrutinised and five were selected. This was complemented with the citation approach—searching the reference lists of papers and books relevant to the topic for ‘leads’ to articles that can be used (Umeokafor *et al.*, 2014). This then added additional nine papers, hence a total of 14 academic papers informed the review. Then, Websites and government reports were also reviewed.

FINDINGS, ANALYSIS AND DISCUSSION

Cultural context

This is the situation in the country that relates to the people's way of life (Kheni, 2008). Although diversity is emphasised in Nigeria, it is of the collectivism national culture dimension (Hofstede, 2001). In a study of 72 countries, Hofstede (2001) found that West African (WA) countries including Nigeria have a low individualism index as against Western countries where it is high. The WA countries are also feminine societies hence characterised by affection—concern about the needs and interests of others (Darwish and Huber, 2003 Hofstede, 2001). The collectivism cultural dimension is characterised by the closer tie (Hofstede, 2014) and loyalty to the group, where group interest is prioritised over individual interests (Darwish and Huber, 2003; cf. Furber et al., 2012). The extended family style is an indispensable aspect of the culture (see Kheni 2008). The elders in the extended families are well respected in communities and help instill values and norms in younger people.

Consequently, the communities work with local councils or relevant authorities to set up laws (Nkonya et al., 2005). Evidence in Nkonya et al. (2005) shows that the level of compliance with such laws is higher. Also, collectivist views, including family values, have been found to determine contractors' engagement in H&S management in Ghana (Kheni, 2008; Kheni et al., 2010). Umeokafor (2015) postulates the same for H&S Nigeria but opines that some beliefs of Nigerians impact on the ability of the collectivism culture dimension to optimally drive H&S. Additionally, communal culture and local traditional laws have also been found to coerce poor safety practices in construction in Ghana (Furber et al., 2012). By implication, while the collectivism national cultural dimension of Nigeria is an opportunity for improving H&S, it requires the support of other factors including the opportunities covered in this study. Meanwhile, Dabup (2012) indicates the involvement of communities in Health, Safety and Environment in Nigeria, for example in the Niger Delta.

Furthermore, African cultures and traditions preach morals (Kheni, 2008), one of the principles of H&S; this presents opportunities for academics and community leaders to exploit if interested in H&S in terms of instilling values in students or younger people.

Social Context

This relates to the 'society and living together in an organised way' (Cambridge Dictionary, 2018). The media, including social media, in Nigeria is lively and with significant contributions to Africa (Uanikhehi, 2017; Uzuegbunam, 2015). Each of the 36 states runs at least a TV and radio station. Access to international TV stations is now commonplace. Nigerians are well informed and active on the use of social media (Uzuegbunam, 2015) hence have a significant level of access to the Internet. Uanikhehi (2017) shows that there are 22 million monthly users of Facebook and 10 million log in daily on a mobile device.

Social media has become a very powerful tool for driving changes, discussions, election campaign platforms, and serves as a voice for the masses irrespective of social class (Uzuegbunam, 2015). Uzuegbunam (2015) offers a treatise on this subject providing examples which include how Nigerian youths have used social media to initiate the call for a reduction in the pump price of petrol. A similar event is 'a call to abolish Special Anti Robbery Squad'. As a result, Umeokafor (2017) recommends the use of social media as a means of gathering

and passing H&S information in Nigeria, hence an opportunity. Also, the media present opportunities, but the onus is on the Nigerian youths to drive their involvement.

The private contribution of individuals (such as qualified workers and managers, who received proper H&S education) and communities to H&S in the midst of the lack of governmental attention is also an opportunity. The voluntary adoption of H&S regulations by contractors (Idoro, 2011) and the informal IOSH branch noted elsewhere in this paper are also examples. These show the unexplored potentials, undeveloped fields and the quest to embrace change. It also calls for state-supported policies and suggests the possibility of the general acceptance of state-supported H&S improvement measures if introduced.

Political context

This is the situation within which the ‘activities of the government, members of law-making organisations or people who try to influence how a country is governed’ exists (Cambridge Dictionary, 2018). Nigeria is a federal state with three branches of government, executive, legislative and judicial arms; it operates a democratic system. Like most African countries, it is ‘experiencing leadership crisis at both national and organisational level’ and political level (Dabup, 2012: 79). Authors demonstrate that politicians or people in the higher echelon of power lack accountability and transparency; the government is corrupt; the leaders have failed to effectively guide the countries to economic and industrial growth (Angaye and Gwilliam, 2008; Dabup, 2012). According to Dabup (2012), the political system, government policies and attitudes influence decisions making and strategies in organisations, including H&S.

In the midst of all in the preceding paragraph, power relationship which is a challenge to H&S in Nigeria (Okojie, 2010) has been found to drive H&S, in other context hence an opportunity (Umeokafor, 2017). Power relationship in this context is the ability of people to control or influence others. Many companies are owned by the people in the high echelon of the society (Okojie, 2010) hence resist any opposition in the country including the enforcement of H&S; however, some of them drive H&S to protect their status in the society (Umeokafor, 2015), but the impact is likely to vary (cf. Angaye and Gwilliam, 2008). The social and cultural status of people determine how they are treated in the society and the level of respect (Kheni, 2008).

Understandably, while the democratic process needs improvement, the ability of politicians and policymakers to introduce and pass bills towards reforms in Nigeria and create committees that oversee and control various matters remains an opportunity to improve H&S. It can be argued that if this is the case, then why is the Labour, Safety, Health and Welfare Bill of 2012 still awaiting the presidential assent as at 2018? Possible answers include the lack of enforcement and implementation culture (Umeokafor, 2017), corruption, lack of political ‘will’ and safety culture (Idubor and Osiamoje, 2013). The point here is that with the current democratic regime and process, H&S has more opportunities than in the military regimes. The influence of the international community, including transferring better H&S cultures, advising, encouraging or coercing Nigeria to improve H&S standards and practices, is likely to be easier and more welcomed in a democratic setting.

Economic Context

This is conceptualised as the situation in a country that relate to money, trade, industry and profit making (Cambridge Dictionary, 2018). Although the recent fall in oil prices impacted on

the Nigerian economy in 2016, it remains the largest in Africa and the 27th in the world (Nordeatrade, 2017). The GDP contracted 1.58% in 2016, the worst in the past 2 decades (Nigerian National Bureau of Statistics (NNBS), 2018; Nordeatrade, 2017). However, according to NNBS (2018), in 2017, the GDP recorded an annual growth of 0.83% higher by 2.42% than -1.58% in 2016. The construction sector contributed 3.77% in 2017 and 3.55% in 2016 and the telecommunication and communication sectors including music and movie industries contracted from 11.57% in 2016 to 11.35% in 2017.

The above shows the economic growth in Nigeria, but the state of H&S therein is evidence that the economy is yet to benefit from the H&S sector because it is unharnessed, a missed opportunity that is an additional source of revenue and contribution to the GDP. For example, if harnessed, the H&S sector will provide employment opportunities, result in the development of equipment, training and other services. In turn, this will generate revenue, increase productivity and save lives. A similar situation is recorded in the telecommunication and communication sectors including music and movie industries which until recently has not been covered by GDP reports, as its contribution was unrecognised. However, with the introduction of the Global System for Mobile communication and the governmental and private investors involvement in the music and movie industries, their products and services are exported and of international standards, providing a platform for integration with international experts. Currently, the contribution of the industry to the GDP is significant.

Religious context

Sulaiman (2016) argues that while there is no universally accepted definition for religion, it means a link or relationship between man and a greater being. Religion does not support wastage including damage to plant and equipment and injuries to persons (Smallwood, 2002). Eckhardt (2001) discusses moral reasons for H&S including quoting a passage in the Bible, Deuteronomy 22:8, which suggests or advises the provision of a safe building that considers all occupants. Nigeria is a highly religious nation (Pew Forum, 2010), and as morality is one of the principles of religion and determines behaviours (Smallwood, 2002), it is logical to conclude that religion presents opportunities for improving H&S. This includes involving religious leaders and incorporating religious arguments for H&S in relevant courses or modules. Pukenis (2014) reports similar steps where religious leaders have been invited to tackle social issues. Conversely, the sensitive nature of religion poses problems such as resistance from religious leaders (Sulaiman, 2016), but religious leaders have the moral obligation to support what will save lives—a possible argument to get them involved.

Table 1 presents the summary of the SPECR contexts-based opportunities for improving H&S. They also have implications for improving other project indicators such as time, cost, and user satisfaction, but the focus of this study is how they can improve H&S in developing countries. Some characteristics of the contexts interrelate to become relevant opportunities.

Table 1: Summary of social, political, economic, cultural and religious contexts-based opportunities for improving H&S. Source: Authors' elaboration

Contexts	SPECR Characteristics
Social	Freedom of speech and press. High level of access to the Internet. Ability of youths to initiate changes, discussion etc through Social media Social media, a platform for discussion and social mobilization. Private contributions of individuals, social actors, and communities. Unexplored potential and undeveloped field. The quest of Nigerians to embrace change.
Cultural	Leadership features and ability of community leaders to command respect Moral codes in cultures. Characteristics of the collectivism cultural dimension. Affection attributes of the feminine society.
Political	Ability of people to control or influence people in the society—Power relationship. The features of democracy, which has been absent during the military regimes. Points of attraction for the international community.
Economic	Potential of the large economy of Nigeria. Source of revenue through H&S. Source of employment, business. Possible reduction in antisocial behaviours and crime. Opportunities for exports. Potential for raising standards of services. Platform for integration with international counterparts.
Religion	Moral stance of religion. High level of religiousness of Nigerians.

CONCLUSIONS AND RECOMMENDATIONS

Using Nigeria as a case, the study identified and discussed social, political, economic, cultural and religious contexts-based opportunities for improving H&S. The systematic critical review of literature shows that there are voluntary contributions of social actors, professional institutions, communities, and contractors in driving H&S. While this calls for state-supported policies, it suggests the likelihood of its general acceptance if introduced. While the ability to control or influence people in the society—Power relationship—is a challenge to H&S, it is also an opportunity. The features of democracy which have been absent during the military regimes, the potentials of the large economy of Nigeria and the potential contributions H&S to the economy of Nigeria are also opportunities that policymakers, investors and even the government should consider. The social media, which has been an avenue for driving social change and a platform for discussing issues, also remains a key opportunity, which is supported by the quest of Nigerians to embrace change. While the above two points are systematically focussed but the latter point is also individual behaviour-focussed, some opportunities and recommendations can be mainly individually behaviour-focussed. For example, although religion is sensitive, as Nigerians are highly religious and religion teaches morals, this is an opportunity that all, including academics, should explore. Indeed, religious principles could underpin H&S related lectures in schools; academics could include this in the curricula. Emphatically, the recommendations should not be misconstrued as oversimplifying complex phenomena. Importantly, some features of SPECR contexts are interrelated, complementing the features and abilities of each other to become opportunities. The identified opportunities

can also improve other project indicators such as cost and quality. The findings suggest various hypotheses of which one is that H&S policies and strategies would be practical and more acceptable in the society resulting in improved H&S if the opportunities in Table 1 are exploited in the development of H&S policies and strategies. Another hypothesis, H&S knowledge, attitude and culture would improve if religious and tradition-supported moral teachings are embedded in H&S courses/lessons. It is also possible to hypothesise that if social media platforms are used, governmental involvement in H&S is likely to increase. While the study is limited to the literature review and authors' views, a survey where, for example, these hypotheses are tested is recommended.

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SELF-REGULATION AMONGST SOUTH AFRICAN CONTRACTORS IN ACHIEVING LEGISLATIVE REQUIREMENTS ON OCCUPATIONAL HEALTH AND SAFETY

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The study examines how self-regulation helps construction contractors in South Africa to achieve legislative requirements relating to national and international standards of Occupational Health and Safety (OHS). Despite considerable studies on OHS, self-regulation and its impact on health and safety performance on construction projects are under-researched. In this paper, we report a critical review of literature on OHS in the South African construction industry. The review identifies the various forms of self-regulation practices within construction organisations in South Africa. A mixed method approach was used in determining the relationships between self-regulation of construction organisations in relation to OHS and health and safety performance of projects undertaken by the observed construction organisations. Findings suggest, although there is a high level of self-regulation amongst South African construction organisations, construction organizations are still poorly incentivised. The implication of this is significant, in that businesses loose motivation to succeed in a course unless they are incentivised appropriately. Recommendations are drawn on the forms of strategic incentives that are likely to work in South Africa and in other developing countries.

Keywords: Accidents, Construction OHS, Performance, Self-regulation, South Africa.

INTRODUCTION

In an attempt to prioritise Occupational Health and Safety (OHS) within the construction industry, health and safety has been the focal point of extensive research done in the construction over the years (Cooper, 2000). Nowadays, research into improved culture of construction OHS is emphasising the shift from prescriptive legislation to self-regulation (see Gunningham, 2011). This has come with some challenges. According to Umeokafor (2017), there is no single definition for self-regulation across industries and countries. Also, the various forms in which organizations self-regulate can be informal and soft, thereby their impacts on organizational culture and performance have been difficult to measure.

In the current study, self-regulation is defined as self-imposed standards, agreed within a cohort of practice community (Levinson, 1984; Dawson et al., 1988). Contextually, this refers to

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health and safety standards adopted by construction organisations in South Africa, as minimum reference for the purposes of process control, rather than by an external instrument such as legislations. The Occupational Health and Safety Act (OHSA) No. 85 of 1993 and the complementary Compensation for Occupational Injuries and Diseases Act No. 130 of 1993 (COID Act) are the policies used in regulating OH&S in the South African construction industry. Construction Regulations, a rule promulgated explicitly under the OHSA Act, focusses on OH&S.

Evidence by Lingard and Rowlinson (2005), South Africa's Construction Industry Development Board (cidb) (2009) and The Federated Employers' Mutual Assurance (FEMA) Statistics (2014) demonstrates OHS record of the construction industry is poor. In particular, Lingard and Rowlinson (2005) show that there are more deaths and injuries among construction workers annually than in most other industries. FEMA (2014) also shows just under 2800 accidents were recorded in the South African construction industry in 2014 alone. Proposals for improving levels of OHS during construction include designing to prevent hazards (see Lingard *et al.*, 2012), regulation of H&S (see Hutter, 2001) and organizational self-regulation (see Gunningham, 2011).

The South African construction industry has had considerable number of legislations and policy regulations regarding H&S issues. A key causation of poor OHS culture within the industry is a high level of non-compliance by contractors (Windapo, 2013). This is because contractors have often found legislation and policy interventions as exogenic and least motivating as profit margins are in persistent decline. Goetsch (2009) adds the impact of human element as another causation of OHS issues. Another dimension to this is the apparent lack of enforcement of safety regulations in practice (cidb, 2009). Each of these perspectives has had serious implications.

Gunningham (2011) and Scharrer (2011) elicit how self-regulation resulted in a reduction in construction accidents and fatalities in the United States and New Zealand respectively. However, Umeokafor (2017) found self-regulation to result in low standards of OH&S. The smaller the size of contractors' business, the more disadvantaged they are likely to be if self-regulatory effort is the main determinant of their business operations. Some holistic research had done reported in South Africa on construction health and safety (Geminiani *et al.*, 2008; Gunningham, 2011; Scharrer, 2011; Windapo and Jegede, 2013). Despite these, there is inadequate substance on self-regulation in relation to OH&S within the construction industry. Umeokafor's (2017) examination of the subject shows it is evident that approaches and frameworks to self-regulation in the unique South African construction industry has not been examined empirically. Hence, the main aim of this study is to examine the various characterizations of self-regulation and show how these helps to achieve compliance with legislative requirements of OHS, and improve safety outcomes of construction projects.

THE CONCEPT OF SELF-REGULATION AND OHS

Levels of Self-Regulation

Self-regulation is a spectrum. According to Sinclair (1997), there is pure self-regulation on one end and strict command-and-control system on the other end. The level of self-regulation or co-regulation (i.e. a combination of government regulation and self-regulation) at which an entity operates is somewhere within this spectrum. Rees (1988) adds the three main points

through which the level of an entity's commitment to self-regulation can be assessed. There is 'voluntary self-regulation' which involves making and enforcing rules within an organization or the industry with no external, and the 'mandated full self-regulation' where rulemaking and enforcement are privatised. One key difference between voluntary and mandated full self-regulation is that, though both are privatised, government formally sanctions the regulatory program in the latter and not in the former. The reason for this is to monitor the effectiveness of the planned regulatory program and modify it if required. The third level is the 'mandated partial self-regulation', in which only one regulatory function (i.e. either rulemaking or enforcement) is privatised. These two sub-categories are 'public enforcement of rules written privately' and 'internal enforcement of rules written privately as mandated or moderated by government' (Korosec, 1990).

Self-Regulation Practices

Levinson (1984) identifies self-regulation practices to include H&S Policy, H&S Plan, OHS Management System, H&S training and Personal Protective Equipment. The South African Labour Guide (SALG) (2015) describes health and safety policy as a written statement of the principles and goals representing an organisation's commitment in maintaining a safe and healthy workplace. A health and safety plan is a process for identifying to workers, setting steps to prevent or control them and reactions in their occurrence. An Occupational Health and Safety Management System (OHSMS) or OHS Programme is a part of an extensive organisational management system used to establish OHS policies of an organisation and to manage OHS risks (OHSAS 18001, 2007). According to Robson *et al.* (2012), OHS training is the planned efforts to facilitate the learning of competencies that are specific to OHS.

Overview of the OH&S Regulatory Framework in South Africa

OH&S in the South African construction industry is regulated by two legislative Acts. OHS Act No. 85 of 1993 provides for the protection from hazards and the health and safety of persons at work and, of persons other than persons at work. The Complementary Compensation for Occupational Injuries and Diseases Act No. 130 of 1993 (COID, Act) covers compensation for accident and diseases relating to health and safety. In addition to these, Construction Regulations (CR) of 2003, introduced due to the poor H&S statistics in the construction industry, is a component of the OHS Act. CR recognises and allocates specific responsibilities to construction stakeholders. For example, project owners reserves the duty to provide H&S Specifications and to ensure that the principal contractor make the right allowance for H&S. The OH&S Inspectorate of the Department of Labour (DoL) in South Africa is responsible for the enforcement of OHS Act. Nevertheless, evidence by cidb (2009) questions the frequency and efficacy of site visits and blitzes inspection by DoL. Co-regulation, which involves government and voluntary self-regulation by construction stakeholders, is the paramount practice in South Africa.

METHODOLOGY

A mixed methods research approach was used to collect data. Initially, a survey was undertaken to determine the level of self-regulation by construction contractors in South Africa as they strive to meet OHS' legislative requirements. Semi-structured interviews were used to triangulate the findings from the surveys. Findings from this analysis are presented graphically (Figure 2). Population sample includes all construction organisations (N=1234) listed in the

Professionals and Project Register (PPR) 2014. The research scope is limited to organisational levels of regulations, a requirement met by all the entities listed on the Professionals and Project Register. Probability sampling technique was used to select half of the entities on the sample frame to obtain a sample size of 617 construction organisations. A framework, shown in Figure 1, was developed to compute data relating to levels of self-regulation. The quantitative data had to be analysed such that a level of self-regulation for each respondent could be determined. As shown in the flow diagram (Figure 1), a particular sequence of processes was considered in determining levels of self-regulation by South African construction contractors towards meeting their considered OHS in-house objectives and meeting operational requirements mandated by government.

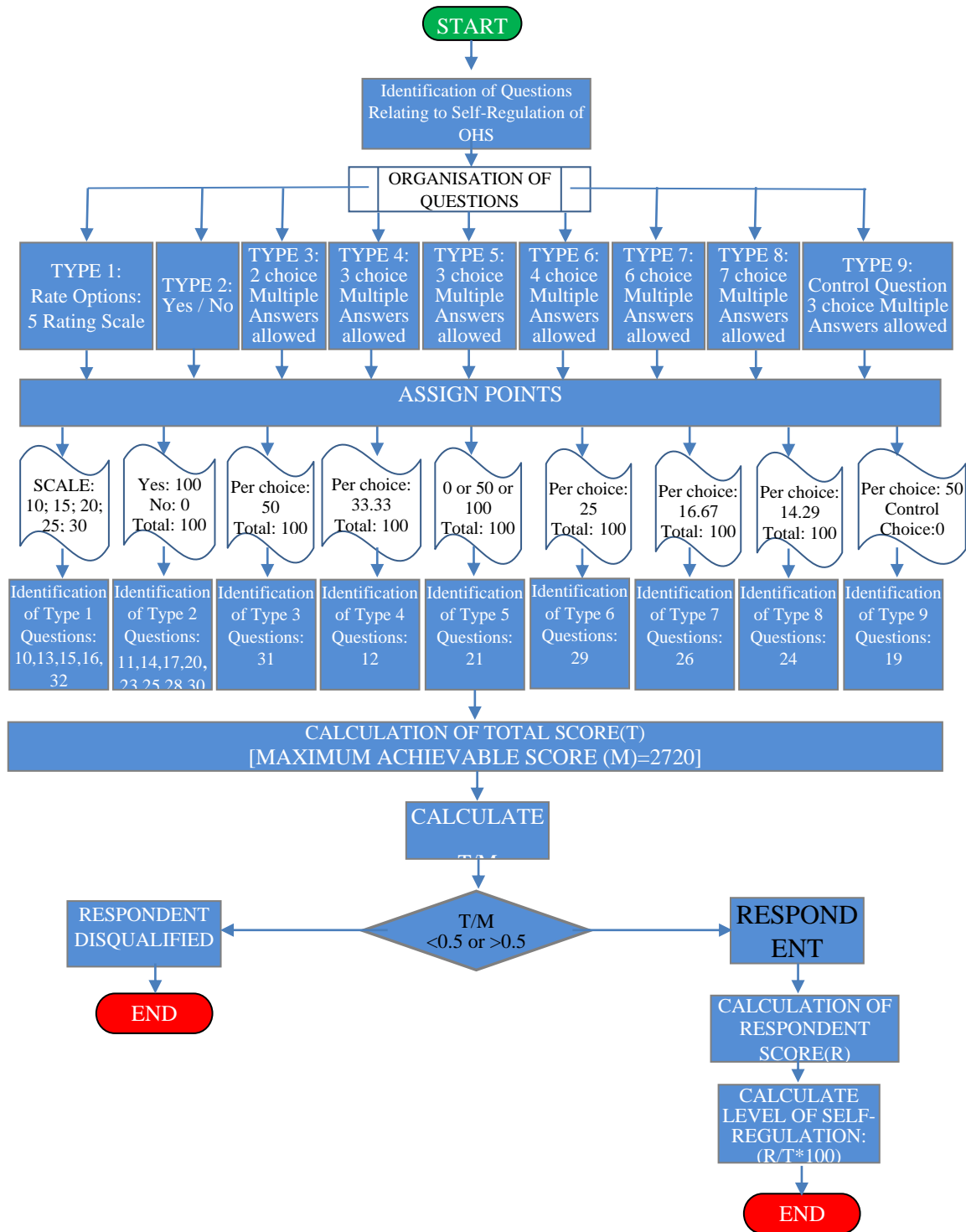


Figure 1: Self-regulation Framework

Figure 1 has four components. First, components of the data exploration instrument in relation to OHS self-regulation. The second component classifies the identified components (n=20) of OHS self-regulation into distinct types. Twenty questions that addressed self-regulation were used in the study for example – enquiry of the organisation’s commitment to creating and maintaining safe working conditions (Q10), established health and safety plan (Q11), safety awareness initiatives (Q16). The questions relate to the self-regulation practices identified by Levinson (1984), concerning H&S Policy, Plan, Management System, Training and PPE use.

The third component involves the assignment of weightings to the variables (the questions), whilst the fourth calculates total weighted score for each considered level of self-regulation. To preserve internal validity of the survey, experts were used to vet the questions objectively, paying attention to their relevance to the subject of self-regulation and their coverage of the entire topic. Also, a control question (Q19) was included, Although not related to self-regulation, the question was used to test the respondent's consistency in answering the questionnaire. To maintain external validity, the results of the research was compared to previous studies undertaken in other contexts and conditions.

Figure 1 also helped in identifying the questions attempted and/or skipped by each respondent. This helps to determine whether a response is valid or not. For each question attempted, the respondent is awarded one point, and zero for each question skipped. A total score (T) is then calculated for the respondent. The Maximum Achievable Score (M) possible is 2720 points. A respondent has a weighted score obtained by dividing T by M . A respondent is disqualified if the weighted score is less than 0.5 (i.e. only less than 50% of the survey items were completed). Respondent's Actual score (R) for each question is calculated and summed up and used in calculating the respondent's level of self-regulation ($R/T*100$).

DATA, FINDINGS AND DISCUSSION

The online survey gathered 59 responses, a response rate of 9.72%. A significant number of the respondents (89%) were from the Director Cadre or Management category hence from the company top echelons, 78% had over ten years of experience in the construction industry, at least 47% have a Bachelor's and higher level of academic qualification attained. These suggest that the respondents will provide valuable, relevant and meaningful information useful for this study. The respondents were working for contractors listed in Grades 4 to 9 of the cidb Register of Contractors in South Africa, a majority (19) of whom are Grade 7 contractors listed in the General Building and Civil Engineering categories.

Level of Self-Regulation

Figure 2 shows respondents and their corresponding level of self-regulation to OHS requirements, derived from the framework in Figure 1. 15 of the 59 responses were disqualified achieving a weighted score of less than 0.5. The mean level of self-regulation of 80.35% and a standard deviation of 7% were obtained. Respondents' level of self-regulation ranged from 65% to 97%. This suggests a very high level of self-regulation for the responding companies.

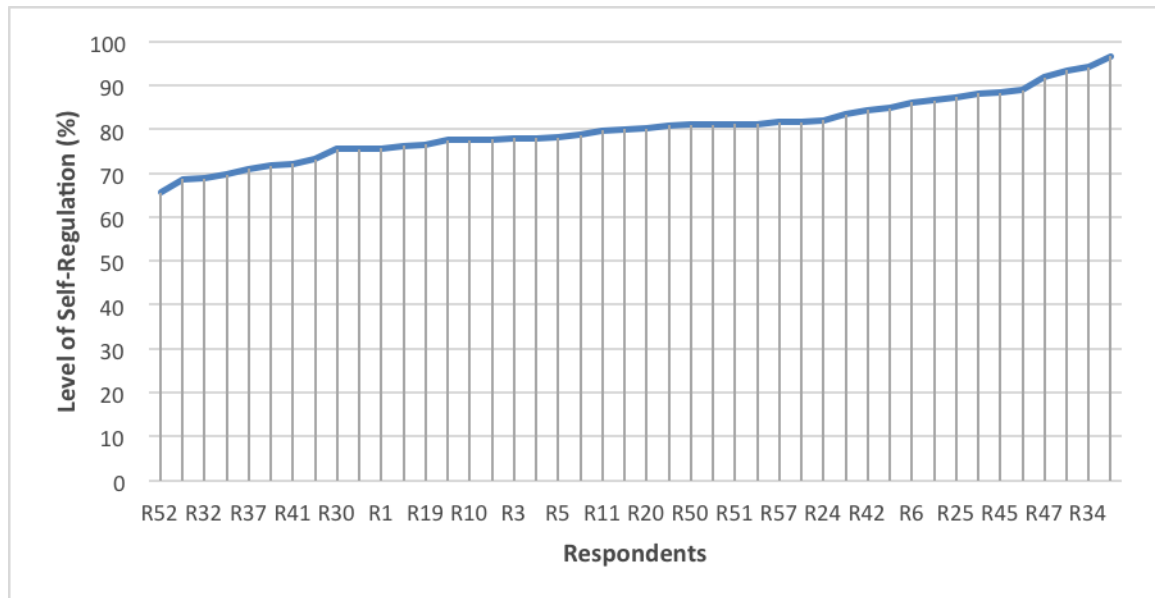


Figure 2: Level of Self-Regulation of the Respondents

Interview Results

Three semi-structured interviews were conducted with the aim of validating the results obtained through the questionnaire survey. The study sought to know the views of the respondents concerning the concept of self-regulation in South Africa, the level of adoption by construction organisations and whether self-regulation is practiced at individual or organisational levels. Interviewee 1 is a professional project manager who also doubles as the Head of OHS and tender management unit of a prominent construction firm in the Western Cape. They have had more than 20 years of experience. Interviewee 2 is a Health and Safety Site Officer. They work for a medium sized building construction firm based in Johannesburg, and have had more than five years of experience in the industry. Interviewee 3 is a Registered Quantity Surveyor and an Acting Chief Executive Officer of a construction firm that specialises in civil and mining works. Interviewee 3 has had more than 18 years of experience in managing various sizes of multi-disciplinary engineering projects from inception to client handover.

Interviewees 1 and 2 view self-regulation in an organisation as a “critical” aspect of OHS. Interviewee 1 does not believe that companies can self-regulate unless through dedicated training and there is a better appreciation of the purpose of OHS legislative requirements. Interviewee 2 added that the onus is on the contractor to ensure that workers adhere to health and safety procedures. Interviewee 3 thinks higher-grade contractors can better self-regulate as they have support resources that smaller organizations are unlikely to have e.g. establishing a H&S administrative unit, while smaller contractors may be unable to provide such. Likewise, Interviewee 2 contends that self-regulation will not eliminate Accidents Frequency Rates (AFR) absolutely; rather a leading factor that drives stakeholders towards good H&S practices. Interviewee 3 recommends outsourcing H&S to specialised organisations who are more knowledgeable about health and safety as a way of reducing accidents, injuries and fatalities on construction sites.

DISCUSSIONS

The findings of the study showed that there is a high level of voluntary self-regulation to OHS

requirements within contracting firms in South-Africa with a mean score of 80.36% and a standard deviation of 7.10%. The findings also validate self-regulation practices identified by Levinson (1984). While there is a paucity of quantitative studies on construction OH&S self-regulation, this finding is consistent with that of Umeokafor (2017) who examined, among many, the extent of various types of construction OH&S self-regulation in the Nigerian construction industry including pure, industry and enforced self-regulation. Umeokafor's study suggests pure self-regulation was mainly adopted in Nigeria followed by enforced self-regulation. Interviews in the current study indicate higher grade contractors self-regulate better than other forms of construction organizations. This finding is consistent with Umeokafor's study.

CONCLUSIONS

The research examined the level of self-regulation to OH&S requirements among contractors in South Africa. It emerged that the level of self-regulation to OH&S requirements by South African contractors is high. There is a paucity of data concerning the subject matter, specifically in South Africa. The progression of the conceptual framework and the issues highlighted in the literature review have framed a logical path from which future self-regulation tool will evolve. The study recommends that the government should encourage the use of voluntary self-regulation to augment the infrequent and ineffective enforcement regime and provide incentives such as preferential procurement for companies that self-regulate. It is also recommended that self-regulation should be used as a tool to rate contractors and that contractors should be mandated to advertise their self-regulation score alongside their cidb grade. Further research is recommended to investigate the relationship between the level of self-regulation to OH&S legislative requirements and the H&S performance/cidb grade of construction companies. Such study should test the hypothesis that there would be fewer accidents on construction sites in managed by contractors with high voluntary self-regulation to OHS legislative requirements compared to companies with lower levels of voluntary self-regulation. In addition, it is worth examining self-regulation in South Africa. The findings put forward in the current study can be streamlined and improved as a self-regulation measurement tool and validated in a comparative study. We acknowledge the limited sample of the qualitative aspect of the study as a limitation of the study, thus should be viewed as indicative.

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THE INTEGRATION OF SAFETY MANAGEMENT SYSTEM TO REDUCE ACCIDENTS ON CONSTRUCTION SITES

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In construction, safety management systems (SMS) are embedded in how the works are planned and executed. An SMS is integrated with the construction procedures because the industry is a complex system where the basis of a project (and system) failure can be traced to the varying influences of the organization, workers, and the environment. The problem that elaborates upon in this paper is the notion that tensions between methods and deployed SMS contribute to accidents on construction sites. The study adopted a case-based strategy for comprehending the various factors through qualitative and quantitative data. The approach aided the replication of questions with consistent intended meaning. The study reveals that the purpose of a valid SMS in construction is to help management to identify and reduce safety risk before construction work start. In contrast, poor SMS induces a human failure situation that is systemic. The systemic failure is linked to human contributions of site management in the organization and the workers involved in project realization. The central argument in the paper is that poor SMS on construction sites should not be blamed on construction workers alone.

Keywords: Accidents, Construction management, Safety management system, Workers.

INTRODUCTION

The nature of construction work has been categorized as unsafe, unhealthy and dangerous for the well-being of people working in construction (Sherratt and Sherratt, 2017). The construction industry remains one of the most dangerous sectors where the impact of manual (labour-intensive) work-related accidents, injuries, and fatalities is felt by the entire society (Awwad et al., 2016). As a case in point, Sherratt et al. (2013 citing HSE, 2012) explained the impact of accidents in the construction industry in the United Kingdom (UK) that recorded 28% of all fatal workplace accidents in the period 2011/12, making it to account for almost a third of all deaths at work. People at the front line of construction are always devastated by accidents because of its impact on their life and well-being (Emuze, 2017).

Accidents which are the outcome of a weak safety management system (SMS) lead to a substantial organizational, social, and environmental losses, which can be described as waste in the construction industry. Safety waste in construction is explained by Nahmens and Ikuma (2009). The authors, states that safety waste includes accidents, injuries, and fatalities, and should be addressed by the employer in the organization. The safety waste has a negative

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impact in the construction industry, concerning human life and money; relating to accident prevention, compensation, legal dispute, accident investigation and project period extension (Aslam et al., 2016).

The literature shows that most accidents experienced on a construction site are due to the problems that are not discovered in an SMS of a project. To overcome this problem, Benjaoran and Bhokha (2010) propose that SMS of a project should be integrated with the construction management (CM) procedure in the design and construction phase of a project. The reason why SMS should be integrated with the CM procedure is because the construction industry is a complex system and the basis of failure in a complex systems and processes of the project implementation can be traced to management and the organizational factors influencing the workers' attitudes, perceptions, decisions, and behaviours (Yorio and Wachter, 2014).

The influence of a poor SMS in the construction industry has remained roughly the same for decades (Okorie et al., 2016). The International Labour Organization (ILO) stated in 2016 that 317 million accidents occur worldwide on the job yearly (Porru et al., 2017). Accidents are the legacy of unsafe acts and conditions in construction (Smith et al., 2017). More so, accidents can be eliminated if people can perceive and understand the importance of safety practice on construction sites (Okorie et al., 2016). For example, safety is described as the state in which the possibility of harm or danger to people is eliminated and maintained through continues process of hazard identification and safety risk management (ICAO, 2013).

OVERVIEW OF SAFETY MANAGEMENT SYSTEM

SMS can be described as a set of channels or networks that promise the safe action through effective management of the safety risk in the workplaces (ICAO, 2013). To address the subject of SMS, construction organizations should understand safety regulations and their implementation requirements (HSE, 2012). An appropriate SMS would help the contractors to identify hazards and manage safety risks encountered during the construction of the project (ICAO, 2013). It is essential for management to be involved in the design of the safety planning and safety control processes of the project (Isaac and Edrei, 2016). The reason why management should be included in the design of safety planning is that the construction managers control the activities undertaken by workers that use various resources to produce the project (Bergin, 2013).

The safety planning processes initiated by management are pursued to eliminate possible hazards on construction site using the site layout planning and worker training (Isaac and Edrei, 2016). The idea of safety management lies with the construction managers and supervisors of a project. This statement is supported by Bergin (2013) who said that the development of a definite safety idea lies decisively in the hands of the construction managers and supervisors.

It is crucial for construction manager to record and report the safety practice on sites. The construction managers could make use of safety observation to understand the effect of safety practice on site (Smith et al., 2017). The reason why the safety observation program is preferred is that it does not only make adequate preparation for a pure statistic of directing safety performance, but tries to analyse the data or results by describing both the safe and unsafe acts and conditions that could lead to better observations. Knowledge and awareness can address the issues around SMS on construction sites. Safety awareness could result in a clearer understanding of accidents prevention in the design and construction phase of the projects

(McAleenan and McAleenan, 2017).

A cause of poor safety practice in a CM procedure is the nature of the work environment (Loushine et al., 2006). The problem of inadequate CM procedure and safety management could be addressed if management is entirely dedicated to the projects (Hallowell et al., 2013). In the construction industry, safety management often conflicts with the production work because the CM focuses on the productivity to save time, and cost while improving the quality of a project (Benjaoran and Bhokha, 2010).

METHODOLOGY

This study adopted a case-based strategy to explore factors influencing gaps in the awareness of SMS and CM procedure on construction sites (Yin, 2014). A case-based strategy is designed to help researchers to clarify the phenomenon highlighted in the literature (Byrne and Ragin, 2013). The data were collected between October and November 2017 from four construction projects in Sandton in South Africa. There were more than 80 laborers (general workers) on each project site. The design of the study adopted the multiple case design as illustrated in Table 1 (Yin, 2014).

Table 1: Research Sample

Case Projects	Interviewees	Response
Case Project 1: Village Walk Mixed Use Development	Site manager, Safety manager (2), and Safety officer (2)	5
Case Project 2: The New Discovery Global Headquarters	Site manager, Foreman, and Safety manager	3
Case Project 3: Masingita Towers	Safety manager	1
Case Project 4: Illovo Point Mixed-use Development	Safety manager, and Site supervisor (2)	3
Total interviewees		12

Both qualitative and quantitative data were collected in the interviews that utilized a semi-structured instrument. The qualitative data were collected through open-ended questions, and the quantitative data were collected through structured questions in the same interviews. The interviews took place face-to-face between the interviewer and interviewees on construction sites. The interviews were recorded and later transcribed to aid analysis. The average interview period was between 30 to 60 minutes. The selection of the interviewees was based on purposive sampling. The reason for adopting a purposive sampling was to meet the goals of researchers which was to understand the context of the study problem (Byrne and Ragin, 2013). Because of the adopted sampling technique, only professionals who had site management and safety responsibilities took part in the study. The descriptive qualitative data enriched the insights from the qualitative interview data. Among others, the questionnaire focused on the factors causing accidents, injuries, and fatalities on construction sites.

FINDINGS, ANALYSIS, AND DISCUSSIONS

Qualitative Results

Safety description

From all four-case projects, it was discovered that each construction firm had designated a safety management team to work in collaboration with the construction team on projects. The safety management team includes safety manager, safety officer, and safety representatives. Most of the interviewees responded that safety in construction is a very problematic task to manage the nature of a project. For example, an SMS of a road construction project is not the same as the one for a building project. A safety manager in case 1 defined safety as an ongoing monitoring and measuring system of compliance designed from the construction regulations, which should be adopted by the principal contractor and subcontractors on site. He further explained that safety in construction had been a never-ending coaching exercise to endorse physical safety compliance as described in the construction regulations of 2014. The concept of construction regulations 2014 in the South African construction industry is to help the construction practitioners to fully understand the construction work (Department of Labour, 2014). Furthermore, a site manager in case 2 described safety in construction as a designed system made up of rules and regulations to govern people working in construction. A safety officer in case 1 said that controlling risk and safety policies on the site is an unending trial that will never end if people are still involved in the construction production. She further explained that construction is a hazardous industry and depends wholly on the decisions made by the construction team during the project construction.

An Overview of SMS on Construction Site

When questioning about the importance of SMS on construction sites, a safety manager in case 4 responded that it is very significant to have a well-detailed SMS on site to help management and workers to comply with regulations while promoting a safe working culture. More so, a site supervisor in case 4 responded that SMS helps management of the project to identify possible hazards which might be experienced when undertaking the construction activities. Furthermore, SMS also helps the safety management team to recognize and discipline individuals who fail to comply with the safety rules on site. A safety manager in case 3 responded that a designed SMS is used to help them to inspect and identify the possible H&S hazard, which in turn influence the drafting of a safety report of the project. A safety manager and officer in case 1 had a similar response about how they are governing the SMS on site. They explained that their organization had designed a safety management team to promote a safe working culture on site. They further revealed that they have members who are responsible for the following tasks, medical records of the workers, safety induction and training, risk management, safety observation and safety sign board installation.

Collaborating SMS with CM procedure on the Sites

Most of the interviewees responded that it is essential to collaborate SMS with CM procedure because it helps the construction team to produce the best quality of the project not at the expense of the well-being of individuals working in construction. However, a safety manager in case 3 responded that most construction practitioners promote the safety of the workers without giving a thought to the environmental impact. For example, as the results of poor SMS and CM procedure, often practice contractors create material wastage which is harmful to the

environment. A site manager in case 2 responded that embedding SMS in the works is crucial because the nature of construction is complicated, dangerous and is driven by the workers and machines. A site supervisor in case 4 responded that the collaboration between SMS and CM procedure would help the construction organization to prevent incidents and accidents, which are mostly caused by people who often ignore safety practices in the workplace. Furthermore, a safety representative in case 1 responded that they are working on a complicated and dangerous project, which is made up of a 16m deep basement, and they have employed more than 100 workers who need to be skilled monthly about safety and be audited. Poor safety training and audit of the workers influence the quality of the project negatively. Most of the interviewees responded that because of the tendering system in South Africa the contractors do not form part of the conceptual or design stage of the project, and they think that SMS and CM procedure should be integrated during the design stage (designing for safety or prevention through design). A foreman in case 2 responded that architects and engineers often fail to identify hazards and their corresponding prevention measures at the design stage of projects. They only focus on the complexity and the uniqueness of the design at the expense of the project safety. A safety manager in case 4 responded that it would be in the best interest of the client to change the method of tendering and allow the contractor's team to be part of the design of a project. This would enable management of the contractor to be able to identify the possible hazards during the preliminary design of the project and would be able to integrate the method of construction with the safety system at an early stage.

A safety manager in case 3 responded that most of the members of the construction team often fail to adopt the designed SMS of the project and this might be one of the reasons why the industry is still experiencing high accidents, injuries, and fatalities despite the existence of the SMS on site. The reason why they might be failing to respond positively to SMS might be because they are not adequately trained on the safety policies and regulations. A foreman in case 2 responded that work pressure, determines the level of safety compliance and adherence to SMS on a typical site. The foreman noted that:

"Because of the economic challenges of our country, few investors are willing to invest in property, and often the project directors agree on terms and conditions which are difficult to meet, such as project period and cost. So, they are forced to work under pressure whereby completion dates vs the time needed to complete the project and finance available often encourages them to take shortcuts, extend hours of works and along the process they experience fatigue."

Quantitative Results

The designed questionnaire survey to investigate the integration of SMS and causes of accidents in the South African construction industry has been encouraged by numerous studies (Benjaoran and Bhokha, 2010, Hallowell et al., 2013, Bergin, 2013, Yorio and Wachter, 2014; Okorie et al., 2016, and Isaac and Edrei, 2016). The questionnaire survey of this study was designed based on the reported literature review, by comprising the key construction phases to integrate SMS with the CM procedure (Table 1), and factors causing accidents, injuries and fatalities on construction site (Table 2). The questionnaire survey in Table 2 and 3, was analysed using a five-point Likert scale (1=5) and unsure, from 1 = very low (VL) and 5 = very high (VH).

The interviewees were asked to rank factors regarding the phases of the construction project to determine the appropriate phases for embedding SMS in construction procedure. Table 2 presents the respondents' perceptions of proper integration of SMS in the construction industry. It was found that the execution phase of a project had the highest mean score (MS) of (3.92). The next phase is the design phase of a project, and the third-ranked phase is the operational phase. The order of the ranking points to an industry dilemma that requires immediate attention. Given that the safety influence curve shows that the ability to influence safety diminishes with the progress of the works (Lingard et al., 2014), one would have expected the ranking in Table 2 to start with a design where the most significant opportunity to positively influence safe resides. The safety curve illustrates that safety should be controlled at the commencement of a project in the design phase (Zhou et al., 2014; Behm, 2005). A useful measure to improve safety performance in construction is through the design phase of a project (Zhou et al., 2014). The interviews also confirm this notion on the safety curve when a safety manager in case 4 responded that SMS and CM procedure should be integrated into the design phase. The responsibility of designers should be to identify and understand the possible hazards and types of risks and try to avoid them when designing the project, and the principal contractor should reduce or eliminate the recognized hazards and manage the risk on site (HSE, 2015).

Table 2: Construction phases to integrate SMS with CM procedure

Construction phases	Response (%)						MS	Rank
	VL.....VH							
	U	1	2	3	4	5		
The execution phase of a project	0.0	0.0	16.7	16.7	25.0	41.7	3.92	1
The execution phase of a project	0.0	0.0	8.3	33.3	50.0	8.3	3.58	2
Operation phase of a project	0.0	25.0	16.7	25.0	25.0	8.3	2.75	3

Furthermore, the interviewees were asked to rank the factors causing accidents, injuries, and fatalities on construction site. Table 3 presents the feedback from the interviewees. The table shows that the workers' decisions are a leading cause of harm on project sites. The workers' behaviour and organization policy also constitute major accident causation. The findings are consistent with the literature on accident causation. For example, Manu et al. (2012) reported that the accident causation influence of construction project includes the nature of the project, method of construction, site restriction, project duration, procurement system, design complexity, level of construction, and subcontracting.

Table 3: Factors causing accidents, injuries and fatalities on construction site

Factors	Response (%)						MS	Ranks
	VL.....VH							
	U	1	2	3	4	5		
The workers' decisions	0.0	0.0	0.0	33.3	25.0	41.7	4.08	1
The workers' behaviour	0.0	8.3	0.0	41.7	8.3	41.7	3.75	2
The organizational policy	0.0	0.0	41.7	25.0	16.7	16.7	3.08	3
The workers' attitude	8.3	8.3	16.7	33.3	0.0	33.3	3.08	4
The workers' actions	0.0	8.3	25.0	16.7	16.7	33.3	3.42	5
The communication between contractor and project consultants	8.3	25.0	8.3	25.0	25.0	8.3	2.58	6
The nature of the project	16.7	8.3	8.3	25.0	25.0	16.7	2.83	7

CONCLUSIONS

The reported research focuses on construction safety management. The study explored the integration of SMS and CM procedure on construction sites in four projects in South Africa. It can be argued that the integration of SMS and CM procedure should not be a complicated process since safety management is part of the broader planning and management of a project that was developed at the upstream end of the project life cycle (Canah and John, 2015). Furthermore, a safety manager in case 3 reported that they had developed a system for inspecting safety practice and write a safety report to be presented to the construction manager and the affected workers on site. The introduction of SMS and CM procedure during the design, execution and operational or maintenance phase would help to eliminate and reduce the factors causing accidents, injuries, and fatalities on construction sites. This integration would help the construction team to identify possible hazards and risk factors during the design phase. The principal contractors should be able to eliminate and reduce hazards and risk when they are involved in the finalization of designs.

The seven factors causing accidents, injuries and fatalities on-site construction included; (1) the workers' decisions, (2) the workers' behaviour, (3) the organizational policy, (4) the workers' attitude, (5) the workers' actions, (6) the communication between contractor and project consultants and (7) the nature of the project. The workers' decisions ranked 1st with MS of 4.08. The ranking of this factor corroborates the statement issued by an interviewee who explained that construction is a very dangerous industry and depends fully on the decisions made by the project team during the execution phase of a construction project.

The structured questions asked in the interviews contradict the widely known view of safety influence curve in the literature and the perception of one interviewee in response to open-ended questions. The contradiction is not accidental. Rather, it may represent nuances in construction safety practice that scholars should address. This study was limited to the principal contractor, excluding the project consultants, clients, and subcontractors. The inclusion of the project consultants, clients and subcontractors should form part of the scope of the future project because they are implicated in the study findings.

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THE IMPACT OF POSTS ON INTEREST IN A PROFESSIONAL CONSTRUCTION HEALTH AND SAFETY MANAGEMENT ASSOCIATION FACEBOOK PAGE

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Professional associations and institutes use social media to communicate with their respective publics, for varying reasons. One reason being to promote interest in a page and the related 'owner', other reasons being to promote events, opportunities, 'educate', and create awareness. Experience and anecdotal evidence indicate that visitors to facebook pages find certain posts more interesting than others. This is the reality that administrators of facebook pages must contend with, the challenge being to respond in terms of the 80/20 principle, while not ignoring the '20' of the 80/20. The purpose of the study reported on is to determine the impact of posts on the Association of Construction Health and Safety Management's (ACHASM) facebook page during a six-month period to determine, which attract the most interest. The research method can best be described as experimental in that posts pertaining to various aspects of health and safety (H&S) were undertaken at various intervals. The salient findings indicate the importance of the voluntary association role of ACHASM, and that the registration of H&S practitioners is topical. Based upon the findings it can be concluded that certain posts are of greater interest than others. Furthermore, social media is an important communication medium for professional associations, contributes to H&S endeavours, and the advancement of H&S, and raises the profile of the professional association concerned. It is recommended that facebook page statistics be regularly reviewed to determine the impact and relevance of posts. facebook page administrators must evolve a 'cocktail' of posts to optimise the impact of their pages, which includes promoting interest in a page and the related 'owner'.

Keywords: Construction, Health and Safety, Social media, Public Relations

INTRODUCTION

Black (1993) defines public relations practice as "The art and science of achieving harmony with the environment through mutual understanding based on truth and full information." He states that there are two distinct branches of practice, namely the reactive and proactive sectors. Reactive includes reacting to problems, dealing with crises, and managing change, and the proactive includes planned programmes that serve both the organisation, and the public's interest. Black (1993) describes the role of public relations by presenting the hexagon model, the six sides representing the several factors which influence the role and scope of public relations: the publics of concern; issues of concern; media; the nature of the organisation; situational timing factors, and resources. This paper focuses on the media 'side', and more

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specifically social media in the form of facebook.

Then, public relations are frequently ‘confused’ with marketing. Black (1993) refers to The Chartered Institute of Marketing’s definition of marketing: “The management process responsible for identifying, anticipating, and satisfying customers’ requirements profitably.” Marketing and public relations share many characteristics; however, marketing is an exchange process, which involves four stages, namely: seeking the understanding of the ‘other’ party; creating value as perceived by the other party; sharing ideas regarding the value of products or services, and delivering the goods or services through an actual transaction.

Wright and Hinson (2009) state that social media deliver web-based information created by people with the intention of facilitating communication and now represent one of the world’s major sources of social interaction as people share stories and experiences with each other. However, research indicates that public relations practitioners should measure the amount of communication that is being disseminated with respect to their organisations (or client organisations) through blogs and other social media (4.2/5.0), and/or analyse content of what’s being communicated with respect to their organisations (or their clients) in blogs and other social media (4.4/5.0).

To date, no research has been conducted relative to the use of social media by a professional H&S association / institute, and the impact thereof. Furthermore, the Association of Construction Health and Safety Management (ACHASM) uses facebook to promote H&S events, raise awareness relative to H&S issues, generate interest in the association, assist ‘friends’ and the ‘H&S’ community, and provide feedback, and therefore needs to determine the impact of such posts. Given the aforementioned, a study was conducted to determine the impact of a series of posts on the ACHASM facebook page by reviewing issues such as ‘reach’, ‘clicks’, ‘reactions, comments, and shares’. The study was limited to facebook as it is the only social media used by ACHASM.

REVIEW OF THE LITERATURE

The Advent of Facebook

Deckers and Lacy (2011) relate that in 2004, Mark Zuckerberg, a Harvard sophomore, began developing a new kind of web site for fellow students to track their social lives. It became popular, and membership first expanded to include Stanford, Yale, and Columbia universities, and then most universities across Canada, and the United States of America (USA). By 2006 the site was named facebook, and any person globally, could become a member of the social networking phenomenon. In July 2010, facebook announced that it had more than 500 million users (Deckers and Lacy, 2011). Kabani (2012) states “With 750 million users, and growing, this giant can’t be ignored.” Deckers and Lacy (2011) refer to facebook as an incredibly powerful tool for personal branding and contend that the main purpose for using facebook is to create a community and connect people, which helps fuel the influence behind the brand. Furthermore, influence creates viral marketing within a community. Kabani (2012) states that people use facebook to showcase their own identity, which includes both who they are and who they want to be perceived as.

The Impact of Social Media

Wright and Hinson (2009) conducted their fourth study among public relations practitioners globally. Respondents represented, inter alia, a wide variety of segments of the public relations

industry, inter alia, small agencies or consultancies (25%), corporations (20%), and educational institutions (20%). Respondents were required to indicate the extent to which they agreed that the emergence of social media (including blogs) has changed the way their organisation, or their client organisations: communicate(s) (3.9/5.0); handle(s) external communications (3.7/5.0), and handle(s) internal communications (3.3/5.0). Other findings include: social media have enhanced the practice of public relations (4.0/5.0); and blogs have enhanced the practice of public relations (3.8/5.0), and social media offer organisations a low-cost way to develop relationships with members of various strategic publics (4.0/5.0).

Marsden and Chaney (2013) refer to Zero Moments of Truth (ZMOT). A first moment of truth (experiencing the product in-store) leads to experiencing a second moment of truth (experiencing the product oneself). However, this second moment of truth when shared with others, can become somebody's initial moment of truth before they see it on sale. This shared experience is a ZMOT to whom it's shared with. They state that the key to unlocking sales with social media is to use social media to provide 'customers' with the shared 'moments of truth', and personal experiences with the products you are selling.

Current reality

Evans (2011) states that before the advent of the internet, audiences had to endure listening to or seeing advertisements repeatedly, and that the advertisements were in control of the media that people listened to or watched. Then, in the 1990's the internet evolved, and audiences no longer had to endure commercials, as they could fast forward through commercials, and ignore the 'noise' of marketing. Audiences now turn to communities of likeminded individuals to acquire knowledge of products or services that interest them. Social media provides the forum for people to acquire this information in a natural and more honest way than being subjected to marketing messages. Target audiences can be reached through user-generated content sites, and social media communities. The reality is that the users and community members are now in 'control', and do not want to be 'drilled' with marketing messages. Hajli (2014) cites Senecal and Nantel (2004), who contend that consumers have access to many various sources of information and experiences, which have been facilitated by other customers' information and recommendations courtesy of the internet.

RESEARCH

Research Method

The research method can best be described as experimental in that posts pertaining to different issues were undertaken periodically by three designated administrators. Posts were constrained to construction health and safety (CH&S), which included, inter alia, membership and registration aspects and issues, summit and symposia announcements and feedback, awareness and information, news, and visuals depicting 'best H&S practice'. In terms of the review of the degree of interest, the review spanned the six-month period from 15 October 2017 to 14 April 2018, and addressed issues such as 'reach', 'clicks', 'reactions, comments, and shares'. Reach is the number of people who saw any of the page posts. Reach can be broken down into people who saw the posts with or without advertising (paid or organic posts). All posts were organic.

Research findings

Table 1 presents the schedule of ACHASM facebook posts for the period 15 October 2017 to 14 April 2018. Reactions, comments, and shares are presented in the extreme right-hand

column (R, C, S). A total of 75 posts were made during the period, which resulted in a reach of 12 594, 906 clicks, and 265 reactions, comments, and shares. The totals equate to an average reach of 167.9, 12.1 clicks, 3.5 reactions, comments, and shares. The highest reach (883) was relative to a SACPCMP registration promotion (guidance) post on 16/11/17, followed by SACPCMP CPD guidance on 27/11/17 with a reach of 749, and ACHASM Summit feedback in the form of photos on 20/11/17 with a reach of 713. The next highest reach was relative to an ACHASM VA status update (news) on 20/11/17 with a reach of 676, and then accident news on 28/03/18 with a reach of 513. The lowest reach (5) was relative to a generic EXPO announcement on 10/04/18. The highest number of clicks (146) was relative to the accident news on 28/03/18, followed by the SACPCMP CPD guidance on 27/11/17 (60). The next highest number of clicks was relative to the ACHASM Summit feedback photos on 20/11/17 (54). 18 Posts recorded zero clicks. The highest number of reactions, comments, and shares (31) was relative to the accident news on 28/03/18, followed by the ACHASM Registrar birthday wishes (statement) on 11/01/18 (18), and jointly by SACPCMP registration promotion in the form of guidance on 16/11/17 (17), and ACHASM VA status update (news) on 20/11/17 (17). 20 Posts recorded zero reactions, comments, and shares. These findings reinforce the contention of Deckers and Lacy (2011) that the main purpose for using facebook is to create a community and connect people.

Table 1: Schedule of ACHASM facebook posts for the period 15 October 2017 to 14 April 2018

Post No.	Date	Post	Category	Reach	Clicks	R, C, S
1	17/10/17	ACHASM Summit	Videos	179	35	3
2	17/10/17	ACHASM Summit	Videos	150	35	3
3	19/10/17	ACHASM Summit feedback	Photos	215	7	0
4	20/10/17	SACPCMP 5th PCM conference	Feedback	235	3	1
5	20/10/17	SACPCMP 5th PCM conference	Photos	225	3	0
6	10/11/17	ACHASM Directors' update	News	167	16	6
7	03/11/17	Silica exposure	Awareness	290	7	6
8	10/11/17	SACPCMP registration promotion	Promotion	104	9	0
9	10/11/17	ACHASM Summit feedback	Photos	99	24	1
10	15/11/17	SACPCMP membership payment	Guidance	163	0	0
11	16/11/17	ACHASM update	Communication	68	1	0
12	15/11/17	ACHASM update	Communication	62	0	0
13	16/11/17	SACPCMP CPD	Guidance	84	2	0
14	20/11/17	ACHASM Summit feedback	Photos	713	54	9
15	16/11/17	SACPCMP registration promotion	Guidance	84	0	0
16	16/11/17	SACPCMP registration promotion	Guidance	883	33	17
17	20/11/17	ACHASM VA status update	News	676	36	17
18	20/11/17	ACHASM update	News	44	0	0
19	23/11/17	SACPCMP registration promotion	Guidance	109	0	4
20	26/11/17	cidb Stakeholder consultation	Feedback	305	32	7
21	26/11/17	Construction H&S (New York)	Photos	156	36	9
22	27/11/17	SACPCMP CPD	Guidance	749	60	7
23	02/12/17	Access to H&S information (CPWR)	URL referral	90	6	0
24	02/12/17	Access to H&S information (CPWR)	URL referral	65	1	0
25	03/12/17	Historical accident	Photos	162	25	5
26	04/12/17	SACPCMP registration process	News	159	24	6
27	04/12/17	SACPCMP certification process	News	159	20	6
28	06/12/17	Access to H&S information	URL referral	77	1	1
29	07/12/17	Certification of registration	News	84	14	0

Pos t No.	Date	Post	Category	Reach	Clicks	R, C, S
30	11/12/17	Construction H&S (Melbourne)	Photos	101	6	2
31	12/12/17	Construction H&S (Hong Kong)	Photos	105	13	3
32	15/12/17	Safety Management report	URL referral	90	5	2
33	11/01/18	ACHASM Registrar birthday wishes	Statement	224	14	18
34	12/01/18	H&S interventions	URL referral	100	2	1
35	14/01/18	Hue Vietnam, Construction H&S	Photos	153	10	5
36	15/01/18	ACHASM Summit Alert	Announcement	166	9	5
37	16/01/18	ACHASM Presentation	Announcement	208	10	3
38	17/01/18	BIM and construction H&S	URL referral	69	0	0
39	19/01/18	ACHASM Vision Statement	Announcement	106	0	3
40	23/01/18	Bridge collapse, Colombia	URL referral	180	0	3
41	23/01/18	ACHASM Symposium programme	Announcement	58	0	0
42	27/01/18	Maintenance at heights	Video	101	25	2
43	02/02/18	ACHASM Presentation	Announcement	56	0	0
44	03/02/18	Construction H&S	Photos	96	9	4
45	05/02/18	ACHASM Symposium programme	Announcement	212	0	4
46	14/02/18	ACHASM Seminar programme	Announcement	107	0	1
47	17/02/18	ACHASM Seminar programme	Announcement	70	0	1
48	17/02/18	SACPCMP registration	Guidance	70	4	0
49	28/02/18	ACHASM Symposium programme	Announcement	124	3	3
50	03/03/18	ACHASM Symposium programme	Announcement	115	12	8
51	06/03/18	ACHASM 'sign up'	Promotion	37	2	0
52	07/03/18	ECMBA H&S Conference	Announcement	94	15	2
53	07/03/18	ACHASM Seminar programme	Announcement	46	0	1
54	07/03/18	ACHASM Symposium programme	Announcement	93	4	1
55	08/03/18	Cape Town project	News	93	7	1
56	08/03/18	SACPCMP registration	Guidance	61	0	1
57	08/03/18	Silicosis	Awareness	74	5	0
58	08/03/18	ACHASM Symposium programme	Announcement	107	10	5
59	10/03/18	CPD	Reminder	127	2	7
60	10/03/18	CPD	Reminder	122	2	3
61	12/03/18	ACHASM Symposium	Photos (feedback)	223	13	4
62	12/03/18	ACHASM Symposium	Photos (feedback)	148	15	1
63	12/03/18	ACHASM Symposium	Photos (feedback)	78	5	0
64	12/03/18	ACHASM Symposium	Photos (feedback)	132	9	1
65	12/03/18	ACHASM Symposium	Photos (feedback)	97	2	3
66	17/03/18	Stephen Hawking quotation	Quotation	498	14	16
67	24/03/18	ACHASM WC Presentation	Photos (feedback)	99	5	0
68	28/03/18	EXPO	Announcement	58	0	1
69	28/03/18	Accident	News	513	146	31
70	28/03/18	Accident	News	129	6	2
71	29/03/18	ACHASM Symposium	Photos (feedback)	122	18	2
72	10/04/18	EXPO	Announcement	5	0	0
73	10/04/18	EXPO	Announcement	49	0	0
74	10/04/18	EXPO	Announcement	459	17	7
75	14/04/18	SAICE stake-holder meeting	News	63	3	0

Post No.	Date	Post	Category	Reach	Clicks	R, C, S
Total				12594	906	265
Mean				167.9	12.1	3.5

CONCLUSIONS

To date, no research has been conducted relative to the use of social media by a professional H&S association / institute, and therefore the findings have contributed to an understanding of the role of social media in promoting such associations / institutes, and H&S in general, and have contributed to the general and construction H&S body of knowledge. Although only a six-month period was reviewed, a range of posts were made during the period.

Based upon the findings it can be concluded that certain posts are of greater interest than others. Three of the top four reaches in the form of the SACPCMP registration promotion (guidance) post on 16/11/17 (883), followed by the SACPCMP CPD guidance on 27/11/17 (749), and the fourth highest (676) in the form of an ACHASM VA status update (news) on 20/11/17, indicate the importance of the voluntary association role of ACHASM, and that the registration of H&S practitioners is topical. The reach (713) relative to the ACHASM Summit feedback in the form of photos on 20/11/17 indicates the importance of ACHASM's premium event, and feedback in the form of photos. The next highest reach (513) in the form of accident news on 28/03/18 indicates the reality that accident related reports are 'newsworthy', and topical. A quotation, awareness, feedback, and an announcement also realised substantial reaches, and are clearly of interest. The reach (513), clicks (146), and number of reactions, comments, and shares (31) relative to the accident news on 28/03/18, further reinforce the 'newsworthy', and topical nature of accidents, which are what H&S practices and endeavours are supposed to prevent. The lowest reaches were in the form of the EXPO announcement on 10/04/18 (5), followed by the ACHASM 'sign up' (promotion) on 06/03/18 (37), an ACHASM update (news) on 20/11/17 (44), the ACHASM Seminar programme (announcement) on 07/03/18 (46), and the EXPO announcement on 10/04/18 (49). The EXPO announcements were generic construction as opposed to H&S in nature. It is likely that ACHASM's facebook friends are members and hence the reach. The ACHASM Seminar programme (announcement) was relative to a seminar in a city with limited ACHASM friends and a small H&S community, and hence the reach.

Furthermore, social media is an important communication medium for professional associations, contributes to H&S endeavours, and the advancement of H&S, and raises the profile of the professional association concerned.

RECOMMENDATIONS

It is recommended that facebook page statistics be regularly reviewed to determine the impact and relevance of posts. facebook page administrators should evolve a 'cocktail' of posts to optimise the impact of their pages, which includes promoting interest in a page and the related 'owner'. Future ACHASM posts should focus on: guidance and feedback relative to registration, and CPD; accidents; events, and feedback relative to accidents, and events. However, ACHASM has a 'duty' to raise awareness relative to issues such as silicosis.

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CONSTRUCTION HEALTH AND SAFETY RESEARCH IN NIGERIA: TOWARDS A SUSTAINABLE FUTURE

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This paper presents a systematic review of Construction Health and Safety (CH&S) research in Nigeria, identifying and analysing the current trend, dissemination and implications including its alignment to addressing CH&S problems. Of the 6241 papers published in conference proceedings and found after systematic literature searches of journals and databases over a 36-year period, 49 relate to CH&S in Nigeria. There is evidence of growing interest in CH&S research, but it mainly centres on creating awareness on site safety and the causes of accidents (14 of the 49 studies); regulation and standards, and safety performance are six studies respectively; but none on design for safety and advanced technology. Twenty-two papers are in peer-reviewed international conference proceedings, eight are in highly rated journals, the rest are published in low-ranking (including non-referred) journals. Quantitative strategies remain dominant, 30 of the 49 papers, qualitative strategies are only three, and mixed methods account for 13. By implication, CH&S knowledge and improvement measures are lagging behind compared to other countries. There are indications that the direction of CH&S research may not be aligned to addressing the problems in the society. Hence, there is need for a shift in research focus and attitudes.

Keywords: Academics, Construction, Health and safety, Trend, Nigeria.

BACKGROUND AND RATIONALE

The roles of academics and research in socioeconomic development and policymaking have inspired much research, for example, Ejohwomu and Oshodi (2014) and Laryea and Leiringer (2012). Evidence shows the imperativeness of ensuring quality and currency in research, but most importantly, its ability to adequately address problems towards socioeconomic development (AlSehaimi et al., 2013; Laryea and Leiringer, 2012; Zou et al., 2011). Consequently, authors, for example, AlSehaimi et al. (2013), Ejohwomu and Oshodi (2014), Laryea (2011), Laryea and Leiringer (2012) and Zou et al. (2011) assess the research output of the built environment at various capacities including the topics covered, the research strategies and methods, and the practicality of the recommendations.

In a review of five high-ranking international journals and the International Council for Research and Innovation in Building and Construction (CIB) W099 proceedings, all in 2009, Zou et al. (2011) found that researchers mainly adopt the objectivist position in construction safety research—43.2% were quantitative methods papers. Further, ‘organisational factors, such as safety policy, safety management frameworks and tools, and safety procedures, have been the main objects of construction safety research’ (Zou et al. 2011: 957). Zou et al. (2011)

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indicate that the direction of construction safety research may not be aligned to addressing the problems of the construction industry including in Health and safety (H&S), which may have resulted in the non-implementation of safety management research findings. While the study of Zou et al. (2011) is indicative because of the limited duration of the conferences and journals reviewed, it offers insight into what may obtain. A review of 15 CIB W099 conference series from 1994–2012 shows that Africa is underrepresented but well represented when the conference was held in South Africa and New Zealand in 2005 and 2011 respectively (Finneran and Gibb, 2013). In terms of Nigeria, Ejohwomu and Oshodi (2014) indicate that CH&S research is underrepresented in construction management research, Nnaji et al. (2017) show the dearth of CH&S literature, and Umeokafor (2017) highlights the skewness of the CH&S research but not extensively and in detail as the current study. Nevertheless, CH&S research trend, dissemination and implications including alignment to addressing CH&S problems remain unexamined. The current study fills this gap. According to Zou et al. (2011), this would help avoid the non-implementation of research findings.

The record of CH&S in general is poor with fatality and injury rates the highest among other industries (Health and Safety Executive (HSE), 2016). The case is worse in developing countries. For example, in Nigeria, a study of 115 contractors in the South West, Agbede et al. (2016), found a low level of senior management involvement in H&S where 18% claim their directors have CH&S responsibilities and only 8% review H&S plans during construction. The regulatory system is dysfunctional and fragmented, compliance with H&S laws is very low, and there is little or no governmental attention to H&S (Umeokafor, 2017).

In improving CH&S in general, including Nigeria, there is the need for research that is robust and pragmatic in addressing CH&S issues but most importantly progress with time to ensure currency. Based on the premises established so far, this study examines and analyses the CH&S research output in Nigeria over a 36-year period with the overarching aim of identifying and analysing the current trend, dissemination and implications including its alignment to addressing CH&S problems. In doing this, these questions will be answered:

- What is the coverage of CH&S research during the period?
- What are the implications of the CH&S research coverage during the period?
- How did the theme or focus of the CH&S research change during the period?
- Where are the research outputs disseminated?
- What and how are the research contributions of its academics to current strategies for improving CH&S?
- What is/are the dominant research method(s) during the period?

The study shows the current trend of CH&S research in Nigeria, guides its future direction, improves its knowledge and skills (Ejohwomu and Oshodi, 2014), but most importantly aims to align it towards addressing problems in the industry including CH&S (Zou et al., 2011).

METHODOLOGY

An extensive systematic search of the literature on Google Scholar, Scopus, five international journals and the proceedings of three international conferences, all highly ranked, was followed by content analysis of the relevant studies, and discussion. The selection of the journals builds on the framework in Zou et al. (2011: 955) and Laryea (2011). Firstly, the journals must meet the criteria for high rating set by Excellence in Research for Australia (ERA) for ranking

journals and conferences and rated A+ or A by them (Zou et al., 2011). Secondly, they must relate to construction research. Analogously, Laryea (2011: 204) assesses the contribution of built environment academics by reviewing international highly-rated journals based on the ranking of Chau (1997) where the ‘Bibliometric information available in Journal Citation Reports; Scopus; Journal Impact Factors; Thomas Reuters Web of Knowledge;’ and ERA rating was used. The journals and conferences in both studies are in Table 1. Google Scholar and Scopus were also searched with keywords such as ‘construction safety in Nigeria’, ‘accidents in Nigeria construction’ and ‘safety in building in Nigeria’. The initial searches were in December 2017 and early January 2018, but revised or repeated in March 2018. The last search for indexing in Scopus was on 30 March 2018. Importantly, while there is no agreement on the ‘definite way of discerning “highly-ranked” journals’ (Zou et al. 2011), as some high-quality journals are indexed in journal indexes such as Social Science Citation Index, the approach was adopted for internal validity.

Table 1: Journals, conferences, and databases reviewed in the current study

Journals, Conferences and databases	Period reviewed in the current study
Journal of Construction Engineering and Management *	1984–2018
Engineering, Construction and Architectural Management *	1994–2018
Construction Management and Economics *	1983–2018
International Journal of Project Management *	1983–2018
Safety Science **	1991–2018
CIB W099 Safety and Health in Construction Conference **	2010–2017
West Africa Built Environment Research (WABER) conference***	2009–2017
Association of Researchers in Construction Management (ARCOM)	2008–2017
Google Scholar	1983–2018
Scopus	2004–2018

* Examined by Zou et al. (2011) & Laryea (2011); ** examined by Zou et al. (2011);*** examined by Laryea (2011).

The journals in Table 1 were searched with the relevant keywords not limited to ‘construction safety’; ‘construction safety in Nigeria’; ‘accidents in Nigeria’; ‘hazard, safety in developing countries’; ‘risk in construction’ AND ‘Nigeria’; ‘health and safety’ AND ‘developing countries’. Also, the conference proceedings in the Table were analysed. In both cases, the titles were scrutinised for relevant ones after which the abstracts of the initially selected ones were further scrutinised. From the finally identified papers, the abstracts, methodologies, conclusions (but in some cases more than these) were analysed to answer the research questions of this study. The period reviewed is 1983–2018, overall. The collected data was analysed over seven arbitrarily selected intervals of six, five, five, five, five, five, and five years (1983–88, 1989–93, 1994–98, 1999–03, 2004–08, 2009–13, 2014–18).

From 2009, WABER conference was held annually until 2013 from when it became biannual. CIB W099, an international conference on CH&S organised by W099, a working commission of CIB, is held two years in a row, then one world congress, and another two years in a row.

FINDINGS, ANALYSIS AND DISCUSSION

The study found as follows: '2004–08'—one thesis, three conference and one journal papers; '2009–13'—seven conference and six journal papers; '2014–18'—one thesis, 12 conference and 17 journal publications. By implication, both conference and journal outputs more than doubled in the past fifteen years. Tables 2 and 3 show the research dissemination outlets of

Nigerian construction academics, including high and low ranking (and even non-referred) journals. Drawing on the Tables, of the 49 papers found, 22 are published in peer-reviewed international conferences of which three are encouraged by CIB, eight are published in journals indexed in Scopus of which four are encouraged by CIB, and the rest are not indexed in Scopus. Does this mean that CH&S researchers do not consider the bibliometric information in Journal Citation Reports, Journal Impact Factors, to name but a few, or ‘what’? Explanations are not limited to motives for publishing such as continuing professional development, job promotion (Adjei and Owusu-Ansah, 2016; Umeokafor and Windapo, 2017) and barriers such as the low acceptance rate of high-ranking journals (Adjei and Owusu-Ansah, 2016). Nevertheless, Laryea (2011) argues that while academics can publish in many places, high-quality research should be disseminated in leading journals in the field. The bibliometric information in Journal Citation Reports, Journal Impact Factors and Thomson Reuters Web of Knowledge indicate the leading journals in the field, and academics should consider this (Laryea, 2011). High-quality research publications ‘is the most important feature of an academic CV... it is not just the quantity that matters but where they are published’ (Hughes 2005 in Laryea 2011). It also counts toward the ranking of universities (Laryea 2011). The implications of this include that high-quality research outputs in low rated journals make a little impact (including readership) as against if published in highly ranked ones (Adjei and Owusu-Ansah, 2016). The publications count little to the promotion of the academics (Adjei and Owusu-Ansah, 2016), their ranking and that of the universities. Additionally, as Table 2 shows, 49 papers—the contributions of Nigerian academics—are a small fraction considering the size of Nigeria and its academics.

Table 2: Research in CH&S in Journals and conferences

Journals, Conferences and Databases	Total No of papers	No of papers on CH&S in Nigeria
Journal of Construction Engineering and Management	*530	0
Engineering, Construction and Architectural Management	*651	0
Construction Management and Economics	*545	0
International Journal of Project Management	*Over 500	0
Safety Science	*Over 1900	0
Association of Researchers in Construction Management	1090	0
CIB W099 Safety and Health in Construction Conference	411	8
WABER conference	610	9
Google Scholar	*46	**26
Scopus	*18	**6
Total	6241	49

*The papers (including those that appeared more than once) found with the keywords noted in the methodology; **The relevant papers obtained from those found after the searches.

Table 3: Details of the journals and conferences in Scopus and Google Scholar from 1983–2018

Databases	No	Indexed in Scopus and/or CIB encouraged.
Scopus		
Architectural Engineering and Design Management	1	Scopus, CIB
International Journal of Civil Engineering and Technology	1	Scopus
Jordan Journal of Civil Engineering	1	Scopus
Journal of Civil Engineering and Management	1	Scopus, CIB
Journal of Construction in Developing Countries	1	Scopus, CIB
Journal of Engineering, Design and Technology	1	Scopus, CIB

Conferences on Google Scholar		
<i>British Academy of Management 2016 Annual Conference</i>	1	None of the above
CIB W107 (Construction in Developing Economies) and CIB TG23 (Culture in Construction)	1	CIB
CIB World Building Congress	2	CIB
cidb conference	1	None of the above
International Conference on Infrastructure Development in Africa	1	None of the above
Journals on Google Scholar		
American Journal of Social and Management Sciences	1	None of the above
British Journal of Economics, Management & Trade	1	None of the above
British Journal of Environmental Sciences	1	None of the above
FUTY Journal of the Environment	1	None of the above
International Journal of Business and Social Science	1	None of the above
International Journal of Civil Engineering, Construction and Estate Management	1	None of the above
International Journal of Health and Psychology Research	1	None of the above
International Journal of Innovative Research & Development	1	None of the above
International Science and Technology Journal of Namibia (ISTJN)	1	None of the above
IOSR Journal of Mechanical and Civil Engineering	1	None of the above
Journal for the Advancement of Performance Information & Value	1	CIB
Journal of Earth Sciences and Geotechnical Engineering	1	None of the above
Nigerian Journal of Environmental Sciences and Technology	1	None of the above
Nigerian Journal of Medicine	1	Scopus
Online Journal of Health Allied Sciences	1	Scopus
PM World Journal (Non-refereed)	1	None of the above
Science Journal of Environmental Engineering Research	1	None of the above
Thesis on Goggle Scholar		
MSc thesis, Eastern Mediterranean University, Cyprus	1	None of the above
Master's thesis, Covenant University	1	None of the above

Table 4 shows that CH&S research has gained recognition. From 1983–2004, there was no CH&S research, but it tripled from ‘2004–08’ till ‘2009–13’, and afterwards, more than doubled. This shows a growing interest in CH&S research, consistent with Nnaji et al. (2017) where a literature search of Google Scholar and Scopus shows that while H&S literature has grown in Nigeria recently—where only 35 of the 47 studies found on construction safety were relevant to workers safety and not duplications—70% were in the past seven years.

Table 4: Coverage and trend of CH&S research from 1983–2018

Focus/topic	1983– 88	1989– 93	1994– 98	1999– 03	2004– 08	2009– 13	2014– 18	Total
Accidents e.g. causes	0	0	0	0	1	0	5	6
Behaviour-based safety	0	0	0	0	0	1	0	1
Contextual environment	0	0	0	0	0	0	2	2
Education in H&S	0	0	0	0	0	0	2	2
Environmental safety	0	0	0	0	0	2	0	2
Ergonomics	0	0	0	0	0	0	1	1
H&S in Procurement	0	0	0	0	0	0	1	1
H&S management (mgt) system & practices	0	0	0	0	0	0	5	5
Regulations & standards	0	0	0	0	0	2	4	6
Safety awareness and knowledge	0	0	0	0	0	0	1	1
Safety culture & climate	0	0	0	0	0	1	2	3
Safety innovation	0	0	0	0	0	0	1	1

Focus/topic	1983– 88	1989– 93	1994– 98	1999– 03	2004– 08	2009– 13	2014– 18	Total
Safety Performance & Productivity	0	0	0	0	2	2	2	6
Safety risk analysis and risk management	0	0	0	0	0	1	0	1
Site safety and mgt. eg. Equipment & facilities	0	0	0	0	1	4	4	9
Stakeholder involvement in H&S	0	0	0	0	0	0	2	2
Total					4	13	32	49

However, it is evident that the research focus is on creating awareness on the status quo of site safety (nine studies, the highest in number), accidents including the causes, safety performance, and regulation and standard, all ranking second with six studies each (Table 4). Most of the safety performance and site safety studies mainly reiterate ‘common knowledge’, with little or no contribution to knowledge. The table also shows that in the past decade, site safety was the main focus, but studies on regulation and standards increased. Most of the studies on accidents were in the past five years (Table 4). Okorie and Aigbavboa (2016: 507) state that ‘Much has been researched on the causes of construction site accidents in Nigeria’.

In controlling risk, the hierarchy of control should be applied; it helps in eliminating risks, for example, by designing out hazards (HSE, n.d). Where this is not possible, there can be substitution where hazardous activities or materials are replaced by the less hazardous ones (ibid). This will then lead to engineering control, the third on the hierarchy, then Administrative control such as H&S training, and Personal Protective Equipment, the last control (HSE, n.d). The concept here is that the higher the control on the hierarchy, the more effective it is in risk control. As Table 4 shows, the CH&S research in Nigeria is not focussed at the top of the hierarchy such as designing out hazards, building information modelling and H&S, and advanced technology. Other areas overlooked are not limited to achieving the goal of zero incidents, subcontracting and safety management, and safety benchmarking.

The implications of this include that the knowledge on these areas in the context of Nigeria is lacking hence little or nothing to inform context-based measures; research is also lagging behind. Authors such as Kheni (2008) and Umeokafor (2017) strongly argue that without understanding the social, political, economic, and cultural contexts of developing countries, H&S issues therein will remain challenging. In other words, the solution lies in understanding and factoring in these contexts. If this is the case, then Table 4 that shows two studies on the contexts of Nigeria in terms of H&S and the gap in terms of hierarchy of control, imply that the research direction of Nigerian CH&S academics may not be aligned to address the problems in the society, consistent with the findings of Zou et al. (2011) noted elsewhere.

Drawing on Zou et al. (2011), the methodologies are presented in Table 5 covering quantitative, qualitative, mixed, review or conceptual papers. This has been purposefully simplified by comparing the methodologies and not using positivist, interpretivist, etc. views for the benefits of novice research (Umeokafor and Windapo 2017). Table 6 shows more than 49 research methods because in mixed methods, more than one method is adopted.

Table 5: Methodologies in CH&S research from 1983–2018

Methodology	Frequency
Mixed methods	13
Others, Lab experiment	1
Qualitative	3
Quantitative	30
Review or conceptual paper	2
Total	49

Table 5 shows that quantitative strategies are dominant; Table 6, which shows that quantitative methods are also dominant, supports this. However, while both Tables show that Qualitative Methods and Strategies (QMS) are underrepresented, Table 6 shows an increase in the adoption of qualitative methods. Authors (e.g. AlSehaimi et al., 2013, and Ejohwomu and Oshodi, 2014) found that quantitative methods and strategies are dominant in construction research while qualitative strategies are underrepresented. Of course, there are implications for this. For example, AlSehaimi et al. (2013) found that the recommendations of studies examined in developing countries do not match the research findings because the quantitative methods adopted therein identify and describe the current state of affairs and the knowledge produced. This is where qualitative methods should have been adopted.

H&S issues are context-based and QMS have the potentials of addressing issues therein (Kheni, 2008) because they ensure 'close collaboration with industry partners, ... solving practical problems and generating new knowledge in the form of systems, models, or frameworks' (AlSehaimi et al., 2013: 411). QMSs help gain the in-depth understanding of social phenomena including H&S problems, which survey and questionnaires are unable to do. QMSs take into account the nature of the research subject in explaining its behaviour and enables interaction with the subject in their language (Kheni, 2008). Also, the 'subjects' perceptions of the world around them, the meanings, understandings and opinions about the world are of significance and can be the subject of investigation' (Kheni, 2008: 91). Admitted that quantitative methods and strategies can also address H&S issues, the adopted research methods and strategies should be fit for purpose and not based on convenience or bias against qualitative methods (Umeokafor and Windapo, 2017).

Table 6: Research methods in CH&S research from 1983–2018

Methods	1983– 88	1989– 93	1994– 98	1999– 03	2004– 08	2009– 13	2014– 18	Total
Content analysis	0	0	0	0	0	2	4	6
Group interviews	0	0	0	0	0	0	1	1
Lab experiment	0	0	0	0	0	1	0	1
Questionnaires	0	0	0	0	5	13	21	39
Semi-structured interviews (individual)	0	0	0	0	0	1	11	12
Structured interview	0	0	0	0	0	3	0	3
Structured observation	0	0	0	0	0	3	2	5
Unstructured Observation	0	0	0	0	0	0	1	1

Umeokafor and Windapo (2017) report that the bias against qualitative research is explained by the science and engineering backgrounds of many academics in the built environment, the level of skills it requires and the culture and norm of quantitative research. Evidence shows

that the implications of this bias include that some research questions are unaddressed or poorly addressed and some recommendations impractical (Umeokafor and Windapo, 2017).

CONCLUSIONS AND RECOMMENDATIONS

The study examined CH&S research in Nigeria, identified and analysed the current trend, dissemination and implications towards ensuring the right alignment of CH&S research in addressing problems in the industry. It shows a significantly growing interest in CH&S research but indicates that it is not aligned with addressing CH&S problems. Contextualised CH&S strategies or measures are lacking. While publications on the awareness of safety performance, site safety and accidents are high and many just reiterate what is already known, design for safety, building information modelling and safety, and advanced technology that would eliminate or substitute the hazards at the preconstruction stage remain unexamined. By implication, the research lacks currency. While QMSs would provide vital information and knowledge in CH&S, they remain underrepresented. There is the need for a shift in current research attitude and focus towards well informed and grounded research that will increase the contributions of research in problem-solving and socioeconomic development. For example, while not overlooking other topics in Table 4, research areas on more effective risk control measures such as eliminating and/or substituting the hazards at the preconstruction stage should also be considered. Adopted research methods and strategies should be fit for purpose and not based on convenience or bias against QMSs. Academics should consider publishing in high-ranking journals with the understanding that research quality contributes to university rating and their CVs. In being a guide for the future direction of CH&S research, the study advances the understanding of underexplored areas in CHS research which academics, especially the novices, students and policymakers should consider in research and H&S strategies and policies development. While the inclusion of journal indexes such as Social Science Citation Index may have produced a different result, the difference is likely to be little, if any. As the study is limited to desktop study, further research, perhaps through interviews, can seek to understand the direction of CH&S research in Nigeria.

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RISK ASSESSMENT OF CONSTRUCTION SITE SAFETY FROM STAKEHOLDERS' PERSPECTIVE

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A building construction has many associated risks; however, the most important is life safety of all workers involved. The staff of an enterprise are faced with several difficulties, such as lack of adequate conditions to perform their service. Therefore, the purpose of this study is to evaluate the safety risks of a construction site from stakeholder's perspective. The evaluation of this case study consisted of interviews and meeting with workers (mason, carpenter, plumber, and electrician) and owners from several contract companies. As an outcome, there was a misalignment between leadership and operational viewpoints. In the contractor owners' point of view, the safety issues are related to workers cultural aspect, for even providing training, safety equipment, work environments and accommodation, they are not used because of laborers neglect. On the other hand, from the operational standpoint, most of employees identified that they are not encouraged to use the appropriate equipment by the companies. Indeed, these employees are exposed to numerous risk situations, and this situation is worsen by the lack of professional appreciation, so it is necessary to reassess the structuring of these companies, so they can motivate and value the workers lives reducing risks.

Keywords: Safety, Organizational structure, Work environment.

INTRODUCTION

Brazil occupies the fourth position in the world in terms of accidents at work, behind China, India and Indonesia. According to data from the Digital Observatory for Occupational Health and Safety (OHS 2018), from January 2012 to March 2018, more than 4 million work accidents were recorded in the country. Moreover, the fourth occupation with more accidents reports is by the construction workers, representing 2.94% of the occurrences. Studies mentioned considered only formal workers safety, so it is estimated that the number of accidents is much higher, since many workers are informal, and are not considered in statistics.

These accidents are more frequently caused by inadequate conditions on construction sites, an environment that exposure health and safety of workers. Ensslin *et al* (2014) also points to the low standardization of work in association with constant improvisations, chaotic decision-making processes, and lack of effective safety and health management systems as explanations to this reality. In Brazil, the reference to be followed for accidents prevention and workers' health is regulatory standard NR-18, which aims to improve working conditions in civil construction sector, meaning to promote worker health, life quality improvement and accidents prevention through elimination or risks reduction in work environment (Medeiros *et al* 2016).

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However, even full compliance with legislation is not enough to ensure a substantial reduction in number of work accidents. It is essential that construction industry, with its particularities, develop not only workers safety culture but also specific management systems that can meet the needs of this sector, guaranteeing the highest quality of its products and social commitment. For Cambraia, Saurin and Formoso (2008), the consequences of lack of construction sites safety are evident through human, economic or social losses, and have stimulated the need of searching for improvements in construction safety performance

In this context, Saurin and Carim Junior (2011) add that good OSH management practices are usually prescriptive and have implicit principles. However, once the underlying principles of management practices are not known, it becomes more difficult to keep the OSH management system continuously appropriate to changes in the socio-technical system in which the organization is inserted. By law, companies have the duty to safeguard the wellbeing of their employees, and the employee has a responsibility to report the absence of appropriate equipment for dangerous situations. Therefore, it is essential to understand the perspective of all those involved regarding the safety risks in field. Thus, the objective of this article is to evaluate the safety risks of a construction site from the stakeholders' perspective.

CONTEXT

Labor Relations in Construction

In Brazilians construction sites there is a hierarchy: Command team (Strategic) that are the engineers and technicians; support staff who are the administrative assistants, warehousemen and lookout; and the operational team, composed by master builder, contractors, workers and servants. The command teams are responsible for the work supervision, compliance with the norms and the supervision of the use of safety equipment and accident prevention. The direct workers makeup the operational team (Gomes 2011).

The operational team has its own hierarchy, with the master builder playing the role of supervisor, engineer, and technician in most of the time. The contractors are the professionals who take care of a team. The workers are those who perform a specific task, and the servants are unskilled workers, who carry materials, take out rubbish. However, the smaller is the construction site size, more precarious is working relationship, reflecting precariousness safety and prevention of accidents (Clemente 2015).

In civil construction, the employee can be in several work circumstances, like autonomous or contracted, with or without employment bond, or outsourced. Azevedo (2018) points out that the issue of outsourcing in Brazil's construction appears as one of the main factors causing the large number of work accidents.

Accidents in Brazilian construction area

Historically in Brazil, civil construction is described as being an artisanal production process, where it is very easy to contract unskilled labor, without preparation or knowledge necessary for the work (Gomes 2011). In addition, the author indicates that this industry has many factors that contribute to create an environment inclined to accidents and harmful to workers' health, such as its nomadic and temporary character, high workers turnover with elevated dismissal rates, low wages and the fragility of formal employment relationships.

According to Medeiros *et al.* (2016), poor food and sanitary conditions, poor workplace safety and long working hours can also be presented as factors contributing to the weakening of worker health. In addition, the construction site offers several risk situations for workers: falls, handling of machines, handling of puncture-cutting equipment, electrical installations, among others. Rocha, Saurin and Formoso (2000) assert that in civil construction, as in any other sector, is primarily aimed at obtaining profits, continuously seeking to reduce costs of its processes. Thus, the investment in work safety ends often neglected, as the industry cannot always see the impact of work safety on product quality, leaving safety behind.

NR-18

Gomes (2011) indicates, Brazil has as its main instrument of accident prevention in Civil Construction Industry the Regulatory Standard, NR-18, Working Conditions and Environment in the Construction Industry. This code was created in 1978 and its major change / update was made in 1995, due to high rates of work accidents, mortality and permanent disability. This change has brought advances in terms of legislation and encouragement for construction companies to improve working conditions (Medeiros *et al* 2016). In summary, NR-18 establishes administrative, planning and organization guidelines that aim at implementation of control measures and preventive safety systems in processes, conditions and working environment in the Civil Construction Industry (Gomes 2011).

METHODOLOGY

In order to achieve the objective of this research, a case study was carried out at a construction site, aiming to identify perceptions regarding work, safety both by leaders of outsourced companies (contractors) and by workers (professionals and servants) from respective companies. The methodology proposed for this study was a descriptive case study, with a qualitative approach, and the main technique adopted for data collection was semi-structured interview, followed by in situ observation. The choice of this methodology came from understanding that, in order to evaluate and analyze the contextual issue of outsourcing and safety at work, it is fundamental to guarantee an expanded understanding of work process and perceptions of professionals involved.

This case study was carried out in a medium-sized construction company. Excluding some servants, most of the workforce is outsourced, divided among several companies. The enterprise is a residential building of thirty-two floors, located on a site with high rate of built area, but with a large garage area (three floors) which enables the planning of its physical arrangement. At the time of the research, the company had only this building in construction phase, but it had several buildings phases (structure, masonry, installations, coatings and finishes).

The construction company is certified by the Brazilian Program of Quality and Productivity of Habitat (PBQP-H). In this way, there is a training routine in the field that involves the application of the Program of Occupational Health Medical Control (PCMSO), Work Conditions and Environment Program in the Construction Industry (PCMAT), Internal Commission for the Prevention of Accidents (CIPA), in addition to quality policy training and supervised enforcement services.

Five companies participated in data collection, in a total of 6 owner contractors and 54 workers. Described below:

- Company 01: responsible for the building of reinforced concrete structure molded in loco, there were 2 owners, and 19 workers (1 master builder, 6 riggers, 6 carpenters and 6 helpers) participating.
- Company 02: responsible for execution of masonry and internal lining mortar, there were 1 owner, and 21 employees (1 master of works, 6 masons, 6 helpers and 8 servants) participating.
- Company 03: responsible for interior painting and lined plasterboard lining, there were 1 owner, and 8 workers (4 painters and 4 installers) participating.
- Company 04: responsible for the hydrosanitary installations, there were 1 owner and 3 plumbers participating.
- Company 05: responsible for the electrical and telecommunication installations, there were 1 owner and 3 electricians participating.

The group was separated into 6 parts, the first being only with the contractors, and the other five with the other employees divided in similar quantities. Therefore, six meetings were held, one for each group, where some questions were asked in an open way to identify situations that occur in the daily life and that can generate almost accidents and / or accidents.

All interviews were transcribed and documented. Subsequently, they were submitted to thematic content analysis and operationalized in three stages: (i) pre-analysis; (ii) coding, classification and categorization of the material; and (iii) interpretation of results according to Bardin (2011) with Minayo (2013) adaptations. In pre-analysis stage, the material was organized. For this, floating readings were initially performed in order to understand the material collected in the interviews. Subsequently, the material was organized and separated according to items contained in interview script. Then the demarcation of stretches to be treated was made, based on theme and objectives outlined in this research.

FINDINGS, ANALYSIS AND DISCUSSION

After interviews and observations in construction site, it was aimed to identify the points of convergence between interviews, so there were no more than three answers to each question, featuring the most important insights. Responses were classified and grouped into nine topics, based on the Saurin and Ribeiro's (2000) proposed model. The categories were: main cause of accidents, suggestions to improve work safety, job satisfaction, training, activities of higher risk, workload, main priority, frequency of occurrence of minor accidents and near accidents and level of workers awareness.

Topics with similar perception among hierarchical levels

Four topics with similar perceptions among hierarchical levels were related to the main cause of accidents, suggestions for improving safety, job satisfaction, and training of the workforce. As main cause of accidents, interviewees were unanimous in pointing out the victim as the person responsible for the accident, based on their perception the person took risk due to unsafe action. These responses considered only most visible cause of accident, or the last action of a chain of events, it is evident that some accidents described have their origin in causes that were previously unsafe, such as lack of training or non-compliance with the NR-18 standard.

According to Baxendale and Jones (2000), it is already known that most accidents are not caused by careless workers, but due to failure to control work safety, which is responsibility of company's management sector. Throughout the development of occupational health and safety management systems, it is estimated that in small-to-medium-sized construction site, an

accident reduction of 33% could be achieved and the estimated benefit to industry would be 220 million pounds every year. These arguments should be enough to convince builder to invest in training and accident prevention techniques for their workers, for it shows the need for safety programs with detail and implementation schedule for different phases of production process. In addition, it is important to note, no interviewee expressed concern or awareness of many unsafe conditions verified in field, being evident the trend to deny this factor to a secondary plan in accidents prevention.

The second topic perceptions were similar, it is proposition of suggestions to improve safety in the construction site. Most of interviewees presented simple proposals, such as use of guardrails in areas of risk of falling or complaints about difficulty of carrying out the masonry services and formwork in height due to need to use a safety belt and safety strap, revealing dissatisfaction with need to use of a personal protective equipment (PPE).

Although, all these considerations should be included in the Health and Safety Project linked to PCMAT, which must present all data described in item 18.3 of NR-18. They were not followed, having only function of being a mandatory document, without any use. The safety project should ensure the protection of workers through specifications, detailing and elaboration of collective and individual protections. Presenting a schedule of safety implementation measures considering schedule and different phases of enterprise building. The work safety and health design process should be part of life cycle of enterprise, for it needs to evaluate both needs of employees in building production phase and those of maintenance team. For this, it is important that safety professionals participate in design phases of projects and planning of building, contributing with guidelines that could be incorporated to other projects, such as in structure design, making feasible from this moment installation of safety devices during building and maintenance phases.

The interviews also revealed majority dissatisfaction with their hierarchy positions. For contractor's perspective, it is explained by excessive workload and lack of prospects for professional partnerships with building company, since their companies are only service providers and not partners. On the other hand, labors expressed disappointment, since they emphasize decision in working in civil construction was not a personal option, but an outcome from their low qualification.

Although site is relatively clean, the workplace is also pointed out by all as a demotivating working condition. It should be noted that construction site is not only a work place; it is also, where most workers live, mainly due to migration. In this way, extensions are created between work and worker's personal and social life. It is important to understand relationship between productivity and life quality with comfort in workplace. Therefore, environment must be designed in order to harmonize different criteria and indicators of comfort in search for the best overall solution, according to specific requirements of each case. In order to project be well designed, it is also essential to understand physical phenomena during construction. For an adequate work environment evaluation, it is recommended to use methodology proposed by Zeule and Serra (2015).

Deficiencies in labor training process were also evident in interviews. Leaders pointed workforce high turnover as main explanation for lack of training, adopting a conformist stance in relation to this restriction. Some workers also reported very low-quality training by

companies. According to reports, trainings were given by master builders themselves or by head of the contractors of each company, summarizing warning of which PPE to use, without explanations on the procedures of use and environment. It is observed that in civil construction, lack of recognition of worker is a constant, among other things, due to their disqualification, either because they are easily replaceable, either because of their dependence on employment or because they are migrants. There remains to these workers make use of defensive strategies that will eventually endanger their physical and mental health (Borges and Martins 2004).

Topics with different perceptions among hierarchical levels

Five topics in which perceptions among hierarchical levels were different were activities of higher risk, workload, main priority, frequency of minor accidents occurrence and workers awareness level. There are many risk activities in construction site, so it can be said that company leadership own tendency to have a broader view of risks, since its members have cited a larger number of them. The main opinion stands out the common mention of risks in services at height, which, according to some interviewees, could have been avoided or minimized with an awareness among employees.

In workers perspective, there was a tendency to pay more attention to more visible and related jobs risks, such as scaffolding services, circulation on the ground floor (area subject to material fall). Other risks cited by respondents were services on roofs, services involving cement handling, circular saw, freight elevator and handling of concrete pumps.

It was possible to perceive, both only mentioned risks related to accidents, but physical risks (noise, vibration, radiation, humidity, heat and cold ...), chemical risks (agents that interact with human tissues causing changes in their structure), biological risks (bacteria, fungi, bacilli, parasites, protozoa, among others) and ergonomic risks (adaptation of the working conditions to the psychophysiological characteristics of the worker) were ignored. The workload was also discussed by the contractors, who emphasized the existence of a stressful routine in which there is little or no time for personnel training or planning activities, due to pressure exerted by building company and difficulty of managing workers. It was observed that work journey, sometimes extended overtime, is a relevant factor to be analyzed.

Perceptions also diverged on the topic of priority at work, that is, main concern in daily routine. Safety at work was not mentioned by any of the interviewees, which is alarming. It was found that respondents' priority is related to the way in which they are evaluated, formally or informally, by hierarchical level immediately above. Thus, contractors prioritize term and cost, as they are charged to complete the construction within time and cost anticipated.

Although they do not receive awards, masters builders also prioritize the deadlines, mainly as a reflection of companies' owners priorities. On the other hand, workers were unanimous in affirming cleaning of the construction site is their main concern. Such priority is a consequence of insistent master builders' requirement, since it is an aspect encouraged by building company leadership. Even though, either leaders or employers do not see safety as a main priority, a large number of surveys point out that employer's sense of safety and respect for worker integrity brings benefits such as satisfaction, thereby increasing service productivity.

In addition, it was identified perception of interviewees regarding frequency occurrence of minor accidents (without leave) and near-accidents. The company leaders agree that this is an

often reality; while employees do not detect occurrence of this problem. Many minor accidents do not come to knowledge of the workers, because there is no formal registration or disclosure. Thus, workers perception becomes distorted, treating with contempt occurrence of unsafe actions. Many of staff considers that work accidents are facts distant from their reality and unlikely to happen to them.

Finally, perceptions also diverged about level of worker awareness of safety. Consciousness was assessed based on responses about PPE use, risk recognition, initiative to eliminate unsafe conditions, initiative to alert colleagues about risky attitudes and concern about construction site organization. Workers see themselves and their colleagues as conscious, which shows certain tolerance with unsafe acts and conditions, situations that were easily observed in construction studied. However, the main divergence lies in fact that most employees stated that they do not feel motivated to use PPE because they are not encouraged or made aware of using them. Moreover, they understand that they are only stimulating to use by the leaders of their companies for legal obligation, not real concern.

The workers' lack of awareness can be explained, according to Souza (1997) because they have become used to living with precarious working conditions, developing common sense that situations of risks are normal and characteristic of environment. The frequent risk denial cases are linked to factors such as pride, manhood and bravery that workers believe they must show. The most consistent reports of what was observed on were from contractors who recognized existence of two groups of employees, the most conscientious, and the least. From these insights, some of interviews were expected to reveal unconscious workers who may have poor relationships with colleagues or demonstrate a lack of awareness about using PPE importance or cleaning. Although none of interviewees was included in non-conscientious group in their own evaluations, some of them acknowledged the existence of this type of employee, reporting that theft and vandalism in particular are relatively common.

In researcher's perception, although actions like these are practiced by a minority, they end up harming image of most of the workers, contributing to spread of prejudices in relation to sector workforce. The workers' reports have shown that they intend to work in an organized and safe manner, but such perceptions do not correspond to reality, in large part, due to lack of planning and monitoring work safety in companies. In a joint analysis of all topics, it can be seen that leaders themselves are also not made aware, as they devote little time to safety issues, ignore causes of many accidents and there is a certain compliance with current performance levels.

CONCLUSIONS

This work aimed to identify, by qualitative data collection and treatment techniques, perceptions of workers and leaderships of main contractors who work in building construction in relation to job safety at a construction site. Perceptions have revealed several problems in management of work safety in companies, which are probably common or even more serious in most companies in industry. The origin of deficiencies can be attributed to non-prioritization of safety by top management, which is reflected directly in absence of structured safety management and poor understanding of managers and workers on this subject.

In this study were identified some obstacles that should be overcome in order to improve safety performance, such as low quantity and quality of training for staff, high workforce turnover, lack of formal registration, investigation of accidents and near misses. In addition, some

perceptions have shown that contractor owners should also receive training, since they, like workers, had nothing to suggest improving safety and tending to hold employees accountable for accidents. The dissatisfaction in positions occupied by employees in no way contributes to improvement of safety in work, as well as the excessive workload of operational. Strategies to meet deadlines and cost goals (management priorities) would be more effective and realistic if they recognized that safety care could be critical to success in these areas.

It is necessary efforts to change workers mentality, because safety sense noticed in interviews was false. The few risks identified, the fact that they think they are sufficiently aware, the perception that there are few accidents and perception that they are main culprits, are reflections of the lack of training and awareness that do not coincide with reality observed in the works. However, the most worrying factor identified in interviews is personal devaluation that most workers have with themselves. This reality, together with companies owners' negligence, becomes the greatest source of risk for accidents at work. Thus, it is necessary to rethink companies' priorities, where safety must be the first one.

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CULTURAL CUES AND BEHAVIOURAL PATTERNS IN STRESS DYNAMICS: A CASE OF THE CONSTRUCTION INDUSTRY

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Critical factors underpinning stress development in the Construction Industry were investigated in an ethnographic study. Data were collected from three construction organizations in the UK and analysed by content analysis. The results show the pivotal importance of interpersonal relationships to coping with the uncertainty of working conditions, coordination of activities involving teamwork and managing responsibilities and power interactions. The study underlines the importance of dedicated services for stress management and specific training-related abilities devoted to reinforcing positive dynamics between persons and organizations. In particular, these related to managing the impacts of stress on physical status, interpersonal relationships, work performance, and emotional well-being. Communication systems, tools and software and their application were also claimed to have been carefully implemented as effective stress deterrents in the management of daily routine activities.

Keywords: Behavioural patterns, Construction industry, Culture, Stress.

INTRODUCTION

Construction workers are highly exposed to psychological fragilities, including emotional and stress-related problems and have to cope with incessant and physically demanding responsibilities and problems within uncomfortable physical working environments, having limited authority, and sometimes absence of support from their organizations and members of the public (Chan et al 2014). Construction workers experience a lot of stress. There has been a vibrant interest of research, surveys, reports and case studies of stress among construction workers. The preponderance of these cited studies into the subject matter has been framed in the field of Construction and the Built Environment. Most studies are predominantly quantitative and inclined to viewing workers' stress as an individual phenomenon, with individual worker characteristics providing the most frequent variables of study.

CONTEXT

The study of stress in Construction

Stress in the Construction Industry has been tightly linked to repetitive but arduous assignments, scarce interpersonal support, difficult safety climates, uncomfortable physical environments, work overload, lack of autonomy and conflicting roles. Stress can impact negatively on an individual's psychological health and performance, and can manifest as a

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strain, sense of frustration, low motivation, injury and lesser productivity (Lingard and Francis, 2004; Bowen et al., 2014). While some of the stressors have been studied and described in more detail like environmental conditions (for example, extreme temperatures, poor air quality, or excessive noise) which are more tangible and measurable with instruments, other less tangible factors like cultural and interpersonal factors and the behavioural patterns and representations of people within organisations are less described in literature (Haynes and Love 2004; Mitropoulos and Memarian, 2012; Enshassi et al., 2018).

Stress, Data and Epidemiology

The UK Health and Safety Executive (HSE) has defined work related stress as the adverse reaction people have to excessive pressure or other types of demand placed on them (HSE, 2018). In 2006, a pioneering large study conducted by the Chartered Institute of Building (CIOB) in the UK, showed how stress in the Construction Industry was extremely linked to inter alia, interpersonal and cultural/organisational factors i.e.: lack of feedback (56.8%), poor communication (55.7%), inadequate staffing (55%), too much work (64.1%), ambitious deadlines (59.7%), pressure (59.9%) and conflicting demands (52.2%). On the contrary, site safety, inadequate equipment and poor physical environment were among the lowest scoring factors with over 80% of the survey respondents stating that these were not a cause of occupational stress (Campbell, 2006).

Occupational stress outcomes in Construction have been associated with a high presence of anxiety and depression, whereby workers spend less time maintaining their health status, take on less personal responsibility, and invest less energy in their work activities (Chan et al., 2014). However, according to the literature, this tremendous emotional impact on construction workers has never been assessed by certified and qualified professionals (Chinyio et al., 2018). Generally, studies conducted on stress in Construction have not involved other specialists such as Psychologists. Meanwhile, Psychology is a very useful discipline that can enhance a better understanding of interpersonal and organisational factors that impact on peoples' lives as well as stress outcomes, particularly emotional distress (anxiety and depression). Thus a study was commenced, aimed at investigating how stress develops and manifests in the construction setting. The purpose of this ongoing study is to better understand the culture and interpersonal behaviours associated with stress in different construction contexts or organisations. This paper is based on the ongoing study.

METHODOLOGY

Literature on stress in the Construction field presents some criticisms at the methodological and theoretical level, including an absence of a precise competence to assess and treat stress at the work setting, the prevalence of descriptive study designs (surveys) and the recurrent use of ad-hoc instruments (questionnaires, structured scales and self-report measures) without well specified psychometric properties (e.g. Chan et al., 2014). Literature also urges a focusing of the research lens on relationships, systems, roles, culture and behaviours of people within Construction organisations, rather than the mere collection of individual self-report perceptions based on the personal views of the respondents (Chinyio et al., 2018). To build on the existing understanding of this area, it is our trust that a qualitative perspective, and particularly ethnography, offers an intellectual paradigm to better understand organizational dynamics and their impact on the development of stress in the Construction industry.

Ethnographic Inquiry

The current study was a case study conducted using the ethnographic methodology: a process of assembling different types of information about a specific group or culture, and the product that draws together actions, facts, and behaviours into a representative snapshot (Hammersley and Atkinson, 1995). During an ethnographic work, a broad fieldwork describes the production of a cultural and ecological interpretation of environments. To do so, an intensive work is undertaken to grasp the participants' perspective. An important principle in ethnography is that knowledge is grounded in the experiences and culture of the social group members. Ethnography permits the researcher to observe, experience, and engage in dialogue with immediacy as events unfold, allowing insightful knowledge into the behavioural underpinnings of interpersonal dynamics in Construction organizations.

Participants

Three organisations were involved in the study and were sourced through purposive sampling via their Human Resources departments. A meeting with the chief executive officer (CEO) ensued and, following agreement for access to the organization, the first author was introduced by the CEO to all full-time employees in person. Participants were provided with a verbal and written briefing about the study rationale, methods, and potential uses of data including all the necessary information about confidentiality and privacy. Our University's ethical approval was obtained prior to initiating the practical study procedures.

Observations

The great part of the data collection period was structured in observations which ranged between 2 and 4 hours per day in a period lasting 6 months. A total of 10 sites were explored and; on each site, the observations involved activities by 5 to 20 people.

Interviews

Five to ten interviews (by means of unstructured and semi-structured questions as well as colloquial discussions) were conducted on each site, as broken down on Table 1. While the unstructured and the colloquial discussions varied widely throughout all the ethnography observations, the semi-structured interviews were conducted more precisely with 16 people: four of these working in offices at the managerial level and 12 working on construction sites. Three of the interviewees were women: one was office-based while two were site-based.

Table 1: Data collection through interviews and discussions

Company	Nature of construction tasks	Company size	Semi-structured interviews	Unstructured interviews	Colloquial discussion
Company No.1	Housing Maintenance	Medium (< 250-500)	5	3	7
Company No.2	Social Housing	Large (> 500)	10	8	10
Company No.3	Health & safety services	Small (<100)	1	0	1

Data analysis

An ethnographic content analysis was performed. This analysis refers to an integrated method, for locating, identifying, retrieving, and analysing documents for their relevance, significance, and meaning. The emphasis is on discovery and description of contexts, underlying cultural

descriptions and discern meaning, and theoretical relationships.

FINDINGS AND DISCUSSION

We did not explore the management processes promoted in the 3 organisations in detail. However, from the interviews made, we found two main types of management styles across the three organisations:

1- *Coaching style*: professional managers had a great responsibility to train and develop workers to an optimum performance level. The techniques used in this style include regular informal conversations with employees, immediate praise and feedback, frequent reviews and consistent mentoring.

2 - *Participative style*: this style was particularly used when someone in a leadership position wanted to get employees involved in decision-making (e.g. for a demolition plan, working with a shaky wall).

Stress factors

Despite the different experiences between office based and site based workers, the meaning and implications of stress which they proffered were very close to each other. The main categories of stress factors identified were: uncertainty, team working, handling responsibilities, power and leadership.

Time and workload

One of the most visible sources of stress for both office and site based construction workers related to uncertain working conditions in terms of (1) limited time, (2) poor communication and (3) limited resources:

(1) *Limited time*. For different managers stress was attributed to the amount of activities to do in a very short space of time where their working hours were often not sufficient to satisfactorily complete their job-related activities. Other problems were attributed to unexpected changes of the work plan. Generally, each activity is precisely organized and defined in advance. However, once a site is operational, unexpected changes occur frequently due to e.g. encountering uneven grounds, watercourses and asbestos. These problems are managed by both office managers and site workers. Some construction workers reported that covering the required activities within the deadlines was often a source of stress. The perception of excessive workload forced some construction workers to work extra-hours or during weekends, which interfered with their personal relationships and responsibilities. Almost all the construction workers encountered talked about the high number of hours on site. This prolonged presence was central to the stress that many of the construction workers experienced. According to one interviewee: “we work all day all together despite the weather, and this is exhausting”. This constancy of presence was sometimes linked to respecting deadlines, and the responsibility of conveying all this information on time to their chiefs or managers in charge.

(2) *Communication*. Construction workers are positioned in a particular way within the workplace’s institutional hierarchy. Conducting all the activities and managing communication within this hierarchy may be a source of stress. Many construction workers on site identified lack of communication from bosses, clients, and the leadership team as a significant source of

stress. This included lack of advice and feedback around job performance, scarce communication around negotiations and concessions and lack of diligence to explain certain critical working conditions. This has significant consequences like unsafe actions and arbitrary behaviours. Construction workers, in general, indicated that poor communication created a chaotic work environment including constant interruptions and filthy work conditions. One interviewee explained that: “*When you start a job, I receive instructions from the clients and no negotiations are possible: in these cases you work only to finish your job ASAP and this is very dangerous*”.

(3) *Limited resources*. Some construction workers on site highlighted the lack of access to basic supplies and facilities (e.g., suitable kitchen, toilet paper, soaps) as a significant source of stress. They generally brought food from home and warm it up on site. While the quality is not very much evaluated, the impact of such food on the body is markedly considerable: the food must give energy and heat/coolness (depending on season) very soon.

The culture and interpersonal behaviours in the Construction industry is that you have the ability to partake in manual labour and withstand long working hours and you do not care about working facilities. However the construction site environment creates personal stress because job activities and responsibilities are perceived as unreasonable and unequal.

Team working

Construction workers operate with their colleagues both in peculiarly close proximity and spatially. Working closely together for 7 to 8 hours a day means that relationships with colleagues are markedly significant. According to one interviewee: “in this type of work, we all need to learn to get along”.

For people working in offices, their activity was strictly connected with the process of work of their colleagues. Even when they did not share a physical space, they shared temporal proximity because they worked on similar deadlines, with almost the same clients and the outcomes of their activities were intertwined.

The spatiotemporal proximity provides a consistent source of stress. Temporally, construction workers work with each other for extended periods of time and; spatially, they share a very high level of proximity. They thus need to have trustworthy relationships with each other in order to perform risky activities more effectively as most of the activities have to be performed in teams where coordination, trust and sharing information are indispensable. However this relevant aspect is often neglected. The culture and interpersonal behaviours in construction activities take for granted the aspect of spatiotemporal proximity, but it is a core aspect of undertaking activities and procedures in especially dangerous or confined areas.

Handling responsibilities

Handling responsibilities was often perceived as a burden which e.g. included monitoring or supervising the work of other colleagues (depending on the role covered), and in some cases, actually taking the high responsibility of doing some activities autonomously. Taking high responsibility happens in two main ways, when: (a) colleagues are new learners to the field (e.g. trainees), and the safety of the activities to be done depends on the construction workers with more experience; and (b) particular situations, like emergencies or last minute clients’

requests to finish work as soon as possible. During emergencies, negotiating a power-based hierarchy has to be taken on in order to get the work finished. This creates stress and anxiety. One of the office based workers offered a detailed account of his sense of burden for his responsibility when you have to respect all the clients' expectations: "*You need to be precise, quick and kind at the same time but you actually are worried, in apprehension and nervous*". Similarly, a worker on site described his frustration as, when "*you are working in a house, you have the responsibility to do a good job and the responsibility to finish ASAP for respecting clients' expectations*".

The interpersonal behaviours in the Construction industry underpin the idea that the 'customer is king'. The quality of own work is a matter of honour as well as the respect of deadlines. This representation determines not only a very high sense of responsibility in workers but also much stress including emotional problems (anxiety, nervousness), little clarity and a sense of dissatisfaction.

Power and leadership

Construction workers expend considerable mental and physical energy daily on their particular activities. The process of interacting and negotiating with colleagues, supervisors, site managers and more experienced colleagues contributes much to their stress. A common cliché among construction workers is to express their own opinions about how to do a certain activity, or the way to solve a problem. A large amount of these opinions and views are often considered counter-productive for decision processes and this adds to the high stress. This behaviour is often a source of discussions about power and management.

Office managers are apparently in control, but construction workers also exert a considerable amount of control over their activities. However, when social relations are taken into account, the two kinds of control are very different. Office and site managers have an explicitly specified and higher position in the organisational hierarchy, which entails a more recognizable role in the decision-making tree as well as much higher financial remuneration for their work. Conversely site workers (and sub-contractors) occupy a much more ambiguous location in the hierarchy and their attitudes and behaviours of expressing continuous opinions are seen as a source of higher stress. Certainly some decision-making procedures and rules indicate that this tier is below the office managers/site managers. Yet, this is not without ambiguity, because construction workers' lower power status is implicitly elevated when it comes to "getting the job done," especially in the case of emergencies or meeting last minute clients' requests. In addition, this ambiguity is exacerbated by the social positions of these workers: they are generally mostly self-employed and this means they are autonomous and independent of formal authority.

The culture and the organisational behaviour in the Construction industry are strongly impacted by the type of job contract and relationships therein. In a typical relationship, an employee contributes labour and expertise to an employer's endeavour and is usually hired to perform specific duties on a regular basis in exchange for compensation. However, this employee–employer relationship is unusual in the Construction industry because most of the workers are self-employed where respect for hierarchies may not count and communication with peer and supervisors may be confusing.

DISCUSSION

The goal of the current study is to gain a better understanding of the dynamics (particularly behaviours and cultural factors) related with stress development among construction workers. Essentially, the study is being conducted with a psychological orientation, a complete innovative perspective that is very careful to detect hidden actions, thoughts and representations to supplement the tangible and concrete determinants which have previously been reported in the Construction literature. First, a common argument of disparity emerged i.e. the demands of construction workers are perceived as overwhelming (e.g., work overload, pressures due to high responsibility) while the resources to meet these are perceived as particularly inadequate (e.g., lack of information, limited negotiations with the client, and few external resources). Lack of control and great autonomy is not so much a source of stress except in the context of job demands and decision making processes. Instead, a lack of equilibrium between perceived demands and resources was seen as an important contributor to construction workers' stress.

Some of the causes of stress described by our observations e.g. work overload, role overload and lack of resources are consistent with previous reports in literature (e.g. Bowen et al 2013). Perhaps, the difference between our findings and those of previous studies is our in-depth investigation about the cultural meanings and organisational behaviours causing stress. Construction work involves team-working where relationships assume a relevant position: trust, handling responsibilities and managing the level of power are fundamental dimensions of these relationships.

Stress is strongly attributed to the type of relationship. In this context, two important results emerged. First, the cultural approach of construction workers is peculiar and it reflects the idea of 'work as much as possible'. Construction workers tend to work incessantly and meet own professional goals promptly even at high cost to personal life, family and mental or physical health. This approach is also reinforced by self-employed contract jobs that are generally common in the construction industry. Second, the level of stress experienced by construction workers is strongly connected with their level of engagement and commitment: the more they are involved and committed in their job, the greater is their probability to be stressed. We found a positive association between these two variables in our study. The connection between the level of commitment and elevated stress is well documented in some domains, e.g. health (Gustafsson et al., 2010) while it is unreported in the construction discipline. Hence our practical findings are novel in terms of construction practice.

CONCLUSION

Our research established that stress is still prevalent in the construction industry. The sources of stress are known and identifiable. The stress experienced in the construction industry is remarkably intense as to cause apprehension, not only for the health of workers, but also for their continuing contribution to this sector. The harmful consequences of stress have an inexorable impact on the person, and on his/her context, that is on family, community and society. A general recommendation from the analysis of this study is to search for a greater multidisciplinary collaboration with other Professional Bodies (Particularly with psychology) as this is currently neglected. New multidisciplinary interventions in the challenges of construction should analyse not only the detrimental effects of stress but also promote healthy

conducts to cope positively with stress. These interventions should include the offering of individual and organisational resources: mental health programs, ergonomics solutions and trainings on communication abilities and organisational programs.

In addition, there are significant public health and policy implications associated with addressing the sources of construction workers' stress at both the individual and organizational level. At the individual level, it is fundamental to find a new strategy to allow workers to deal with stress issues quickly, particularly in preventing dangerous behaviours (e.g. use of drugs, or gambling) while guaranteeing competence, and privacy. At the organizational level, it is important to provide a continuum of services at the job place, including protective measures to prevent the predictable sources of stress (e.g., providing targeted support with direct access to psychological and counselling services). The organisational interventions should also include specific training activities for construction workers covering several aspects of relationships (e.g., assessable and transparent communication among staff members, assertiveness, equity in the system of hierarchies) to promote resilience, wellness, and enhanced job functioning.

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EVALUATION OF FATIGUE IN CONSTRUCTION WORKERS

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Worker productivity is influenced by the work environment, the physical and mental workload, and aspects related to worker physiology, which may or may not result in fatigue. This article seeks to evaluate and investigate factors that affect the fatigue of construction workers. The research method consisted of a data collection through two questionnaires: sociodemographic data and the Fatigue Assessment Scale for Construction Workers (FASCW), which were applied in three companies and to fifteen workers. In addition, heart rate (HR) measurements were taken from three workers. Among the results, the fatigue of the workers at the end of the workday was 18.60 on the FASCW scale, and the literature indicates that at 20 points workers begin presenting fatigue symptoms. Among workers who exceeded this level, there was a prevalence of physical fatigue, with leg and joint pain symptoms. In the analysis of variance, there was statistical significance between the variables "fatigue at the end of the day" and "age at start of work". With respect to the heart rate, the study enabled physical load to be evaluated indirectly, but the results were within the limits presented in the literature. In addition to the fact that the fatigue evaluation can be replicated at any construction site, some ergonomic improvements have also been proposed that seek to reduce stress at work, minimizing the risk of fatigue.

Keywords: Construction, Worker, Fatigue, Heart rate.

INTRODUCTION

Construction work is considered to represent a high risk for worker safety because of its nature, since its activities require greater physical effort and concentration, thus increasing the risk of accidents. This reality imposes work rhythms that tend to increase the levels of worker fatigue (Zhang et al., 2015; Powell and Copping, 2016). In this context, the role of ergonomics becomes essential to implement improvements in working conditions that may result in safety, comfort and health for the worker (Krüger and Coelho, 2006).

However, the productivity of the company depends on the performance of the worker, who in turn is influenced by the work environment, work post conditions, physical and mental load, intensity of the activity, and aspects related to worker physiology, such as fatigue. Fatigue is a factor that influences the occurrence of accidents and the level of productivity, since the rate of work accidents may increase due to fatigue (Costella, 1999).

Faced with this scenario, fatigue gains special importance as a factor that influences worker performance. In the international literature, few studies (Fang et al., 2015; Zhang et al., 2015)

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present specific methods to evaluate this subject, while in the Brazilian literature no recent studies have been found.

Considering this gap in the literature, therefore, the factors that influence the fatigue of construction workers were investigated regarding the most frequent symptoms so as to provide information and implement improvements for the work, benefiting both companies and workers.

LITERATURE REVIEW

Fatigue and its factors

Fatigue can be defined as an effect caused by continued work, weariness or exhaustion of physical and mental strength, which may lead to a temporary reduction in the ability to work (Iida, 2005; Halowell, 2010).

Muscle fatigue can be understood as a reduction in muscle performance after stress and also as a reduction in speed of movement. General fatigue, on the other hand, is characterized as a general feeling of tiredness, leaving the person without motivation to perform physical or mental activities. Tiredness, in turn, discourages overloading, paralyzing activities to restore normal body processes (Kroemer and Grandjean, 2005; Iida, 2005).

Fatigue is caused by a set of factors that range from worker physiology to psychological, environmental and social factors. These factors can cause a reduction in cognitive functions, thus affecting the execution of tasks (Iida, 2005; Powell and Copping, 2016).

In physiology, fatigue is more easily identified, since it directly affects the muscles (Iida, 2005; Powell and Copping, 2016). Fang et al. (2015) emphasize that activities such as lifting and transporting heavy materials are causes of muscle fatigue and that the degree of fatigue is directly related to human error rates.

As for the symptoms of psychological fatigue, these are more dispersed and occur broadly as a feeling of general fatigue, reducing motivation to work. Environmental and social factors, in turn, are related to the conditions offered at work, including lighting, temperature and noise, or the relationship with the work team (Iida, 2005; Kroemer and Grandjean, 2005). Another factor that may influence fatigue is the circadian cycle, which affects the individual's ability to adapt to the work demands (Hallowell, 2010; Guimarães et al., 2013).

Individual factors, such as, lifestyle and worker health, have a strong influence on this ability. Age should also be considered, since over the years the individual tends to lose cognitive capacity, and a mismatch between the work demands and the abilities to perform these tasks may occur (Tuomi et al., 2001; Chang et al., 2009; Hallowell, 2010).

Methods to measure fatigue

There is still no fully effective method to measure fatigue, but there are methods that evaluate some fatigue indicators (Kroemer and Grandjean, 2005). Muscular fatigue can be assessed through several clinical methods. Sommerich et al. (1993) point to the efficacy of using electromyography (EMG) to evaluate muscular activity. Another method to evaluate fatigue is measuring the heart rate. It is important that the assessment is done by comparing the heart rate before, during and after the activity (Kroemer and Grandjean, 2005). However, the complexity

of the nature of fatigue makes it difficult to use clinical methods to measure it, especially in civil construction.

Fatigue can be measured through questionnaires in which the worker gives his opinion about his level of fatigue (Zhang et al., 2015). Techera et al. (2016) state that there are three potential tools: SOFI (Swedish Occupational Fatigue Inventory), CIS-20 (Checklist Individual Strength-20) and VAS-F (Fatigue Subscale of the Visual Analogue Scale).

In the absence of a specific questionnaire for construction workers, Zhang et al. (2015), developed a multidimensional questionnaire, capable of assessing the degree of fatigue of these workers. This is the Fatigue Assessment Scale for Construction Workers (FASCW), which seeks to evaluate the relationship between physical and mental fatigue and performance in construction workers.

The FASCW can be considered an instrument capable of evaluating fatigue and understanding its symptoms in construction workers (Zhang et al., 2015), results that are corroborated by Li et al. (2016). In addition, a simulation study associated with FASCW reported that increased worker fatigue levels coincided with errors in task execution (Fang et al., 2015).

METHODOLOGY

Data was collected through two questionnaires: sociodemographic data, including questions about the work, such as working hours and position held, and social habits such as drinking and smoking; and the application of the Fatigue Assessment Scale for Construction Workers (FASCW) questionnaire.

The FASCW questionnaire has 10 questions for assessing fatigue. Each of these questions has 5 possible answers: 1 - not at all, 2 - slightly, 3 - a little, 4 - a lot and 5 - completely. The sum of the results of the questionnaire establishes that the minimum level is 10 points, that is, no fatigue symptoms, and the maximum is 50 points.

The study population consisted of 15 construction workers, occupying the role of mason, hodman and carpenter, who developed masonry, mold production and frame assembly activities. There were 5 workers in each of the 3 companies in the municipality of Chapecó, identified as companies A, B, and C, which were engaged in vertical construction works with more than 10 floors. The selection of the participants was done through a non-probabilistic sample for convenience. This research was registered and approved by the Ethics in Research Committee of Unochapecó (CAAE No. 71078417.6.0000.0116).

Three applications of the FASCW questionnaire were carried out for each worker. After an explanation of the research objectives, a sociodemographic questionnaire was applied followed by the first application of the FASCW (at around 7:30 a.m.). The second application of the FASCW occurred during the performance of the activities (at around 11:30 a.m.). The third and last application was done at the end of the day (at 5:30 p.m.).

Three workers from company B were selected to perform heart rate (HR) measurements as an indirect method of evaluating the physical load, using portable monitors of the Polar brand, model RS400. This device consists of a transmitter unit with electrodes attached to the thorax, below the thoracic muscles, kept in place by an adjustable elastic band. First, the workers' resting heart rate was recorded. The equipment was attached to the worker, who remained

seated for 10 to 15 minutes, after which the resting HR was taken. The equipment recorded the HR monitoring during one shift while the activities of the worker were registered through observation.

The working pulse (WP), which consists of the difference between the mean HR during work and the resting HR, was measured and used to evaluate the workers. Another assessment that was used jointly was the maximum aerobic capacity (MAC).

The data of the questionnaires were analyzed through descriptive statistics with the software Statistical Package for the Social Sciences (SPSS) v. 20, being organized according to the type of variable, arranged in tables and graphs.

FINDINGS, ANALYSIS AND DISCUSSION

Evaluation of worker fatigue

When evaluating the group of workers, mean fatigue at rest was 13.47 ($s= 5.96$), a similar value to mean fatigue during activities ($M= 13.33$, $s= 5.81$). Fatigue at the end of the workday was $M= 18.60$ ($s= 6.00$). In all three measurements, the fatigue value did not exceed 20 points. According to Fang et al. (2015), fatigue levels below 20 do not pose a risk to worker safety, while level 20 is considered the critical point where fatigue effects begin to emerge.

Just as in the study by Fang et al. (2015), an increase in the level of fatigue could be observed as the working day progressed. In the assessment of the outcome of the fatigue responses at the end of the workday, the greatest fatigue complaints were related to leg pain, body movement, muscles and joints.

The majority of the workers had fatigue oscillations from the initial phase of the work until the end of the workday. Worker 15 was the only one to declare fatigue after the first application of the questionnaire, while worker 14 was the only one to show no fatigue in any of the applications. Figure 1 shows the workers who exceeded fatigue level 20 at the end of the day.

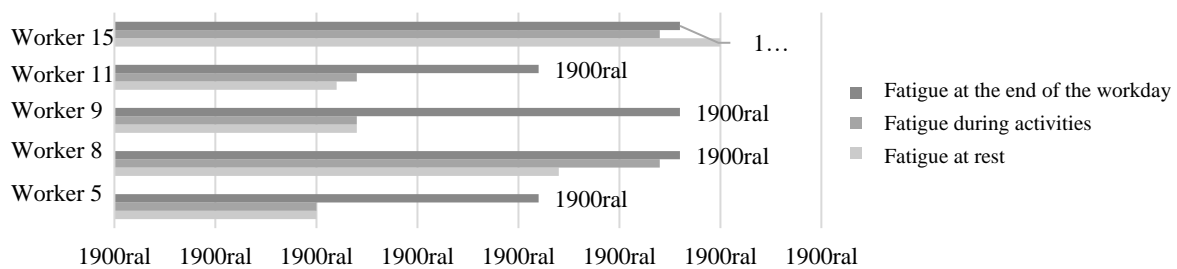


Figure 1: Fatigue levels according to FASCW

The level of fatigue among the workers of company B ($M= 21.2$) was higher than that of company A ($M= 16.8$) and company C ($M= 17.8$). Although the difference between the groups was not statistically significant, in company B there was no rack lift to assist in the displacement of employees between the floors, and some employees reported that going up and down the stairs during the day increased fatigue and was an aggravating factor of the physical load, which can generate fatigue.

Regarding age, it was found that the group of workers with the highest average fatigue was in the 30 to 39 age group ($M= 21.3$), while the group of 20 to 29 years had $M= 18.0$ and 40-49

years $M= 18.2$. It should be noted that the group with more than 50 years presented the lowest mean ($M= 17$), fluctuating at fatigue levels of 15 to 19. This result can be explained by the accumulated experience of the worker over the years, providing better ways to develop his work, thus reducing the risks to his health (Martinez et al. 2016).

Among the functions carried out, the group with the most fatigue were the hodmen ($M= 23.0$), followed by the masons ($M= 20.0$) and the carpenters ($M= 14.0$). The main problems faced by hodmen are related to an inadequate posture and excessive weight lifting, which can cause fatigue.

Indirect evaluation of the physical load through the heart rate

Based on the heart rate measurements, the working pulse (WP) and MAC were calculated. The maximum acceptable working pulse (WP) indicated by the literature is 35 pulses, while the MAC is 35% (Guimarães et al., 2013). As can be seen in table 1, none of the workers exceeded the limits established for WP and MAC. Worker 9, however, exceeded the reference value for fatigue level in the fatigue measurement at the end of the workday.

Table 1: Comparison of fatigue, WP and MAC (N = 3)

Worker	Age	Fatigue at the start of the day	Fatigue during activities	Fatigue at the end of the day	Working pulse	MAC
Work. 7	41	10	10	14	19	17.92%
Work. 9	28	12	12	28	22	16.42%
Work. 10	45	18	16	16	13	12.50%

Workers 7 and 9, both masons, had a WP and MAC that was higher than that of worker 10, a carpenter. In the study by Saurin et al. (2004), where scaffolding work was evaluated, some workers exceeded the WP and MAC limits in some activities. In the study by Visoli (2010), only 1 worker exceeded the limits in the evaluation performed in the afternoon, and for the morning period all workers were within the limits established by the literature. Both the WP and the MAC were observed to be dependent on the type of activity developed. Although worker 9 has the greatest fatigue and the highest working pulse during his fatigue assessment at the end of the day, his aerobic capacity is lower than that of worker 7.

During data collection, it was observed that company B starts its work routine at 7:30 a.m. and ends at 5 p.m. on Wednesday and Thursday, and at 4 p.m. on Friday. In addition, the company offers a 15-minute break on the morning shift, and a 1-hour break for lunch. As such, for the purposes of heart rate analysis, 3 work sessions were considered: in the early morning, before the break; at the end of the morning; and during the afternoon.

The heart rate means of each session were calculated and are shown in figure 2:

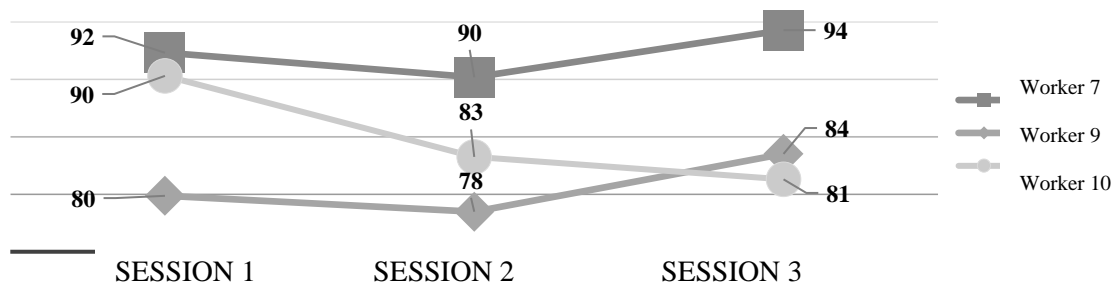


Figure 2: HR mean per work session

During the data collection of worker 7, the mean temperature of sessions 1 and 2 was 22.0°C, and the temperature in session 3 reached 27.4°C. For worker 9, mean temperature in sessions 1 and 2 was 21.4° C and in session 3 it reached 26.8°C. In the case of worker 10, the average was 18.6° C in sessions 1 and 2, and reached 22.8° C in session 3.

Guimarães et al. (2004) state that temperature is one of the factors that can influence workers' HR. In the case under analysis, workers 7 and 9 had an increase in HR in session 3, when the ambient temperature reached around 27°. On the other hand, worker 10, who presented a reduction in HR during the afternoon, was working at a temperature of around 22°C, and with a working day 1 hour shorter than other workers, these factors may have influenced the HR reduction.

DISCUSSION

The assessment of the fatigue of construction workers is an important ergonomic and worker health assessment. This indicator can be an alert for the management of workplace safety, suggesting the adoption of measures to increase the capacity of the worker to process risk information as well as measures to reduce the impact of fatigue on the workers (Fang et al., 2015). In this sense, the FASCW is a useful tool to employ in the scientific and professional environment to support fatigue management programs (Zhang et al., 2015). The prevalence of physical fatigue symptoms revealed by FASCW is corroborated by Chen et al. (2017), who indicated that physical fatigue was one of the most frequent physical symptoms in the participants of their study.

Analyzing a group of 15 workers, the mean fatigue at rest was 13.47, and at the end of the workday the mean fatigue increased to 18.60, not reaching the critical point of "20" on the FASCW scale. Although the group did not present fatigue, five workers reached the critical fatigue point of 20, that is, they began to have the first symptoms of fatigue at the end of the workday. Another relevant data of the research was the indication that workers who started their activities very early, tend to suffer more fatigue during their work life.

This study showed there was no prevalence of the symptoms of mental fatigue. Zhang et al. (2015) explain that the FASCW has items relevant to mental fatigue, and that the mental health dimension deserves attention in the case of construction workers. The physical load, evaluated based on the heart rate, showed similar results, revealing that workers did not exceed their aerobic capacity, nor the tolerable working pulse limit. These results corroborate the application of FASCW for the three workers, since the reported fatigue levels fell within acceptable levels. On the other hand, the HR allowed for the observation that the break during

the work can reduce the physical load, that is, reduce the HR of the worker and, consequently, the incidence of fatigue. A study developed with industrial workers revealed that the need for rest is a factor that can minimize the effects of fatigue due to the recovery time (Moriguchi et al., 2011). This proposal is also in alignment with the study by Fang et al. (2015), which argues that work breaks to minimize the effects of fatigue are important actions in the safety management of construction workers.

Finally, some ergonomic improvements may be proposed. Company B takes a break from work in the morning and the HR heart rate data declined after this period. It is important that companies A and C could adopt these breaks, just as all companies should include a break in the afternoon as well. This way, they can contribute to the reduction of stress at work and therefore reduce the risk of the occurrence of fatigue.

Another improvement suggested for company B, is the use of the rack lift, which has the purpose of transporting people and materials. This way, the physical load imposed on the workers by the non-use of this equipment would be mitigated, since it would facilitate both the displacement of the workers between the floors of the construction project and the transportation of materials. As such, the workers would be less subject to the incidence of fatigue during the work shift.

CONCLUSIONS

The FASCW allowed to evaluate both physical and mental fatigue, and showed that in the workers under study there was a prevalence of physical fatigue, with symptoms relating to leg pain, body movement, muscles and joints.

The fatigue analysis of this study has limitations, since it was not possible to perform clinical evaluations of the workers. In addition, the fact that fatigue was evaluated according to the worker's own perception may be impaired, since the perception of fatigue may involve several elements, as explained by Aryal et al. (2017), who argued that general physical fatigue is more difficult to quantify than localized muscle fatigue, since it involves cardiovascular, metabolic and thermoregulation factors, among others.

Still regarding the limitations to the study, Zhang et al. (2015) warn that both the psychometric properties of female workers and the different cultural, ethnic and socioeconomic backgrounds of different geographic regions were not addressed in the original FASCW studies. In this sense, the participation of 15 Brazilian workers is not able to measure the applicability of this instrument, and future studies are recommended with a larger number of participants.

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INVESTIGATING PHYSIOLOGICAL STRAIN AS A RESULT OF SAFETY HELMET USE AND EXPOSURE TO AMBIENT HEAT ON CONSTRUCTION SITES

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Site managers very often have the arduous task of ensuring construction workers comply with PPE protocols. Several studies have indicated the reasons for this non-compliance with PPE protocols or total rejection of PPEs being discomforts associated with their use. PPE use is a very important aspect of safety discussions as it offers residual protection where all other controls have been expended. It is very often the most commonly available method of protecting employee safety in many developing countries. This paper investigates the discomforts associated with PPE use amongst construction workers, with the aim of identifying levels of physiological strain in users of the safety helmet. A field experiment involving the observation of volunteers' heart rate and body temperature patterns in the line of duty and semi-structured interviews were employed to obtain data in a multiple embedded case study. Although candidates described several discomforts they experience in the interview, their vital signs studied indicated insignificant physiological strain imposed on users of safety helmets. Construction managers need to concentrate efforts at ensuring psychological and physical comfort in a bid to ensure adequate compliance with PPE protocols

Keywords: Discomfort, Physiological strain, Personal protective equipment.

INTRODUCTION

Researchers have linked the major causes of construction accidents to human behaviour, difficult work site conditions, inadequate use of protective equipment, and poor safety management. These factors result in unsafe work methods, equipment and procedures (Haslam et al., 2005; Abdelhamid and Everett, 2000; Sawacha et al., 1999)

In the United States, only 64% of workers, on average, constantly wear the correct protection needed (OSHA, 2007, cited in Ahmed and Azhar, 2015). Millions of dollars are lost each year in the treatment of injuries resulting from preventable accidents. For example, refusal to wear a pair of proper gloves is responsible for a loss of 48 million dollars each year (ISEA, 2006 cited in Ahmed and Azhar, 2015).

In several countries there is poor compliance with PPE protocols in the construction industry. Several researchers attribute the reason for construction workers' refusal to use PPE to several discomforts associated with their use (Adade-Boateng et al., 2016; Tanko and Anigbobu, 2012). Research also suggests that these discomforts are usually experienced by users in hot temperatures of the tropics or hot climatic areas (Abeysekera and Shahnava, 1988). This research thus sought to explore the physiological implications of safety helmet use by construction workers in hot environments. It commences with a review of literature on clothing

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comfort which leads to the formulation a conceptual framework regarding the effect of using uncomfortable safety helmets in hot weather conditions on construction workers. The review is followed by the methodology applied. Subsequently, the research findings, discussion and conclusions are presented.

LITERATURE REVIEW

In recent times, consumers around the world demand comfort requirements of clothing aside their aesthetic characteristics. Thus, major marketers in the fiber and textile industry have identified comfort as one of the key attributes that affect consumers' desirability for apparels (Li, 2001).

Comfort is defined by Slater (1995) as 'a pleasant state of physiological, psychological, and physical harmony between a human being and the environment'. In a bid to show how important the environment is to a person's comfort, Slater (1995) further elaborates the three types; physiological comfort which is related to the human body's ability to maintain life; psychological comfort to the mind's ability to keep itself functioning satisfactorily with external help; and physical comfort to the effect of the external environment on the body. Comfort may be defined for this study as freedom from physiological, psychological and physical strain.

According to Li (2001), comfort is affected by the physical, social and cultural environments of a person. Comparing this assertion to Slater's (1995), we may infer that a person is comfortable when his physical, social and cultural environments do not affect his body's ability to maintain life (physiological comfort), nor his mind's ability to function satisfactorily (psychological comfort).

Construction workers in Ghana operate in a physical environment which is characterised by two main climatic regions; warm-humid climate and hot-dry climates. (Oppong and Badu, 2012). The hot-dry climates are characterized by very hot, dry air and dry ground. Day-time temperatures normally range between 27 and 49°C. Humidity is continuously moderate to low (Koenigsberger et al., 1974 in Oppong and Badu, 2012). The warm-humid climate is characterized by hot, sweaty and sticky conditions as well as continual presence of dampness. Air temperatures remain moderately high, between 21 and 32°C, with little variation between day and night (Koenigsberger et al., 1974).

Holmer (2006), purports that, due to the high level of protection required by personal protective clothing, heat exchange by sweat evaporation is drastically impeded. This results in considerable physiological strain in workers using protective clothing in hot environments leading to early onset of fatigue.

The study hypothesized that the discomforts experienced by construction workers could actually be physiological strain resulting from using uncomfortable safety helmets in hot climatic conditions.

This paper thus chronicles procedures conducted to investigate the presence of physiological strain amongst construction workers using safety helmets and working in hot weather conditions.

RESEARCH METHOD

Three construction sites in Ghana were selected for the study and were generally characterized by an active construction site, the strict enforcement of PPE protocol and the presence of diverse skilled workers. Volunteers were taken through a screening/pre-testing exercise where they had their blood pressure readings taken over a one-week period to ensure they were eligible (i.e. had no chronic illnesses, and were generally healthy adults for the study). Sixteen

(16) volunteers were finally selected to take part in the study. Site 1 had five (5) volunteers, site two had five (5) volunteers, and site 3 had six (6) volunteers. The first part of the study employed semi-structured interviews to elicit information from construction workers as regards the discomforts they feel while using safety helmets and how they manage the discomforts felt. A content analysis was done on the data collected during the first part of the study.

The second part of the study involved an observational field study conducted on the sixteen (16) volunteers in an effort to investigate physiological strain associated with the use of safety helmets. Volunteers in both Cases 1 and 2 were young men who fell within the age range of 20-39 years and had 5 to 10 years of working experience on the construction site. Case 3 had middle-aged volunteers with ages ranging between 40 to 49 years and with construction work experience above 15 years.

Physiological strain indicators, i.e. heart rates and body temperatures were measured concurrently on all three construction sites at set times within the day for five days. During this time air temperature and relative humidity readings were also taken. Physiological readings were entered into the physiological strain equation:

$$\text{Physiological Strain (PS)} = 5(\text{Tret} - \text{Tre0}).(39.5 - \text{Tre0})^{-1} + 5(\text{HRt} - \text{HR0}).(180 - \text{HR0})^{-1}$$

Where Tre = Core Body Temperature and HR = Heart Rate) (Moran, 1998) and the results rated on a universal scale of 0-10 as shown in Table 1.

Table 1: Scale for interpreting physiological strain

Strain	PSI
	0
NO/LITTLE	1
	2
LOW	3
	4
MODERATE	5
	6
HIGH	7
	8
VERY HIGH	9
	10

Physiological indicators of strain (heart rate and body temperatures) were measured with the use of well calibrated Sphygmomanometers (*OMRON HEM 907XL*), and non-contact infra-red thermometers (*RoHS AT-B886*). Ambient temperature and relative humidity readings were taken with a HOB0 Analogue temperature/relative humidity Data Logger.

FINDINGS AND DISCUSSION

Interview Responses

The interviewees complained of feeling intense heat inside the helmet, especially during very hot weather. According to them, coloured helmets accumulated more heat than their white counterparts and plastic harnesses were very uncomfortable in hot weather. One respondent who felt hot inside lamented,

“Some helmets have no ventilation holes...”. Another also remarked, *“I sweat more when I use it...”*.

Almost all the interviewees felt that ventilation holes on the helmets are not enough to allow

for sufficient aeration of the micro-environment within it.

Workers also complained that helmets usually did not fit their heads well. In addition to this, workers seemed to experience discomforts such as itching, and experience marks on their skin upon contact with the harness. According to one worker, *“my head is very small and so even though I adjust it, it keeps dropping down my face”*... Another lamented that *“my scalp itches when in contact with the harness”*.... This makes the harness within the helmet come into direct contact with the skin. One worker mentioned that helmets with fabric harnesses were usually more comfortable than those with the plastic ones.

The safety helmet is also considered quite heavy when worn by respondents. According to one worker, he feels like he is being punished whenever he has to carry the weight of the helmet about. Workers complained that the helmets get smelly sometimes. This may be a result of the constant use and exposure to sweat without a proper maintenance routine. Workers complained that using helmets with all these discomforts often resulted in early onset of fatigue and headaches before the end of each day. The top four discomforts described by the interviewees are; helmet being hot inside, helmets not fitting properly, helmets being heavy, contending with smelly helmets and headaches as a result of using them.

Workers intimated that the discomforts felt with using PPEs were sometimes quite unbearable and described several ways they dealt with these discomforts. For most workers, they took off the helmets at regular intervals while they worked especially when no one was watching. Interestingly one machine operator said *“I take it off, immerse it in water to cool it and put it back on”*. Another worker said *“I tie my head with a head scarf before wearing the helmet so it doesn't scratch me and leave marks on my skin”*.

The interviewees had a few recommendations for making helmets more comfortable. According to them, lighter helmets with fabric harnesses were more comfortable and so should be procured instead of the plastic ones. They asked also if helmets with more ventilation holes could be procured. Some also indicated that only white helmets be used on site because the coloured ones get hotter inside.

Measurement of Physiological Strain Indicators

For the second part of the study, ambient temperature and relative humidity readings during the 5-day period ranged between 26-36 degrees Celsius and 60-81% respectively across the cases.

Heart rate and body temperatures for the 16 volunteers are outlined in the tables 2, 3 and 4.

Table 2: HR and CBT readings from case 1

Description	6.30AM		8.30AM		11.30AM		5.30PM	
	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)
Mean	78.08	35.39	75.16	35.34	74.32	35.75	75.36	35.41
Median	78.20	35.26	75.20	35.44	73.00	35.64	76.60	35.38
Std. Deviation	6.17	1.19	8.10	0.76	6.86	0.76	7.79	0.92
Minimum	70.20	34.10	65.00	34.54	66.40	35.02	65.00	34.40
Maximum	86.20	36.84	85.20	36.24	82.60	36.84	84.00	36.54

Table 3: HR and CBT readings from case 2

Description	6.30AM		8.30AM		11.30AM		5.30PM	
	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)
Mean	67.72	37.98	67.84	36.12	69.88	36.25	71.48	36.13
Median	65.00	36.42	65.60	36.14	66.40	36.30	67.40	36.24
Std. Deviation	10.50	3.73	11.18	0.48	10.83	0.38	12.20	0.52
Minimum	58.40	35.92	57.60	35.52	59.00	35.78	60.80	35.26
Maximum	82.80	36.88	86.00	36.72	84.40	36.76	90.00	36.58

Table 4: HR and CBT readings from case 3

Description	6.30AM		8.30AM		11.30AM		5.30PM	
	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)	HR (beats/min)	CBT (°C)
Mean	71.20	37.09	70.43	36.09	71.83	37.02	71.93	35.93
Median	70.60	36.32	71.70	36.09	72.10	36.11	72.00	36.07
Std. Deviation	9.09	2.46	10.26	0.34	8.09	2.38	9.98	0.54
Minimum	59.20	35.66	57.20	35.62	60.20	35.80	59.20	35.00
Maximum	83.60	36.50	83.00	36.54	81.80	36.54	85.00	36.54

The Median values of heart rate and core body temperature variables were entered into the physiological strain equation index developed by Moran *et al.* (1998) and resulting values subsequently interpreted on the universal scale to determine if workers were subjected to physiological stress while they used helmets on construction sites in hot weather.

Average Physiological strain of workers measured within the different time spells/period is shown in table 5.

Table 5: Physiological strain values observed in the three cases within different time spells

Time spell/duration	Case		
	1	2	3
8.30AM - 11.30AM	0.14	0.27	0.05
11.30AM - 5.00PM	(0.17)	(0.05)	(0.05)
8.30AM - 5.00PM	(0.01)	0.23	(0.02)

Results obtained indicate that physiological strain for volunteers in all three cases fall under the “little or no strain” category (see Table 1) implying that construction workers experience little or no physiological strain while they work in hot weather using their safety helmets. Slater

(1985) asserts that Physiological comfort is related to the human body's ability to maintain life. Based on this assertion, we can safely infer that workers' life is not compromised while they work using safety helmets.

DISCUSSION

Heat stress may be described as the total load exerted on an individual as a result of his metabolic activities, environmental conditions and clothing worn. Physiological strain is the body's compensatory thermoregulatory response to this stress. Heat stress results in increased risk of frequency of accidents and therefore threatens the safety of workers. Additionally, heat stress increases the potential for heat-induced disorders such as heat cramps, heat exhaustion, heat stroke and effectively reduces worker productivity as work-rest cycles need to be employed to reduce heat strain (Gotshall et al., 2001).

Construction workers in hot climates are vulnerable to heat stress as they undertake several physically exerting tasks in hot and humid environments. The values of physiological strain recorded in this study (little or no strain) in spite of the hot ambient temperatures may be explained by acclimatization of the individuals involved in the study as explained by Gibson et al. (2015). Gibson et al., (2015), opine that, heat acclimation (HA) attenuates physiological strain in hot conditions via phenotypic and cellular adaptation.

While this information is welcoming, the issue of construction workers (especially those working in hot weather conditions) not using provided PPE remains a big challenge for the industry's safety performance.

Responses from the interviewees indicate a lack of psychological and physical comfort with using the helmets. According to Li (2001), Body-clothing interactions (both thermal and mechanical) play important roles in determining the comfort state of the wearer and external environments i.e. physical, social, and cultural also have great impact on the comfort status of the wearer. Unlike people working in an indoor environment, construction work environments are usually quite harsh and little can be done to alter the worker's external environment to ensure physical comfort. That notwithstanding, efforts can be made to enhance physical comfort within the micro-environment between helmets and the skin surface. Perhaps some consideration could be given by the procurement officers of construction firms, to the interviewees' suggestions on making helmets more comfortable. McPherson (2008) asserts that workers are more apt to use PPE that is comfortable. According to her, wearability/fit/compatibility and style factors should be considered as well in the selection of PPE, as this makes compliance more automatic, allow workers to express their individuality and give workers some control over how they look, without compromising safety.

McPherson (2008), again purports that PPE procured in consultation with users is more likely to be used. It would be prudent for Construction Managers to obtain feedback from workers on their user-experience with procured PPE, analyse and consider this feedback in subsequent procurements. In instances where workers complain intensely about discomforts with a particular PPE, management could provide alternative PPEs to workers, compare the user experience and use the information obtained to aid the procurement of user-friendly PPE. Such actions by management would boost worker confidence that their welfare is important and may just have a positive effect on psychological comfort.

CONCLUSION

Several studies have reported discomfort with PPE use as a reason for non-conformance with PPE protocols by construction workers. This study set out to investigate the presence of

physiological strain amongst construction workers using safety helmets in hot environments. Although construction workers mentioned several discomforts in their interview responses, results from physiological strain tests indicate that construction workers do not experience significant physiological strain as a result of using safety helmets in hot environments.

The findings obtained suggest that the hypothesis tested (i.e. the discomforts experienced by construction workers could actually be physiological strain resulting from using uncomfortable safety helmets in hot climatic conditions) is not supported by reality. However, further testing in other contexts or settings would be useful to reach firmer conclusions. It must be noted that the study was limited to sixteen volunteers working in the warm-humid climatic region of a country. Data was taken over a 5-day period. It is not known if alternative results may be obtained from workers from a longer duration of study or in the hot-dry climatic region.

It is recommended that with the absence of physiological discomfort, physical and psychological comforts should be enhanced to encourage full compliance with protocols regarding safety helmets. Physical comfort can be enhanced through the selection and procurement of user-friendly safety helmets taking into consideration user-complaints summarised as a lack of comfort fit and style in the helmets given expressed by interview respondents. Psychological comfort on the other hand may be enhanced through a behaviour-based approach which has been shown in several researches to be effective in improving safety performance.

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IDENTIFYING INTERPERSONAL STRESSORS–STRESS RELATIONSHIPS FOR EXPATRIATED HONG KONG CONSTRUCTION PROFESSIONALS IN THREE CHINESE CITIES

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It has been common for Hong Kong (HK) construction professionals (CPs) to work in various Chinese cities, especially in economically-developed cities such as Beijing, Shanghai and Macau. Expatriated HK CPs need to interact and cooperate with their local colleagues to ensure project success, causing them to face prominent interpersonal stressors. The current study identifies the relationships between interpersonal stressors and stress for them in three Chinese cities. A questionnaire survey with purposive sampling was conducted along with sophisticated statistical analyses. The final results show that: 1) there were significant differences in the irresponsibility and passiveness of the local colleagues between the three Chinese cities; 2) the local colleagues in Beijing had a more significant lack of contractual concept than those in Macau; 3) expatriated HK CPs were unhappy with their local colleagues' irresponsibility, disloyalty and lack of contractual concept; 4) the expatriated HK CPs were more anxious about their local colleagues' passiveness and lack of foresight; and 5) expatriated HK CPs' worry significantly and positively correlated with local colleagues' passiveness. Practical recommendations are made to tackle the interpersonal stressors, such as the cultivation of contractual spirit, educating local colleagues, and so on. Future research directions are also suggested.

Keywords: Cities, Construction Professionals, Expatriated, Interpersonal Stressors, Stress

INTRODUCTION

It has been widely recognized that working in the construction industry is very stressful for the construction professionals (CPs) (CIOB, 2006; Leung et al., 2015). Stress could lead to negative consequences for both individual CPs and the construction organizations (e.g., low productivity, absenteeism and health claims, together costing 200-350 billion US dollars in the USA) (Nixon et al., 2011). With globalization and intensified regional interactions, more and more Hong Kong (HK) CPs have been expatriated to work abroad especially in the greater china region (Wong et al., 2004). According to the statistics, around 30% of HK CPs work in Mainland China (Census and Statistics Department (CSD, 2011). In general, the CPs' stress level often increases after expatriation, because of the need to adapt to various differences between their home and the host country/district (Chen et al., 2009).

The success of any construction project often relies on efficient and effective project management teamwork, while dysfunctional interpersonal interaction has long been stressful in the construction industry (Brockman, 2014; Leung et al., 2015). Moreover, facing interpersonal stressors may also be a common issue for expatriated HK CPs in the three Chinese cities, because they have to deal with their local colleagues whose professional skills and

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practices are usually different (e.g., HK CPs are used to following the working systems /procedures, while people in mainland China often emphasize relationships) (Ren et al., 2009).

China is a big country, having a size of over 960 million km² and various policy systems (e.g., central government and the special administrative region in Macau). Beijing, Shanghai and Macau, which are respectively located in the North, Middle and South parts of the Greater China Region, are among the cities accommodating the highest numbers of expatriated HK CPs (CSD, 2011). All three cities are economically developed, but expatriated HK CPs may be facing different interpersonal stressors in the three cities. The objective of the current study was to: 1) identify the differences in the interpersonal stressors for expatriated HK CPs in the three Chinese cities; and 2) establish interpersonal Stressors–Stress relationships for these.

LITERATURE REVIEW

Stress

Stress has been commonly regarded as a wide range of individual responses to overwhelming demands (Nixon et al., 2011). When facing stressful events, it is common that several emotional stress symptoms manifest in human beings, such as unhappiness, anxiety and worry (Ganster and Rosen, 2013). Unmanageable stress can develop into morbidity and even mortality for individuals, and in a working context, it also results in significant losses to organizations, such as low productivity, high absenteeism and accidents (Finney et al., 2013).

Interpersonal Stressors

The source of stress has been defined as stressors (Ganster and Rosen, 2013). The complicated nature and huge scope of construction projects make it necessary for the CPs to work with different parties to ensure project success, which often causes prominent interpersonal stressors to manifest (Brockman, 2014). Moreover, the differences in various aspects of working and private life between HK and the three Chinese cities may render a lot of difficulties and problems through the interactions between expatriated HK CPs and their local colleagues, making the interpersonal stressors more demanding. Based on the literature (Leung et al., 2012), the interpersonal stressors for expatriated HK CPs could be generally divided into two groups, including the demanding *personal traits* and inadequate *professional skills* of local colleagues.

Expatriated HK CPs often comment that the characteristics of local colleagues are *utilitarianism*, *irresponsibility*, *stubbornness*, *passiveness*, *lack of foresight* and *disloyalty* (Leung et al., 2012), requiring them to adjust to the *personal traits* of local colleagues with whom they need to communicate intensively and cooperate closely. However, expatriated HK CPs may be unhappy if they have to deal with the dysfunctional personal traits of their local colleagues. Both expatriated HK CPs and their local colleagues should have certain *professional skills* for ensuring construction project success. However, local colleagues' inadequate professional skills, such as *incapability*, *lack of professional knowledge* and *lack of contractual concept*, could cause difficulties to the expatriated HK CPs at work and lead them to worry about project success.

CONCEPTUAL MODEL

Based on the literature review, a conceptual model for the interpersonal stressors–stress relationships has been established for expatriated HK CPs in three Chinese cities (i.e., Beijing, Shanghai and Macau) (see Figure 1). It shows that interpersonal stressors, including the personal traits and professional skills of local CPs, are related to the stress symptoms of the expatriated HK CPs in the demanding construction industry in Beijing, Shanghai and Macau.

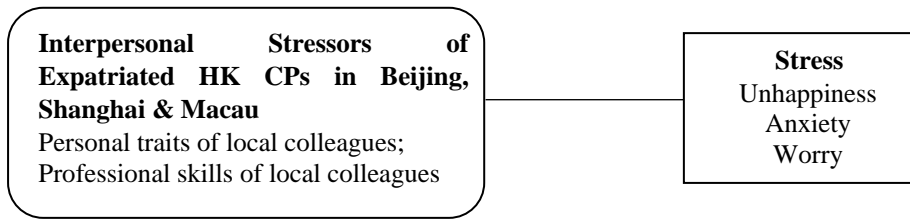


Figure 1: A Conceptual Interpersonal Stressors–Stress Model for Expatriated HK CPs in three Cities

RESEARCH METHOD

A questionnaire survey was administered among expatriated HK CPs working in the three cities in order to identify the differences in interpersonal stressors and the hypothesized interactions between interpersonal stressors and stress for these. The questionnaire consisted of questions extracted from validated scales, concerning the expatriated CPs' personal background, interpersonal stressors and stress (e.g., Maslach et al., 1996; Leung et al., 2012). Respondents used a seven-point Likert-type scale, ranging from 1 (strongly disagree/rarely true) to 7 (strongly agree/totally true), to rate their agreement with statements about their stressors and stress.

The participants were intentionally selected for the current study to ensure that: 1) they were expatriated HK CPs working in one of these three cities at the time of the study; 2) they have practical working experience of both HK and Chinese cities; and 3) they were working for a major construction organization (e.g., developers, consultants or contractors). Of the 400 questionnaires distributed, 87 were returned, representing a response rate of 21.7%. Among respondents, 43.7% were expatriated to work in Shanghai (i.e., Middle), 28.7% expatriated to Macau (i.e., South), and 27.6% to Beijing (i.e., North). In terms of age, 47.1% were aged between 40-49, 25.3% were aged between 30-39, 13.8% aged between 20-29, and 12.6% older than 50. The duration of time spent living in the expatriated city was as follows: 39.1% of participants had lived in the expatriated city for 1-5 years, and 32.2% for 5-10 years.

RESULTS

Analysis of variance (ANOVA)

To examine the differences in interpersonal stressors, an ANOVA analysis was carried out to compare the interpersonal stressors for expatriated HK CPs in the three Chinese cities. Nine items of the interpersonal stressors were compared, and the significant differences in specific stressors for expatriated HK CPs working in the three cities are highlighted below in Table 1. The personal traits of local colleagues include six aspects, including *utilitarianism*, *irresponsibility*, *stubbornness*, *passiveness*, *lack of foresight* and *disloyalty*. The cross-cities comparison shows that the *irresponsibility* of local colleagues in Beijing was significantly higher than in Shanghai (mean difference = 1.018, $p < 0.014$) and Macau (mean difference = 1.073, $p < 0.019$). The *passiveness* of the local colleagues in Beijing was also significantly higher than those in Shanghai and Macau, with the discrepancy at 1.376 ($p < 0.001$) and 0.854 ($p < 0.030$), respectively. With regard to professional skills, expatriated HK CPs only rated *lack of contractual concept* significantly differently in Beijing and Macau, with a positive discrepancy of 0.921 ($p < 0.046$).

Table 1: Comparison of the Interpersonal Stressors between Expatriated HK CPs in Different Cities

	One-way between-groups ANOVA					Post-Hoc Test for Significant Differences				
	Org.	Mean	S.D.	F (ANOVA)	Sig. (ANOVA)	Sig. (Levene)	Diff. group	Meandiff.	S.D.	Sig.
Stressors										
Personal Trait										
1. Utilitarianism	Beijing	4.783	1.757							
	Shanghai	4.816	1.312							
	Macau	3.958	1.197							
	Beijing	4.833	1.404	5.083	.008	.332	Shanghai	1.018*	.355	.014
2. Irresponsibility	Shanghai	3.816	1.270				Macau	1.073*	.389	.019
	Macau	3.760	1.451							
	Beijing	4.783	1.650							
3. Stubbornness	Shanghai	4.237	1.261							
	Macau	4.167	1.204							
	Beijing	5.417	1.316	7.255	.001	.169	Macau	1.376*	.367	.001
4. Passiveness	Shanghai	4.895	1.311				Macau	.854*	.331	.030
	Macau	4.040	1.207							
	Beijing	5.043	1.492							
5. Lack of foresight	Shanghai	4.368	1.460							
	Macau	4.167	1.373							
	Beijing	4.333	1.551							
6. Disloyalty	Shanghai	4.368	1.384							
	Macau	3.560	1.261							
	Beijing	4.458	1.215							
7. Incapability	Shanghai	4.263	1.245							
	Macau	4.280	1.487							
	Beijing	4.208	1.062							
8. Lack of professional knowledge	Shanghai	3.763	1.422							
	Macau	4.040	1.338							
	Beijing	5.042	0.999	3.032	.054	5.675	Macau	.921*	.381	.046
9. Lack of contractual concept	Shanghai	4.703	1.392							
	Macau	4.120	1.509							

Correlation Analysis

Correlation analysis was used to investigate the strength and direction of the relationships between interpersonal stressors and stress for expatriated HK CPs in the three Chinese cities (Pallant, 2011). To ensure the reliability of the research results, only significant relationships (at 0.05 or 0.01 level) confirmed by expatriated HK CPs from at least two cities were considered (between-projects triangulations) (Cooper and Schindler, 2006). The results are presented in Table 2, which shows that expatriated HK CPs' *unhappiness* positively correlated with local colleagues' *irresponsibility* (Beijing: 0.414, $p < 0.05$; Shanghai: 0.509, $p < 0.01$), *disloyalty* (Beijing: 0.595, $p < 0.01$; Shanghai: 0.367, $p < 0.05$; Macau: 0.417, $p < 0.05$), and *lack of contractual concept* (Beijing: 0.433, $p < 0.05$; Shanghai: 0.410, $p < 0.05$). Their *anxiety* was positively related to local colleagues' *passiveness* (Beijing: 0.530, $p < 0.01$; Shanghai: 0.438, $p < 0.01$; Macau: 0.460, $p < 0.05$), and *lack of contractual concept* (Beijing: 0.506, $p < 0.05$; Macau: 0.426, $p < 0.01$). Their *worry* positively correlated with local colleagues' *passiveness* (Beijing: 0.444, $p < 0.05$; Macau: 0.673, $p < 0.01$).

Table 2: Congruence of the Correlation Results between Three Cities

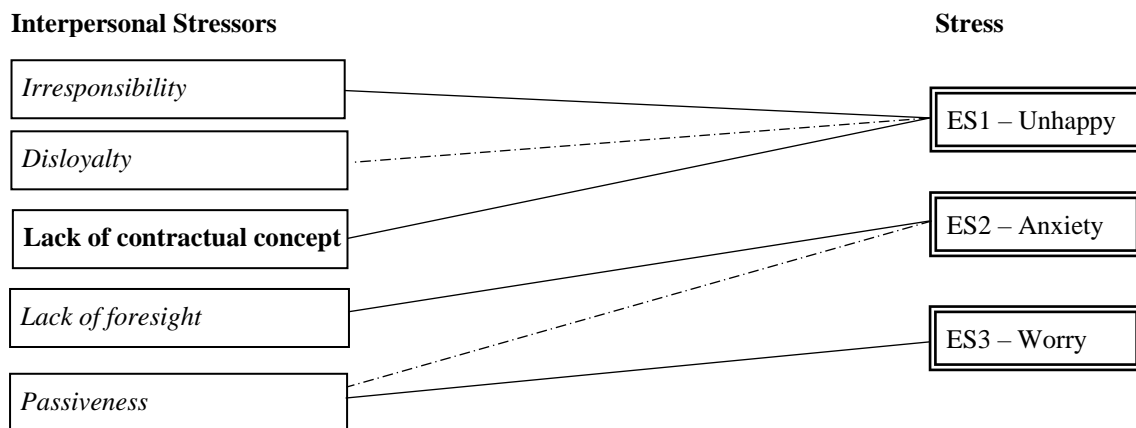
Correlation relationship	Beijing	Shanghai	Macau
1.Expatriated HK CPs' unhappiness and irresponsibility of local colleagues	.414*	.509**	.148
2.Expatriated HK CPs' unhappiness and disloyalty of local colleagues	.595**	.367*	.417*
3.Expatriated HK CPs' unhappiness and lack of contractual concept of local colleagues	.433*	.410*	.362
4.Expatriated HK CPs' anxiety and passiveness of local colleagues	.530**	.438**	.460*
5.Expatriated HK CPs' anxiety and lack foresight of local colleagues	.506*	.179	.426*
6.Expatriated HK CPs' worry and passiveness of local colleagues	.444*	.189	.673**

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

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

DISCUSSION

Three out of nine interpersonal stressors were found to be significantly different for expatriated HK CPs among three Chinese cities, including local colleagues' *irresponsibility*, *passiveness*, and *lack of contractual concept*. The interactions between interpersonal stressors and emotional stress for expatriated HK CPs are also confirmed and presented below in Figure 2: 1) expatriated HK CPs' *unhappiness* is positively related to local colleagues' *irresponsibility*, *disloyalty*, and *lack of contractual concept*; 2) their *anxiety* has a positive relationship with the local colleagues' *passiveness*, and *lack of foresight*; and 3) expatriated HK CPs' *worry* is positively correlated with local colleagues' *passiveness*.



Note: - - - - - significant relationship confirmed by expatriated CPs in all three cities

————— significant relationship confirmed by expatriated CPs in either two cities.

Xxx - personal traits stressors

Xxx - professional skill stressors

Figure 2: Interpersonal Stressors-Stress Relationships for Expatriated HK CPs in Three Chinese Cities

Comparison of Expatriated CPs' Interpersonal Stressors between Three Chinese Cities

The results revealed that expatriated HK CPs' local colleagues in Beijing and Shanghai were significantly more *passive* than those in Macau. As Macau is close to HK, the expatriated HK CPs and their local colleagues in Macau may have had many opportunities for working together, which was not the case for Beijing and Shanghai. Without mutual understanding and given the conservative Chinese culture in Beijing and Shanghai (Lin, 2013), the expatriated HK CPs may think their Beijing and Shanghai colleagues more passive than those at Macau. At the same time, it was also interesting to reveal that local colleagues' *irresponsibility* in Beijing was significantly higher than in Shanghai and Macau. An employees' sense of

responsibility has been related to their company's corporate social responsibility (Yuan et al., 2010). Beijing is the location of Chinese central government, and home to the headquarters of almost all governmental departments, companies and other organizations. Perhaps the construction company in Beijing has a lower level of participation in social issues than those in Shanghai and Macau, in turn leading to reduced corporate social responsibility and higher irresponsibility in their employees.

The comparison also discovered that, with regard to professional skills, local colleagues in Beijing were more often than their Macau counterparts considered to have a *lack of contractual concept*. It has been widely reported that the people in Mainland China tend to emphasize interpersonal relationships (Guan et al., 2010). In contrast, Macau was colonized by Portugal for hundred years, which is similar to HK, and thus, local colleagues in Macau should have long been educated to follow the contract, which is one of the core values of western countries.

Interpersonal Stressors and Expatriated CPs' Unhappiness

The results show that expatriated HK CPs were unhappy with the local colleagues' *irresponsibility, disloyalty and lack of contractual concept*. Both the expatriated HK CPs and their local colleagues bear significant responsibility in ensuring the success of construction projects in terms of cost, quality and time. The irresponsibility of local colleagues can cause project failures (e.g., accidents due to careless management), while the expatriated CPs have to suffer negative consequences caused by irresponsible local colleagues (e.g., punishment due to accidents). The *disloyalty* of local colleagues to their company may reflect in the high turnover rate, low productivity and poor working attitudes, which could significantly affect the project performance (Xu et al., 2013). As the expatriated HK CPs often hold senior positions in overseas projects and their own interest is closely related to project success, they are unhappy with the negative consequences caused by the disloyalty of their local colleagues.

It has been widely reported that HK CPs have long been trained to work according to procedure, regulation and contract, while their local counterparts in Beijing and Shanghai often emphasize relationships more than the contract (Guan et al., 2010; Leung et al., 2012; Ren et al., 2009). Lack of contractual concept would bring negative consequences to construction projects (e.g., disputes, additional cost and delay in completion). The expatriated HK CPs would be unhappy to discover the conflicting views of their local colleagues regarding contract, as that is one of the most important issues for construction projects.

Interpersonal Stressors and Expatriated CPs' Anxiety

As found by the current study, the expatriated HK CPs used to be *anxious* due to their local colleagues' *passiveness and lack of foresight* at work. Because of the unique and dynamic nature of construction projects, it is common for CPs to encounter various project problems at work that need to be actively resolved (Ng. et al., 2005). Therefore, an active working attitude has often been advocated in the HK construction industry (Chan et al., 2003). Although the expatriated HK CPs recognize the importance of activeness, they have to work with their passive local colleagues as a team for the project and are constantly anxious about project performance and the final project outcomes. Moreover, the construction program is usually tight, and construction tasks interrelate with each other (i.e., early decisions will affect later outcomes) (Leung et al., 2011). If local colleagues have lack of foresight for project management, they may make inappropriate decisions that would result in detrimental effects on later tasks and the construction program. For instance, local colleagues may fail to predict the rainy season in a specific period, while deciding to make concrete at that time. This would delay the construction process and in turn induce anxiety in expatriated HK CPs about the possible overall project failure.

Interpersonal Stressors and Expatriated CPs' Worry

The current study also found a positive relationship between local colleagues' passiveness and expatriated HK CPs' worry in Beijing and Macau. In fact, the ANOVA results show that the passiveness of local colleagues in Beijing was significantly higher than those in Macau. The expatriated HK CPs have long been trained to actively work with each other to avoid project failure and the significant associated losses (Chiu and Lai, 2017). For overseas projects, the expatriated HK CPs must work well with their local colleagues to resolve various project problems in Beijing and Macau. However, local colleagues' passiveness affects the efficiency and effectiveness of problem-solving and thus overall project success, which would cause the expatriated HK CPs to worry about project failure.

CONCLUSIONS

The current study was able to identify the differences in interpersonal stressors facing expatriated HK CPs in three developed Chinese cities from north to south. Five critical stressors were confirmed for the expatriated HK CPs, including irresponsibility, passiveness, lack of foresight, disloyalty and lack of contractual concept. To manage expatriated CPs' stress, necessary actions should be taken for tackling the critical stressors. First, the construction organizations should provide platforms for the cultivation of greater responsibility and activeness for local colleagues in Chinese cities through emphasis on the importance and provision of motivational measures. Second, to foster the foresight of local colleagues, the companies should educate local employees to understand the interrelations between construction tasks. Third, in order to improve the loyalty of local colleagues, appropriate compensation and clear promotion mechanisms should be available. Last, construction companies and expatriated HK CPs should regularly educate local colleagues in the specific contractual terms, and strictly regulate local colleagues' work practices in according with the contractual terms.

The current study adopted various measures to ensure the reliability of the final results: 1) questions were extracted only from validated scales; 2) selection criteria were adopted for selecting appropriate participants; and 3) only the relationships confirmed by participants from at least two cities were used to make final conclusions (i.e., between-projects triangulation). Future research is encouraged to study more stressors in expatriated CPs' work, private and social life around the world. For example, studying the task, organizational and physical stressors in more Chinese cities, and developing a stress management model for expatriated HK CPs working at the Belt & Road projects. This study used quantitative research methods while future study is recommended to adopt a case study method (i.e., qualitative method) in order to cross-check and verify the causal relationships between stressors and stress for expatriated HK CPs.

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PROFESSIONALS' PERSPECTIVES REGARDING STRESSORS IN THE CONSTRUCTION INDUSTRY

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Unhealthy stress has a significant impact on professional psychological and physiological wellness, and, job performance, which influence the success of construction projects. Therefore, this paper aims to explore key stressors which lead to stress among professionals in construction projects in the Gaza Strip-Palestine. Four main stressors groups were identified and investigated: personal, task, physical and organizational. A questionnaire survey was administered to construction professionals; descriptive analysis was used. The results indicated that personality of construction professionals was identified as the most important factor affecting personal stress. This study revealed that overload was identified as a critical factor affecting task stressors. The organizational stressors were found to have a considerable impact on construction professionals' stress. The study recommends that the identified key stressors in this study should be considered in order to enhance the well-being of construction workers, improve safety and productivity. This study contributes to the body of knowledge of stress and work in construction industry in the Middle East. This study is limited by its quantitative method in data collection.

Keywords: Stressors, Construction projects, Professionals, Stress

INTRODUCTION

Stress has become a general phenomenon for construction professionals in which 68% of the construction professionals had found themselves suffering from stress, anxiety or depression directly due to working in the construction industry (CIOB, 2006) Construction professionals (CPs) are constantly exposed to varying stressors in their working environment and are likely to experience a high level of job burnout. Burnout threatens the mental and physical health of individuals and hence decreases levels of job satisfaction and productivity.

Stress is not always bad and it is not necessary to eliminate it (Turkington, 1998). Turkington (1998) stated that a world without any stress at all would be boring place. Stress can also be the motivation for individuals to optimize their work performance. The goal of stress management should not be to totally eliminate stress, but to learn how to manage it effectively (Greenberg, 2002). Nevertheless, human beings have their own ways to cope with stress, which is named "coping behaviour" (Leung et al., 2006). There is a growing body of literature on occupational stress among professionals and workers in the construction industry (CIOB, 2006; Leung et al., 2008). This paper aims to explore key stressors which lead to stress among

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professionals in the construction projects in the Gaza Strip, hence improve stress management.

LITERATURE REVIEW

Stressors are divided into four major categories: task, personal, physical, and organizational (Leung et al., 2007, 2008). Work stress is known to impact negatively on productivity and job satisfaction among workers in different professions (Ng et al., 2005). The consequences of occupational stress on job performance of individuals in various disciplines have been receiving increasing attention during the past two decades (Leung et al., 2008). It is also believed that work stress is a major contributor to absenteeism, low employee morale, poor performance, low job involvement, a loss of responsibility and creativity, and high accident (El-Kot, 2011).

Leung et al. (2008) stated that four critical stressors have significant impact on both the subjective and the objective stresses, including work overload, poor interpersonal relationships, poor work environment, and poor non-work environment. Leung et al. (2006) found that work overload, role conflict, job ambiguity, and working environment to be the critical stressors involved, with work under-load and distrust being indirectly influencing factors. Due to the demanding nature of the construction work tasks, home-work conflict has long been identified as one of the significant factors causing stress to construction professionals (Leung et al., 2007). Cultural values are predicted to have direct impacts on the stressors perceived by the individual construction professionals (Leung and Chan, 2011).

Although excessive workload leads to negative impacts on individuals, it doesn't mean that the complete absence of work pressure of any sort would create a psychologically comfortable state (Turkington, 1998). Work under-load represents the state when people find themselves in a position where the demands of their jobs are insufficient to make full use of their skills and abilities (Leung et al., 2008). Role ambiguity, role conflict and responsibility often referred to as role stressors, which are the most studied stressors in occupational stress research (Cousins et al., 2004). The basic notion behind role stressors is that most jobs have multiple task requirements and responsibilities or roles and that a job is likely to be particularly stressful if role stressors conflict with one another or is unclear (Nasurdin et al., 2005).

Physical work condition refers to the poor environment around the individual either the work or the home environment of CPs. This may include excessive noise, extremely high or low room temperatures, inappropriate lighting, a lack of privacy, ventilation, and hygiene of the place (Ibem et al., 2011; Ng et al., 2005). Organizational stressors refer to the sources of stress coming from and within an organization itself including the organizational structure, and the degree of autonomy given to employees (Leung and Chan, 2010).

RESEARCH METHODOLOGY

The study approach involves both literature search and the use of structured questionnaire. The population of this study was contracting companies that are registered in the Palestinian Contractors Union (PCU) in the Gaza Strip and classified by the national classification committee to have valid registration. Three hundred and twenty questionnaires were randomly distributed to construction professionals. Out of 320 questionnaires distributed, 183 were received, representing a response rate of 57%. The questionnaire was designed based on an extensive literature review of previous studies (Leung and Chan, 2010; 2011; Enshassi and

Al.Swaity, 2015; Enshassi et al., 2016).

The respondents were asked to rate the identified stressors according to five-point Likert scale. The relative importance index (RII) was used to determine the ranks of the stressors (Enshassi, et al., 2007; 2009). The Cronbach's alpha coefficient is one of the most popular reliability test used for measurement of reliability of scale. The Cronbach's alpha coefficient was calculated and found=0.86. This indicates that the instrument is perfect in terms of reliability and a good proof of internal consistency.

RESULTS AND DISCUSSION

Personal Stressors

Table 1 illustrates the RII and ranks of personal stressors. The results indicated that the attribute "I enjoy competition and feel I always have to win" with a mean value of 4.04 and RII= 80.88% was ranked first. This was closely followed by "I am an achievement-oriented person" with a mean value of 4.02 and RII= 80.44% as the second ranked attribute, while "I often feel that nothing matters in life besides my job" with a mean value of 3.65 and RII= 72.97% was rated third. These attributes reflected the personal traits of individual. As the RII and mean scores were very high, the personality of the construction professional was identified as the most important factor affecting the personal stress. Such results are consistent with previous studies (Enshassi et al., 2016; Enshassi and Al.Swaity, 2015).

Table 1: RII and ranks of personal stressors

Personal stressors attribute	Mean	RII (%)	SD	Test value	P-value (Sig.)	Rank
I enjoy competition and feel I always have to win.	4.04	80.88	0.78	11.08	0.000*	1
I am an achievement-oriented person.	4.02	80.44	0.80	11.02	0.000*	2
I often feel that nothing matters in life besides my job.	3.65	72.97	1.18	5.75	0.000*	3
My devotion to work is usually in conflict with my devotion to family.	3.33	66.56	1.13	4.35	0.000*	4
People sometimes say that I easily lose my temper.	3.14	62.84	1.12	3.00	0.001*	5
Family problems often concern me (e.g. trouble with children & marriage).	3.02	60.44	1.23	1.65	0.050*	6
It is hard for me to focus on one activity for a long time.	2.91	58.13	1.13	-0.09	0.465	7
I always end up disagreeing with customers, co-workers, supervisor, or management.	2.20	44.07	1.03	-7.81	0.000*	8
I am not sure I have divided my time properly among task.	2.09	41.76	1.08	-8.14	0.000*	9
My subordinates are friendly.	2.03	40.66	0.96	-9.83	0.000*	10
My colleagues and I do not cooperate with team spirit.	2.02	40.44	0.90	-10.42	0.000*	11
I do not have social contact with people at work.	2.02	40.33	1.18	-8.78	0.000*	12
There often seems to be a lack of trust between me and my colleagues.	1.78	35.69	0.97	-10.51	0.000*	13
I do not have a good relationship with my superiors.	1.70	34.03	0.75	-12.07	0.000*	14
All attributes of personal stressors.	2.72	54.32	0.36	-8.16	0.000*	

*The mean is significantly different from 3

SD: Standard Deviation

RII: Relative importance index

Task Stressors

Table 2 shows the RII and ranks for task stressors. The results indicated that the attribute “I work for long hours” with a mean value of 3.82 and RII= 76.48% was ranked first. This was closely followed by “I have a lot of responsibility in my job” with a mean value of 3.80 and RII= 75.93% as the second ranked attribute, while “I am often required to work on multi-tasks at the same time” with a mean value of 3.67 and RII= 73.37 % was rated third. The results showed that there is a small difference of importance between the first three ranked attributes. These attributes reflected the workload quantitative and qualitative. This means that work overload was identified as the most important factor affecting the task stressors. Professionals need to reduce/eliminate work overload in order to minimize the effect of task stressors. These results confirm previous results (Leung et al., 2008; Ibem, 2011; Enshassi et al., 2016).

Table 2: RII and ranks for task stressors

Task stressors	Mean	RII (%)	SD	Test value	P-value (Sig.)	Rank
I work for long hours.	3.82	76.48	0.91	9.35	0.000*	1
I have a lot of responsibility in my job.	3.80	75.93	0.84	9.47	0.000*	2
I am often required to work on multi-tasks at the same time.	3.67	73.37	0.85	8.53	0.000*	3
The tasks I have to work on are often urgent and have tight deadlines.	3.58	71.65	0.87	7.70	0.000*	4
I have to put much effort into guiding my subordinates in their tasks.	3.54	70.77	0.86	6.97	0.000*	5
I frequently work overtime (evenings and weekends) to finish my work.	3.54	70.77	1.03	6.04	0.000*	6
There is constant pressure to work every minute, with little opportunity to relax.	3.51	70.22	0.90	6.35	0.000*	7
The project problems I have to handle are often complicated.	3.40	68.07	0.84	5.43	0.000*	8
I frequently find my job boring and repetitive.	3.37	67.36	1.14	4.92	0.000*	9
I often meet with team members and do not have enough time to myself.	3.36	67.14	1.02	4.94	0.000*	10
I feel my skills and abilities are not being used well.	3.19	63.85	1.07	1.76	0.039*	11
I am given very limited authority.	2.99	59.89	1.19	-0.52	0.300	12
I am often caught by conflicting demands between different parties.	2.88	57.60	1.24	-0.09	0.466	13
Things I do are often accepted by one person but not another.	2.71	54.21	1.24	-2.05	0.020*	14
I often have difficulty deciding between high productivity and high quality.	2.58	51.58	1.21	-3.97	0.000*	15
Explanations of what has to be done are often unclear.	1.85	36.94	0.99	-10.04	0.000*	16
My job responsibilities are generally vague, unclear and inconsistent.	1.67	33.33	0.91	-11.12	0.000*	17
The organization goals and objectives are intangible and not clearly spelled out.	1.64	32.79	0.89	-11.32	0.000*	18
All attributes of the task stressors.	3.05	61.09	0.48	1.14	0.126	

*The mean is significantly different from 3

SD: Standard Deviation

RII: Relative importance index

Physical stressors

Table 3 depicts the RII and ranks for physical stressors. The results indicated that the attribute “My job is dangerous” with a mean value of 2.97 and RII= 59.34% was ranked first. This was followed by “It sometimes gets too hot or cold in my office/workplace” with a mean value of 2.67 and of RII= 53.44% as the second ranked attribute, while “Home is far from my work and there is often traffic congestion” with a mean value of 2.57 and RII= 51.48% was rated third. This finding indicated that physical stressors had less importance of other stressors and did not cause much stress to construction professionals. This results are in line with Enshassi and Al.Swaity (2015).

Table 3: RII and ranks for physical stressors

Physical stressors	Mean	RII (%)	SD	Test value	P-value (Sig.)	Rank
My job is dangerous.	2.97	59.34	1.10	-0.66	0.254	1
It sometimes gets too hot or cold in my office/workplace.	2.67	53.44	1.16	-2.57	0.005*	2
Home is far from my work and there is often traffic congestion.	2.57	51.48	1.32	-3.42	0.000*	3
My office/workplace is abnormally noisy and crowded.	2.28	45.57	1.22	-6.23	0.000*	4
The lighting in office/workplace is not suitable.	1.91	38.14	1.11	-9.05	0.000*	5
There is a lack of technology use in my work.	1.89	37.81	1.21	-8.14	0.000*	6
My home environment is not comfortable.	1.50	30.05	0.94	-11.12	0.000*	7
All attributes of the field physical stressors.	2.26	45.12	0.71	-8.92	0.000*	

*The mean is significantly different from 3

SD: Standard Deviation

RII: Relative importance index

Organization Stressors

Table 4 illustrates the RII and ranks for organizational stressors. The results indicated that the attribute “I have to carry out the work in complicated work procedures” with mean value of 4.01 and RII= 80.22% was ranked first. This was followed by “I usually characterize my organization as very hierarchical in decision making” with a mean value of 3.86 and RII= 77.6% as the second ranked attribute, while “The financial incentives and allowances provided by my company are generous” with a mean value of 3.86 and RII= 77.27% was rated third. As RII and Mean values are high, this means that organizational stressors should be considered by professionals in order to reduce stress factors. Such results are consistent with previous studies (Leung, 2008; Enshassi et al., 2016; Enshassi and Al.Swaity, 2015).

Table 4: RII and ranks for organizational stressors

Organizational stressors	Mean	RII (%)	SD	Test value	P-value (Sig.)	Rank
I have to carry out the work in complicated work procedures.	4.01	80.22	1.07	9.10	0.000*	1
I usually characterize my organization as very hierarchical in decision making.	3.88	77.60	0.93	9.96	0.000*	2
The financial incentives and allowances provided by my company are generous.	3.86	77.27	1.21	7.38	0.000*	3
My company does not provide adequate support for my work.	3.65	72.93	1.21	5.38	0.000*	4
My company does not take an interest in my career.	3.64	72.79	1.23	5.02	0.000*	5
My company provides me with suitable career and promotion opportunities.	3.58	71.54	1.26	4.96	0.000*	6
I often have to consult other people before making a decision.	3.38	67.65	1.18	5.70	0.000*	7
I can get feedback from my supervisor on how well I am doing.	3.34	66.81	1.11	3.77	0.000*	8
The organization has policies and procedures to adequately support employees.	3.25	65.03	1.37	1.28	0.101	9
I am working in a politicized environment.	3.15	63.06	1.27	2.27	0.012*	10
An overabundance of rules and policies do not allow me the freedom to make my own decisions or use my own ideas.	3.12	62.40	1.21	2.02	0.022*	11
I find the reward I get is relatively low when comparing with the effort I pay or external market.	2.94	58.78	1.09	0.00	0.500	12
The company that I am working in is a bureaucratic one.	2.67	53.33	1.13	-3.53	0.000*	13
I often feel unfair for the organization treatment.	2.54	50.82	1.38	-3.49	0.000*	14
All attributes of the organizational stressors.	3.36	67.17	0.38	8.42	0.000*	

CONCLUSIONS

The aim of this paper was to explore key stressors which lead to stress among professionals in the construction projects in the Gaza Strip. This study is considered very important in Palestine due to the negative effect of stress factors on professionals' daily activities that affect the success of projects. Four main stressors group were identified from previous literature, these were: personal, task, physical and organisational. The results indicated that personality of the construction professionals was identified as the most important factor affecting the personal stress. It was found that overload was identified as the most important factor affecting the task stressors they suffered. The results revealed that physical stressors have very low mean value and relative importance index which means that construction professionals in the Gaza Strip believed that physical stressors are not very important. The organizational stressors were found to have a considerable impact on construction professionals' stress.

The construction stakeholders are recommended to perform regular reviews and monitor the abilities of their employees and allocate their job responsibilities and workload accordingly. In order to equip professionals properly with stress-management skills, staff development programs involving stress coping strategies of both emotion-based and problem-based varieties are recommended. Construction managers need to allow sufficient autonomy in order to avoid unnecessary stress. This means allow sufficient flexibility for decisions based on construction professionals own information. This study contributes to the body of knowledge of stress and

work in construction in the Middle East. This study is limited by its quantitative method in data collection. It is advisable to employ more qualitative method such as interview and case studies.

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INTRUSION BEHAVIORS ON CONSTRUCTION SITE: THE EFFECT OF AGE AND GENDER

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Intrusion, which means to enter hazardous areas on a construction site without any permission, is one of the most serious rule-breaking behaviors. It has been rarely seen in present studies since the existing manual safety observation can hardly obtain massive and complex intrusion related information effectively. This paper explores how age and gender impact on various kinds of intrusion behaviors on construction site. A location tracking technology combined with BIM (Building Information Modeling) was applied for identifying and recording intrusion behaviors of 147 construction workers for 4 months. The results, empirically tested by ANOVA and non-parametric, show that age and gender have significant interactive effects on both intrusion frequency and duration. The analysis further indicates that male workers are more intrusive-prone than female ones. For both genders, middle aged workers (31 to 40 years and 41 to 50 years) have significantly higher intrusion frequency than young and old workers. Meanwhile, the youngest workers behave best in terms of intrusion frequency and duration. At last, the corresponding intrusion reasons and management methods were put forward by interviews like tough-guy thoughts and targeted training. The findings in this study also provide insights into the use of location tracking technology for intrusion management and safety improvement in the construction industry.

Keywords: Intrusion, Gender, Age, Location tracking system, Construction site.

INTRODUCTION

Rule-breaking behaviors have contributed to more than 80% of all workplace accidents (Choudhry et al., 2007). As one of the serious violation behaviors on construction site, intrusion, which means unauthorized stepping-into or staying-in a hazardous area, may cause construction process disturbance (Winsemius, 1965). In China, this situation has become more common as, in recent years, the aging problem and increasing labor shortage (National Bureau of Statistics, 2007-2017) have forced construction companies to employ more elderly workers

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or who with little relevant work experience.

Current construction safety assessment and management mainly depend on post-factum outcomes, such as accidents, injuries, illnesses or diseases, which plunders the opportunity of prevention and correction in time. But this kind of lagging measurement still exists and is popularly used because it is relatively easy to collect data, easily understood, objective and valid (Lingard et al., 2011). Then the group-level safety assessment calculated by the percentage of safe behaviors of all observed ones, without doubt, conceals need for personal safety (Choudhry, 2012). Furthermore, the observed behavior is judged by “all or nothing” normality (Wiegand, 2007) and cannot reveal the detailed process involved in the behavior. The lack of individual-level assessment compromises the ability of safety management to improve individual safety behavior. The last issue concerns the inefficiency of behavior inspection. With current practice, trained observers or safety supervisors are responsible for safety behavior inspection based on safety plans or operation regulations (Zhang and Fang, 2013). This time-consuming activity largely depends on the supervisor’s safety knowledge and experience, which often results in omissions or biases.

As to factors that may change the track of rule-breaking behaviors, age and gender are first to spring in mind. Both of them have been regarded to impact the occurrence of injuries and accidents in many industries including construction (Azadeh et al., 2015). Old and male workers have been notorious since their fatality rate ranks on top all the way (Cebador et al., 2014). But more accidents or injuries do not equal to more unsafe behaviors since the workers in two age groups may have different reaction ability like balance and sense, where Lombardi et al. (2009) proved the younger workers were less able to perceive eye injury dangers and also were less likely to use protective equipment. Also, little research attempted to combine age and gender together to explore the interactive effects as much more behavior data would be needed.

In the context above, although personal intrusion has been on a table for long, it is still believed to be a puzzle both in research and practice, since it is hardly possible to capture this kind of rule-breaking behaviors on a large scale. This paper is somewhat a development of Li et al. (2015), in which a real time location system for intrusion monitoring and warning is presented. Li et al. proved the effectiveness of their tracking system in identifying intrusion behaviors on construction site, but left questions like how workers behave differently between two age and gender groups and how to improve their behaviors to be answered. Based on the big intrusion data collected by the location tracking system mentioned above, the intrusion frequency and duration are compared between different age and gender groups. Then the potential reasons and improvement methods are provided through interviews.

BACKGROUND

Intrusion Problems on Construction Site

A near-miss, identified as a special kind of accident precursor, is defined as an event in which no damage or injury actually occurs but, under slightly different circumstances, could have resulted in harm (Phimister et al., 2004). It is widely accepted that reported accidents on construction sites are just the tip of the iceberg, with the very large number of near-misses that occur resembling the portion of under-water surface (Wu et al., 2010). This is also supported by the estimation that 90.9% of all accidents produce no injuries, while 8.8% result in minor injuries and only 0.3% cause major injuries (Heinrich et al., 1950). For construction work, an

unauthorized presence in a hazardous area - termed an intrusion in this study - represents a very common near miss. It is the major cause of process disturbance (Swuste et al., 2014) and leads to many critical safety issues such as falling from height (Zhou et al., 2012), electric shocks and being struck by working equipment (Wu et al., 2010). It not only causes the unauthorized intruder to suffer from an accident such as that of falling from height (Zhou et al., 2012), but can also interrupt or hurt workers in the danger zone.

Intrusion is often neglected because current assessment is mainly focused on visible outcomes such as critical injuries and accidents, and it is hard to identify near-misses in time (SWA, 2013). Intrusion records are mainly kept by self-reporting, which is inhibited by a blame culture for error, time-consuming paperwork, and lack of feedback on how the information reported has been used (Van Der Schaaf and Kanse, 2004). Undoubtedly, near misses provide insights into possible accidents and present a significant opportunity to further improve safety margins. It is possible to significantly improve safety by learning from previous near misses and tracking them in real time in order to take appropriate action prior to an accident (Wu et al., 2010). Although some previous studies have proved the effectiveness of location tracking technologies for intrusion capture (Li et al., 2015), little research has been done in further data mining.

Age, Gender and Unsafe Behaviors

In previous research, age has been regarded as one of the most significant impacts on injuries in construction, which is treated as an important index of severity of accident (Azadeh et al., 2015). In fact, it has been proved that the seriousness of the accident increased as at the same time the age of the involved worker increased (Camino et al., 2011). Most of the studies found out young worker's fatality rate is much higher than the overall fatality rate (Ehsani et al., 2013), but the older worker's injury rate is the highest one in all (Salminen, 2004). All these similar findings intend to indicate the age interval of victims who are most vulnerable to injuries or fatal accidents on construction sites. Moreover, age also emerges as a sensitive factor leading to unsafe behaviors. For example, Dong et al. (2013) stated that construction workers who were under 45 years old owned a larger perception of fatal falls from height, while the youngest (16 to 19 years) workers and oldest (65 years and older) ones had the highest rates of falling fatalities.

In terms of gender, Male workers in the construction industry are predominant on real sites, so that male workers are always thought to be the victims who are more vulnerable to injuries or fatalities (Chi et al., 2014). Actually, by taking both genders into consideration, male workers really seemed to have a higher fatality rate than female ones (Cheng et al., 2012; Lin et al., 2011). And male workers also had an eight times higher occupational injury rate than female workers (Zhang et al., 2011), which was consistent with similar studies elsewhere. In addition, Bena et al. (2006) stated that men also has the higher for second accidents. Lin et al. (2008) further illustrated that for female workers there existed a significant correlation between age and number of fatalities, while male workers presented an inverted U-shaped mode where the male occupational fatality rate decreased sharply in the age group of 25–34, then raised up along with the advancing age, and the pattern of fatalities in female age groups differed from that of males. Although the great importance has been given to both of the two factors, the scarce intrusion data on construction site impedes the in-depth consideration of their possible impacts on this kind of serious rule-breaking behavior.

RESEARCH METHODS

Intrusion Data Collection

In this study, intrusion behaviors are the objects to observe and related information should be collected for further data analysis. In general, the technology selected should provide the accurate information about who gets into which danger zone at what time. Based on the requirements above, the location tracking system developed by the virtual construction laboratory of Hong Kong Polytechnic University was selected as the most appropriate system to manage intrusion behavior and collect all the data needed. Although other location tracking technologies exist, they have not been applied for intrusion detection yet. This three-layer system, which is shown in Figure 1, consists of real-time location tracking and virtual construction parts. The detailed information about this system could be found in the paper of Li et al. (2015).

The whole data was collected from December of 2014 to April of 2015. There were 147 workers participate in this experiment. In order to guarantee the comprehensiveness, the 147 experimental subjects had 17 females and 130 males, and their ages ranged from 23 to 60. The sample almost covered all the female workers on the construction site to balance the gender proportion. In this project, five main trades were taken into consideration, and they were electric welding, carpenter, concrete, bar setter and bar tensing. These trades included almost all the jobs on the construction site to completely capture the intrusion behaviors. On every experiment day, different workers were invited as the data collection subjects and everyone had an ID number from 1 to 147. Two researchers were responsible for setting up the system and the safety manager was needed to find out the danger zones where the workers easily intruded and specified which danger zone was forbidden to which worker. The behavior related information was recorded both by the system and camera to make sure the accuracy. The intrusion records were checked one by one which costs 6 months.

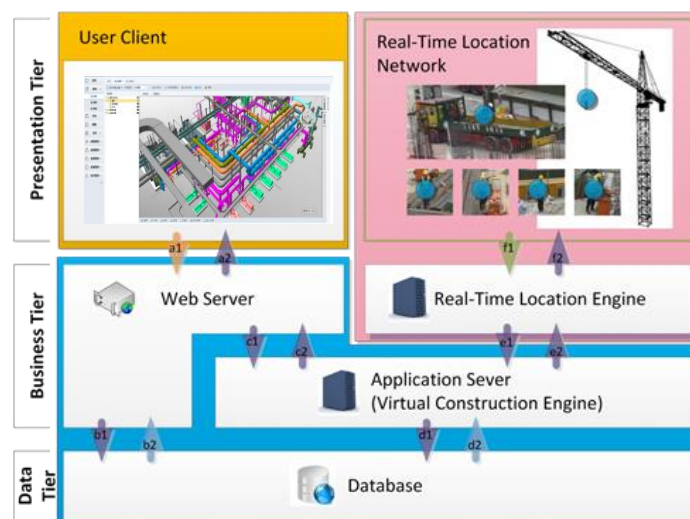


Figure 1: Three-layer system workflow (Li et al., 2015)

Data Analysis Methods

Two-way ANOVA is selected as the primary data analysis method since this study has one continuous dependent variable, more than one categorical and independent groups for each

independent variable, and takes both of age and gender factors into consideration (Lared, 2013). The outlier is checked in boxplot and normality is tested by Shapiro-Wilk method at the beginning. The normality assumption is strictly met when significant value is smaller than 0.05, or conservatively accepted with a statistical significance level of .01, which equates to a z-score between ± 2.58 (Laerd Statistics, 2013). In this study, z-scores of skewness and kurtosis are calculated by the functions of $z_s = \frac{Skewness}{Std.Error}$ and $z_k = \frac{Kurtosis}{Std.Error}$. Then the homogeneity assumption is tested by the formal Levene's test and should be met with a non-statistically significant result ($p > .05$), which indicates that the data has equal (population) variances and has not violated the assumption of homogeneity of variances. In the face of data which not satisfies the fundamental assumptions, three methods are applied, i.e. proceeding on original data, removing the outliers and transformation, and the results from different analysis methods are compared with each other in the following part. Specifically, transformations used in this study includes $\log(X_i)$, $\sqrt{X_i}$ and $1/X_i$, which have been proved to correct positive skewness effectively. In this study, all three transformation methods were applied and the corrective effects were compared in terms of outlier number and normality, then the best transformed data was selected for further ANOVA analysis.

After all the data preparations above, the assumption of interactive effects are tested by the ten-step classical ANOVA procedure. Simple main effects are analyzed further following the significant interaction (interactive sig. $< .05$) to explore the detailed differences between two age and gender groups. The significant values help to dig out whether difference of mean intrusion behaviors in any two age and gender groups exists (pairwise sig. $< .05$). To ensure the accuracy of data analysis, all the results from different analysis methods are compared with each other in the following parts and the reasonable outcome is obtained finally.

Because the prior information about intrusion behavior is very limited and the brand new automatic intrusion assessment method is designed and developed for this specific research question, the interview should be adopted as an excellent method which can effectively reveal the reality without stripping away details or imposing any preconceived framework of the researchers. Three rounds of interviews are conducted in different phases during this whole study. All the interviewees include two workers with the working experience of more than 5 years, and three senior construction safety managers with management experience of 2-13 years.

ANALYSIS RESULTS

Table 1 and 2 present the analysis results about how age and gender affect intrusion frequency and intrusion duration. The intersection of the analysis results from all the alternative analysis methods cannot prove age and gender have interactive effects on how often the workers intrude danger zones. But on most occasions, which means after removing the eight outliers, it is identified that the male workers in the youngest group have least intrusion records than male workers in other age groups. What's more, the result after removing outliers also shows that the male workers intrude danger zones much more often than females in the age groups of 31~40 and 41~50. As to the outliers of intrusion frequency, we can see that all the outliers are related to males, and all of them are much higher than normal intrusion frequency. What's more, the highest intrusion frequency happened on the male workers in the age group of 31~40, which also proves our result that male workers in middle age are more risk-taking than others.

Table 1: The interactive effects of age and gender on intrusion frequency

	Female (n=17)		Male (n=130)		Sig. of original data (p<.05)	Sig. of data without outliers (p<.05)	Sig. of transformed data (p<.05)
	Mean	Std.D.	Mean	Std.D.			
21-30	.00144	.00082	.00346	.00452	NS	5 different from all others; 2, 3 different from 6, 7.	NS
31-40	.00281	.00110	.00989	.02430			
41-50	.00256	.00130	.00786	.01763			
51-60	.00191	.00187	.00546	.00475			

*Note: Female & 21-30 = 1, Female & 31-40 = 2, Female & 41-50 = 3, Female & 51-60 = 4.
Male & 21-30 = 5, Male & 31-40 = 6, Male & 41-50 = 7, Male & 51-60 = 8.*

As to how long the workers stay in danger zones, the analysis on both original data and reciprocally transformed one indicate that the female workers with the age of 41~50 stay in danger zones much longer than those with the age of 31~40. In most occasions, the youngest female workers stay in danger zones significantly shorter than the oldest ones. The female workers with the age of 31~40 stay in danger zones for the shortest time, which is significantly shorter than that in the group of 41~50 and 51~60. For the gender factor, the analysis results from original data and transformed one have obtained the same results. It presents that female worker with the age of 31~40 stay in danger zones shorter than male workers with the age of 31~40. After taking the special cases out of consideration, the mean intrusion duration without outliers for a male is significantly larger than that of a female in all age groups except for the eldest one.

Table 2: The interactive effects of age and gender on intrusion duration

	Female n=188		Male n=4798		Sig. of original data (p<.05)	Sig. of data without outliers (p<.05)	Sig. of transformed data (p<.05)
	Mean	Std.D.	Mean	Std.D.			
21-30	14.400	14.096	22.564	31.014	3 different with 2; 2 different with 6.	2 different with 3 and 4; 5 different with 6 and 7; 2 different with 5.	1 different with 4; 1-4 different with 5-8; 2 and 5 different with 3, 4, 7 and 8
31-40	10.783	10.003	24.623	30.614			
41-50	21.881	24.995	25.708	31.710			
51-60	25.762	52.630	27.462	44.159			

*Note: Female & 21-30 = 1, Female & 31-40 = 2, Female & 41-50 = 3, Female & 51-60 = 4.
Male & 21-30 = 5, Male & 31-40 = 6, Male & 41-50 = 7, Male & 51-60 = 8.*

IMPLICATIONS AND LIMITATIONS

Implications

The quotes in this study are from different interviewees and have been picked out to make a story for easy reading. In the face of the challenge that intrusion behaviors in construction sites have been frequently ignored and difficult to manage, location-tracking technology combined with 3D modeling has been determined to be an effective and accurate method to automatically identify, remind, and record this type of risk-taking behavior. After conducting the targeted interview, five main reasons for the occurrence of intrusion behavior have been determined: (1) lack of safety perception, (2) shortcuts due to unsafe site layout, (3) lack of safe places to rest, (4) tight work schedule, and (5) poor safety attitude, particularly the “tough guy” mindset.

The youngest group have least intrusion records than male workers in other age groups. This

may be attributed to better safety attitude of the new construction workers. “The young workers, of course, have relatively less safety knowledge than the experienced ones, but the newcomers are more likely to pay attention to safety issues”. “They like to attend the safety meeting and training on time, and they listen carefully what I tell them”. “Maybe sometimes the young workers cannot behave expertly, but they often behave carefully”. On the contrary, “the elder and experienced workers have much higher safety perception, and surely they believe themselves to avoid the hurts on a construction site, which lead to ignoring safety rules and regulations”. Compared with female workers, “male workers like to brag to others”. “They know clearly where is dangerous for some time, but they like to compete with each other by taking the risk to prove that they are brave”. What’s more, the male workers “have more rest than females, especially those with middle age”, “because they smoke a lot on the dangerous edge areas and have poor safety attitude than the young and eldest workers”. “The young workers have least safety knowledge and the eldest ones have experienced many incidents so that they all cherish their lives than the middle-aged workers, who have a lot of safety knowledge but ignore the dangers”. “Compared with male workers, the females intrude danger zones mainly because of taking shortcuts”, so that the female workers who walk slowly may stay in danger zones longer. Apparently, the female workers with elder ages move relatively slower than the younger ones, so it is not strange that they stay longer in danger zones. What’s more, similar to the age influence on intrusion frequency, “the elder female workers have better safety perception, but poorer attitude”. “They like to go to others’ work areas for chatting while the younger female workers work harder with less rest”.

Interview results indicate that intrusion behaviors could be managed in four main directions, thereby providing practical references for intrusion control and management. In the beginning, the detailed information of danger zones in every project should be presented to construction workers by safety managers, particularly in terms of safety training or reminders on site. These workers should be provided with timely information on the current danger zones. In terms of daily supervision, safety managers should focus on workers and days with special characteristics that may cause extensive intrusion behaviors. In particular, these characteristics are male, middle age, small working areas with danger zones around. Safety workers should provide substantial reminders to workers with high intrusion tendency. The intrusion records indicate that a reward and punishment system should be established to improve the long-term safety behaviors of workers. Thereafter, all intrusion records should be applied to facilitate the design of the construction site layout to eliminate the unreasonable and dangerous areas. Moreover, the establishment of protected rest areas is strongly recommended. Lastly, the intrusion situation can be applied for workload arrangement. Outliers indicate that the workload can be reflected by intrusion behaviors. An extremely high intrusion frequency is often related to extensive work, whereas exceptionally long intrusion duration means workers have substantial time to rest.

After applying the location-tracking system, safety managers can obtain detailed and complete information related to the behaviors of workers, thereby revising the current safety management through real-time monitoring, targeted training, fair rewards and punishment, and reasonable workload distribution. All the interviewed safety managers believe that the recommendations can be applied with the assistance of the location-tracking system.

Limitations

This study is limited mainly in two aspects, namely, partial system test experiment and incomplete data collection. The experiment was conducted in an open construction site, thereby proving the validity and feasibility of the selected location-tracking system in identifying and recording intrusion behaviors. Walls and roofs may result in an out-of-order system by blocking signals, thereby possibly leading to the inaccuracy of the collected data. With regard to the aspect of influencing factors, the data were not collected in all weather conditions and neither in all temperature situations, such as fog, snow, and extremely high temperature. The main reason for these two limitations is the fact that this technology is considerably new in the construction industry; thus, we would not have the opportunity to obtain complete data because the project will apply such technology on a long-term basis.

As technology develops, further research could be conducted on the manner by which this intrusion management system functions in indoor projects. Apart from the two factors considered, further study could consider additional influencing factors, such as level of education, drinking and smoking habits, fog weather, and extreme heat.

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EXPLORING THE HIDDEN SOCIAL CONSEQUENCES OF WORKING IN CONSTRUCTION WITH Q METHODOLOGY: DEVELOPING A STUDY FOR AUSTRALIA AND THE UK

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Construction work is unhealthy and bad for worker wellbeing. The industry structure results in insecure contracts, transient work, long working hours, stressful workplaces and poor occupational health, all of which contribute to poor worker wellbeing, influence their social determinants of health, and impact society in the broadest terms, workers often unable to fully participate due to poor work-life balance. Industry has become more aware of this in recent times, yet interventions continue to focus on readily identifiable symptoms and easy solutions, such as smoking cessation programmes, rather than underlying and more systemic causes. A study which will mobilise Q Methodology is proposed, to reveal how construction workers experience industry demands in the widest possible sense. By exploring subjective evaluations, the organisational and industry characteristics that impact most significantly on workers' health and wellbeing are revealed as well as their influences on workers' wider social contexts. This paper presents the proposed research design alongside the development of the Q-Sample, the data set to be evaluated by the participants, for discussion, evaluation and feedback, before it is mobilised in the field as part of a future research project to be undertaken in Australia and the UK.

Keywords: Health, Q Methodology, Social, Wellbeing, Work-life balance

INTRODUCTION

Awareness and interest is growing around construction trade worker health and wellbeing. Construction practice and how it affects workers, both directly and indirectly, as well as considerations of work-life balance are now the focus of an increasing body of research. There is growing support in the extant literature for an integrated approach to occupational health and safety with health promotion and disease prevention, to prevent injury and advance health and wellbeing (Anger et al., 2015; Sorenson et al., 2011). Improving worker health has not gone unnoticed by the construction industry, specifically within the 'developed' world, where attention has started to give the management of worker health and wellbeing a similar priority to safety. Examples of this can be seen in the UK at the London 2012 Olympic Park construction project (Tyers and Hicks, 2012) which adopted the slogan 'health like safety'.

Less well explored, however, are the wider social consequences of construction work – how

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its organisation, management and practice also affects workers' intimate and local communities. Research in this area is emerging in both Australia and the UK, both considered to be 'world-leaders' in construction safety, health and wellbeing management, and this paper presents the development of the design of a comparative study utilising Q Methodology to be undertaken collaboratively in both countries.

The aim of the study is to better illuminate the hidden social consequences of working in construction, and specifically to examine how workers experience the different demands construction work places on their health and wellbeing, and the impact they feel this has on their families, friends and wider social communities. It is hoped that such research will be able to generate specific insights that are in turn able to better direct effective interventions, either in the form of policy or industry practices. By highlighting the areas of most significant concern for construction workers through this research, programmes can subsequently be developed that directly address and counter these, able to bring about the most positive changes in practice both for both workers and their immediate communities.

CONTEXT

Work characteristics driving health outcomes

The poor state of worker health, safety and wellbeing within the industry is well documented: workers suffer significantly more numbers of injuries and occupational health problems simply because they work in construction (Smallwood and Lingard, 2009). In addition to the stress and anxiety caused by facing a potentially dangerous and high-pressure workplace every day (Health and Safety Executive, 2017), other less 'visible' and certainly less challenged aspects of construction work also pose threats to worker health and wellbeing. For example, the way construction work is traditionally structured, payment on price (the amount of work produced per shift) through insecure and temporary contracts, transient work and long working hours can also directly contribute to poor worker wellbeing (Beswick et al., 2007; Cunradi et al., 2009; Papadopoulos et al., 2010), and research has shown that job insecurity can have as negative an influence on workers as having no job at all (Kim and von dem Knesebeck, 2015).

Such aspects are also closely linked to the social determinants of health (Wilkinson and Marmot, 2003; Dollard and Nesper, 2013; Dhesi, 2014), the underlying reasons why people drink, smoke, take drugs or overeat, which can in part explain why construction workers have significantly higher use of alcohol and illicit drugs than in any other high-hazard industry (Tan and Lloyd, 2016). Yet the consequences of working in construction are not limited to the site, or even to the worker themselves. They also have impact and influence on wider society, as the demands placed on workers mean they can struggle to find fit with their home, family and community lives outside of work (Turner and Lingard, 2014; Turner and Lingard, 2016).

Responding to health concerns

The World Health Organization describes health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Work places have been identified as places where changes can result in significant health improvement through health promotion and disease prevention (Anger et al., 2015). Health promotion programs are interventions put in place by employers to improve the lifestyle choices and health of workers as a way of preventing chronic illness (Comcare, 2010), and the construction industry in the

'developed' world has seen their widespread adoption (Sherratt, 2017a). This has been further supported by significant changes in societal expectations of organisational responsibility. A core aspect of Corporate Social Responsibility (CSR), society now demands demonstrable commitment to not only assuring workers health, safety and wellbeing, but also to seek improvement and enhancement where possible, and the construction industry is no exception (Sherratt, 2015).

Criticisms and limitations of health programs

However, this wider contextualisation of construction worker health and wellbeing has also faced criticism. It has been suggested that it has led to a level of superficiality within many worker health and wellbeing programmes, which focus on individual behavioural factors and 'lifestyle' issues that can be used to deflect '...attention away from serious examining the effects of corporate cultures or the work environment' (Conrad, 2005, p. 546), something that has been suggested of the construction industry in the UK (see Sherratt (2017a) for a mapping to justify this latter statement). In addition, the medium of CSR has also arguably started to shape the message, through the commodification of worker health and wellbeing into a corporate marketing tool that provides suitably photogenic content for social media outputs (Sherratt, 2017b).

It is within this highly complex milieu that construction workers try to balance their health, their personal, family, social and community lives on one side, with the demands of an industry that could be said to be fundamentally unforgiving on the other.

Q METHODOLOGY

The focus of this paper is the development of a key part of the methodology to be used in a comparative and collaborative study of this phenomenon amongst construction trade workers in Australia and the UK. The approach taken here is that of Q Methodology (grounded in the work of Stephenson (1953)), which has been successfully used in similar studies evaluating the demands and resources of construction industry workers (Turner and Lingard, 2011). It is an exploratory research technique (Watts and Stenner, 2005) that focuses on subjective attitudes, perspectives and experiences of the research participants. We consider this aspect of Q Methodology to be of the utmost importance, and one of the key benefits of utilising this approach within the construction management research field. Much construction health and safety research neglects to incorporate the voice of the workers for a number of different reasons, for example they can be a difficult sample to access, there is the potential for language to be a barrier between the researchers and workers, and there can be problems around stopping work for research purposes and the consequences for productivity. Therefore much health and safety research actually gathers its empirical data from management, be they site or safety managers, rather than the workers themselves (Sherratt, 2017c). Management has much more time for research activities and also often have access to a computer for initial contact and online data collection, rather than being located out on a site and busy carrying out physical tasks. We would argue that although the opinions of the workers themselves are perhaps often neglected for logistical reasons, Q Methodology is very able to remedy that by providing a research approach that necessitates involvement of the workers themselves.

In Q Methodology, the research participants, known as the P Set, draw on their understandings and experiences to categorise and rank presented data, known as a Q Sample, and so provide a

subjective hierarchical evaluation of the significance and value of the data from their perspectives (Brown, 1986). This enables a considerable amount of empirical data to be obtained through a relatively 'non-threatening' approach: there are no right or wrong answers, and there is no need to read long instructions or lengths of text. Instead the participants are facilitated through the process to rank the presented data within a set grid.

The P Set is purposive in structure, aiming to sample a range of views and perspectives on the topic under investigation (Stenner et al., 2008). For this study, the P Set will be an equivalent sample of construction trade workers from Australia and the UK. The Q Sample contains the items and statements to be sorted and ranked by the P-Set, along a scale of 'it affects me a lot' to 'it does not affect me at all', in a process referred to as Q Sorting. Within Q Sorting, a Condition of Instruction (CoI) is used to direct the participants in their evaluation of the data within the Q Sample. Here, the CoI has been defined as: "in your current job, how do you experience this?" Q Sorting utilises a sorting grid which dictates a fixed quasi-normal distribution of the Q Sample, and members of the P Set position the Q Sample within the grid according to their own subjective ranking (Watts and Stenner, 2005). Following the Q Sort, information is also gathered from the participant through a post-sort interview, which enables further discussion around the sort and allows the researcher to seek comments to aid interpretation of the sorting configurations and viewpoints (Stenner et al., 2008).

Developing the Q Sample

To develop the Q Sample for the proposed study, a comprehensive literature review was undertaken. The authors have both previously published in the areas of work-life balance (Turner and Lingard, 2014; 2016) and worker health (Sherratt, 2017a) and so this data was used as the initial grounding for the review. In addition, keyword searches of the ARCOM Abstracts database were carried out, an abstracting database that draws on 21 No leading journals in the field, as well as all ARCOM Conference proceedings and PhD Theses. This was supplemented by a search of CIB W099 historical conference proceedings. In all these cases the following keywords were searched for: health, wellbeing, work-life balance, stress.

In order to also go beyond the construction management research field, institutional search engines were mobilised using the following keywords as linked to 'construction': health, wellbeing, smoking, drinking, and lifestyle. This approach led to sources within such disparate publications such as the *Journal of Family Violence* and *Public Health Nursing*. Overall, there is a much more limited amount of research directly associated with construction workers, as opposed to professionals or managers, although this is itself common in our field where access to the trade workforce can be problematic, and those willing and easily contactable are those who work in offices with computers rather than actually out on construction sites. However, there are some notable exceptions and they have been drawn on here where possible.

The main goal in selecting a Q Sample 'is to provide a mixture which, in major respects, contains the comprehensiveness of the larger process being modelled' (Brown, 1993, p. 99). Q Samples are made up of items which are presumed to be relevant to the topic at hand, and are chosen to ensure coverage of all possible sub issues (McKeown and Thomas, 1988). Therefore, in order to maximise the potential for this research, no prescriptive criteria were placed on the data prior to the literature review process. Instead, key themes were collated as they emerged from the literature sources, taking a holistic and inclusive approach in order to ensure all

potential demands were included within the Q Sample.

THE Q SAMPLE

Table 1 shows the key themes as drawn from the literature and the supporting sources, with examples of the demands to be ranked and their associated descriptions that would be used to better articulate the demand to the participant. Here examples are used to demonstrate the variety of demands included, acknowledging that the data includes both positive and negative associations between construction work and the workers' immediate communities. It is also worthy of note that the relationships between work demands and the social determinants of health (Wilkinson and Marmot, 2003) are not always explicitly set out, as it is prioritisation of the demands from the workers' perspectives that is sought, rather than their own analysis of the route that leads them to these consequences.

The final Q Sample is too large to present her in full due to constraints of space. In total, the Q Sample contains 48 demands under these 8 themes, in order to permit their ranking within a prescribed template.

Table 1: Q Sample Themes and Example Demands and Descriptions

N ^o	Theme	Example Demands	Example Descriptions	Supporting Sources
1	Long working hours	Long hours restrict family time	The hours you work mean you don't spend as much time as you would like with your family	Clifford (2009); Turner and Lingard (2014); Turner and Lingard (2016)
		The hours you work cause you stress and worry	The hours you work cause you stress and worry	Beswick et al. (2007); Clifford (2009); Waage et al. (2010); Papadopoulos et al. (2010); HSE (2017)
2	Physical Work	Physical work makes me too tired for community time	The physicality of your work means you are too tired to participate as much as you would like doing activities in the community (e.g. volunteering)	Turner and Lingard (2014); Blackman et al. (2014); Turner and Lingard (2016)
		Physical work makes me healthy	The physicality of your work keeps you fit and healthy	Boschman et al. (2011)
3	Dangerous Work	Dangerous work makes me stress and worry	Working in construction is dangerous and makes me worry about my health and the health of my co-workers	Beswick et al. (2007); Smallwood and Lingard (2009); McGann et al. (2016); HSE (2017)
4	Unhealthy Work	Unhealthy work makes me care less about my health (a)	Working in construction is unhealthy, so I might as well smoke	Wilkinson and Marmot (2003); Frone (2013); Dhese (2014); Tan and Lloyd (2016)
		Unhealthy work makes my family worry	My family think working in construction is unhealthy and they worry about my health	Voydanoff (2007); Turner and Lingard (2014)

N ^o	Theme	Example Demands	Example Descriptions	Supporting Sources
5	Insecure Work	Insecure work gives me freedom	Short term projects and contracts means you are happy to manage your own work and employment	Lowry (2001)
		Insecure work makes my family worry	Short term projects and contracts cause your family to worry	Voydanoff (2007); Turner and Lingard (2014)
6	Payment structure	Payment by how much I produce makes my family worry	Payment on price means my family worry about what my wage will be.	Papadopoulos et al. (2010)
		Payment by how much I produce makes me stressed	Payment on price means I feel pressure to earn a good wage	Beswick et al. (2007); HSE (2017)
7	Working away from home	I miss my community activities working away from home	Working away from home means you miss your community commitments (e.g. volunteering), or cannot establish regular community commitments.	Clifford (2009); Blackman et al. (2014); Turner and Lingard (2016)
		I like working away from home	I prefer to work away from home, the positives outweigh the negatives	Australian Government (2017)
8	Travel	Long travel times make me tired	The hours you travel to work make you tired	Beswick et al. (2007); Clifford (2009); Lingard et al. (2010)
		Long travel times mean I smoke or drink or eat too much	The hours you travel to work mean you partake in unhealthy activities	Wilkinson and Marmot (2003); Dollard and Nesar (2013); Frone (2013); Dhesei (2014); Tan and Lloyd (2016)

DISCUSSION AND CONCLUSIONS

Workers are all too frequently simply the recipients of health initiatives and promotion programmes, as well as organisational policy and practice, and have little say in their own working conditions and arrangements. This research intends to remedy that imbalance, and seeks to add the workers' own voices to the current directions for management of their health and wellbeing. We propose to seek empirical insights as to what and how wider industry demands are perceived by the workers, and how they feel they impact both themselves and their wider social contexts. By mobilising Q Methodology, their perceptions and prioritisations of what really matters to construction workers are revealed, and better understandings and insights of the consequences of how our industry works with regards to both worker and wider societal health and wellbeing can be illuminated.

Grounded in the widest possible literature, the Q Sample presented here deliberately looks to the causes of poor construction worker health, rather than the symptoms. In this way, the project seeks to avoid the current focus on workers' own behaviours, such as smoking or obesity, and instead look to the ways in which working in construction could negatively affect and influence workers' health and wellbeing, such as boredom or stress. It is duly acknowledged that to bring about change in such 'traditional' characteristics of working in construction, for example long

site hours, will be difficult and necessitate changes to business policy, processes and operations, yet that should not negate attempts to try and improve these fundamental problems for construction workers and their local communities.

Comments and feedback on the development of this project are welcomed from CIB W099 and TG59 conference colleagues.

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THE RELATIVE WELL-BEING OF CONSTRUCTION PROFESSIONALS

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The current survey of CIOB members reported here was conducted in 2016 with the purpose of updating an earlier survey of occupational stress in the construction industry conducted by the CIOB in 2006. While the main aim was to present a more current picture of workplace stress and its effects on mental health, we also aimed to improve rigour by using a psychometrically validated scale, the *A Shortened Stress Evaluation Tool (ASSET)*. Two core scales, *6 Essentials* and *Psychological Well-being* were used and compared with the normative data derived from the *General Working Population (GWP) 2015* database. Only two of the *6 Essentials* scales, i.e. *Control* and *Job security & change*, showed construction professionals to be typical compared to the norm group. The *Resources & communication* and *Job conditions* scales measured them as approaching high-risk, and the *Balanced workload* and *Work relationships* scales were atypical, indicating high-risk areas. The two *Psychological Well-being* subscales, namely, *Positive emotions* and *Sense of purpose*, both indicated that construction professionals were typical compared to the norm group. The subscale items identified the main causes of the atypical scores as: lack of feedback on performance; ideas/suggestions about the job not being taken seriously; work-life imbalance; high workload; and poor work relationships. Although some of these problems could be addressed at the firm level, those that are widespread and deeply rooted in the culture of the industry will require formal mental health promotion programmes above the level of the organisation.

Keywords: Workplace stress, Occupational stress, ASSET, Construction professionals

BACKGROUND

Previous research has established beyond question that the mental health and well-being of employees is affected by work stressors and that work-related stress affects organisations negatively (European Commission, 2002; Hoel, Sparks and Cooper, 2001). Not only is there a moral obligation on employers to provide working environments conducive to the mental health of employees (Donald et al., 2005), but both parties also benefit, and the converse is true (Robertson and Cooper, 2011). The cost of work-related ill-health was estimated by the EU-15 to be 2.6-3.8% of their GDPs in 1999 (European Commission, 2002). Assuming ten percent of this to be stress-related, the European Commission (2002) estimated the total cost for the EU-

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15 at €20bn per annum. Safe Work Australia (2012) estimated that work-related mental stress costs Australian society AUS\$ 5.3bn annually, and Rosch (2001) estimated that stress could cost the US economy US\$ 300bn annually. Given the moral and economic drivers and that much work-related stress is preventable, ongoing research is important to deepen our understanding of where and how to intervene.

CONTEXT

Background to the current study

The 2006 Chartered Institute of Building (CIOB) study of occupational stress in the construction industry attracted attention to the problems specific to the industry and reported the majority of construction managers as having suffered from work-related stress, anxiety or depression (CIOB, 2006). Similar findings emerged from subsequent industry-based studies. These were typically confined to: specific professions, like estimators, cost engineers, construction project managers, or engineers (see for example, Leung, Sham and Chan, 2007; Yip, Rowlinson and Siu, 2008); or contexts, like the effect of cultural values (Leung, Chan and Chong, 2010), expatriate status, and gender (Leung, Liang and Chan, 2016; Loosemore and Waters, 2004). Some were country-specific (Enshassi and Al.Swaity, 2015; Love, Edwards and Irani, 2010), while some were inter-country comparisons (for example, Leung et al., 2015).

Notwithstanding the contributions of this historical research, the CIOB (2006) study warrants updating, for several reasons. Firstly, it was a study of members of a single professional organisation with a 2016 global membership of $\pm 35,215$, but it was only conducted among UK members (78% of total membership). Given the influence of cultural values (Leung et al., 2010) and the fact that 11% of CIOB members are currently based in China and Hong Kong, there is a compelling argument for re-surveying the entire CIOB membership. Secondly, recent widespread use of digital communications, smart phones, emails and SMS messaging has fundamentally changed the way people work. The boundary between work and home/family has become increasingly blurred, engendering work-to-family conflict, psychological distress, and sleep irregularities (Bowen et al., 2017; Schieman and Young, 2013) and it is likely that a new survey would reflect such boundary-related stress differences. Finally, the analysis in the CIOB (2006) study was limited to descriptive statistics and no information was given about the source of the questions, nor whether they were drawn from psychometrically validated and reliable scales.

Aim of the current study

The aims of the current study were to: (i) address the lack of rigour in the original CIOB (2006) study by using a different, validated, scale, *A Shortened Stress Evaluation Tool (ASSET)*; and to (ii) benchmark levels of workplace stress and psychological well-being of construction professionals against normative data.

RESEARCH METHOD

Since the initial conceptualisation of stress models (Selye, 1975) and subsequent theoretical development thereof (see Cooper and Marshall, 1978; Johnson and Hall, 1988; Johnson, Hall and Theorell, 1989; Karasek, 1979; Lazarus, 1991), the *Occupational Stress Indicator (OSI)* (Cooper, Solan and Williams, 1988) emerged as a popular stress measurement tool. However, it was lengthy and favoured the specific context of “white collar and managerial workers”,

valid concerns which prompted the development of a new tool, ASSET, that was both shorter and more generally applicable across occupations (Johnson and Cooper, 2003: 182). Faragher, Cooper and Cartwright (2004) describe ASSET as the preliminary screening tool intended for use in a two-stage intervention, in which it would initially be used to flag individuals with potential stress problems, to be followed up with more conventional risk assessment tools, like the OSI. ASSET, or some of its subscales, can, however, be used in isolation. ASSET studies have focused on: the relationship between work-related stress and productivity or organisational commitment (Barkhuizen and Rothmann, 2008; Donald et al., 2005; Jacobs et al., 2007); considered differences across occupation groups (Johnson et al., 2005; Jorgensen, Nel and Roux, 2013); and gender issues (Jacobs et al., 2010). ASSET is a proprietary instrument and the results of previous surveys are available as normative data for comparison purposes. Some studies have used it to highlight relative differences between their target populations and the general working population (represented by the normative data set from previous ASSET surveys) (Johnson et al., 2014).

Since the reliability and validity of ASSET as a measure of stress/psychological well-being has been well established (Faragher et al., 2004; Johnson and Cooper, 2003), it was considered an appropriate instrument for the current study.

THE CURRENT STUDY

Procedures and sample characteristics

The survey population consisted of corporate members of the CIOB, worldwide, who were invited to participate and sent the URL for online access to the ASSET scales and demographic questions used in the study. Although the majority (83%) of respondents were from Europe, 17% collectively came from Africa, Asia, Australia and North America.

Of the 918 responses received, 790 were suitable for analysis after elimination of missing values cases using listwise deletion (Graham, 2012), representing 2.2% of the total professional membership of the CIOB and is similar to the response rate achieved in the CIOB (2006) survey. The majority of respondents were male (93%), married or living with a partner (88%) and older than 41 (62%). Their job functions were mainly construction management (34%), project management (29%) and quantity surveying (16%), with the rest described as architecture, engineering, and 'other'. Fifty-two percent described their roles as partners/owners/directors, 26% as registered professional employees, and 22% as employees. Most (86%) of the sample reported working more than 40 hours per week.

Measures

The 'core' scales of the ASSET model (i) *6 Essentials* (comprising subscales *Resources & communication, Control, Balanced workload, Job security and change, and Work relationships and job conditions*) and (ii) *Psychological Well-being* (comprising subscales *Positive emotions and Sense of purpose*) were used for the current study.

All items in the *6 Essentials* scales are preceded by the phrase: "I am troubled that...". Examples include: (1) Resources & communication scale - "I do not feel I am informed about what is going on in this organization" and "I am not adequately trained to do many aspects of my job"; (2) Control scale - "I have little control over many aspects of my job" and "My ideas or suggestions about my job are not taken into account"; (3) Balanced workload scale

comprises two subscales: Work-life balance; and Workload. Examples of items include: Work-life balance - “I work longer hours than I choose or want to” and “I spend too much time travelling in my job”; Workload - “The technology in my job has overloaded me” and “I am given unmanageable workloads”; (4) Job security and change scale – “My job is insecure” and “My job skills may become redundant in the near future”; (5) Work relationships scale – “My boss behaves in an intimidating and bullying way towards me” and “My relationships with colleagues are poor”; and (6) Job conditions scale – “My physical working conditions are unpleasant” and “My pay and benefits are not as good as other people doing the same or similar work”.

Regarding their *Psychological Well-being*, respondents were asked how often, during the preceding three months, their opinion or emotional state had been consistent with the statement in the questionnaire. Examples of the statements are: Sense of purpose scale – “My current job goals are specific” and “I am committed to achieving the goals of my job”; Positive emotions scale – “Inspired”; “Enthusiastic”; “Contented”.

The ASSET survey items used provided either a 5-point (very slightly or not at all, a little, moderately, quite a bit, very much), or a 6-point (strongly disagree, disagree, disagree, slightly agree, agree, strongly agree) response scale. All of the 6 *Essentials* and the *Sense of Purpose* subscale items used a 6-point response scale and the *Positive Emotions* subscale used a 5-point response scale. Mean scores were calculated for each item and converted to sten scores (‘standardised ten score’- on a scale of 1-10, 4-6 = ‘typical’, 1-3 = ‘more positive’, 7 = ‘cautionary’ and 8-10 = ‘more negative’, or the opposite if reverse coded) to facilitate comparison to the normative *General Working Population (GWP) 2015* dataset (36,928 responses to the ASSET questionnaire from a range of organisations and industries in the public and private sectors, data collected between 2010 and 2014). Thus, the sten scores are not absolute values, but indicate whether the means from the current survey data were “typical”, “more positive”, “more negative”, or approaching more negative, compared with the means from the GWP database.

ANALYSIS AND DISCUSSION OF FINDINGS

The findings of the current study are reported and compared with the normative GWP data using sten scores (see Figures 1 and 2), at the level of the main scale. It is possible to do this at the level of the items in the subscales, but such detailed reporting was precluded here due to space constraints. Instead, the items where divergence from the normative data was observed are identified.

For both of the *Psychological Well-being* subscales, *Positive emotions* and *Sense of purpose*, construction professionals were found to be typical of the GWP, despite the findings reported below that they were atypical for the majority of the 6 *Essentials* subscales.

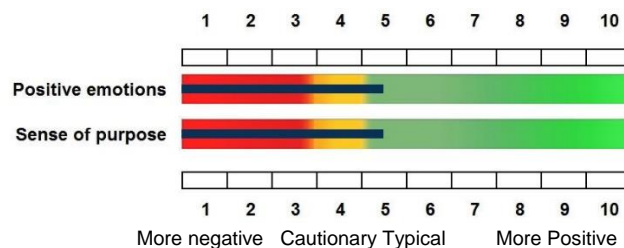


Figure 1: Overall ASSET sten scores for Psychological Well-being

Construction professionals were only typical of the GWP for the *Control* and *Job security & change* subscales of the *6 Essentials* scale. For all of the other subscales they were atypical -- cautionary on the *Resources & communication* and *Job conditions* subscales, and high-risk on the *Balanced workload* and *Work relationships* subscales.

The analysis of the subscale items identifies the causes of the atypical scores as: lack of feedback on performance; ideas/suggestions about the job not being taken seriously; work-life imbalance; high workload (unrealistic deadlines and technology overload); and poor work relationships (isolation at work, poor relationships with colleagues and lack of support).

Several of these causes mirror those identified in the CIOB (2006) study as the main causes of stress, namely “lack of feedback”, “too much work”, “ambitious deadlines” and “pressure”. Whilst this is noteworthy because the current study appears to validate those findings, the purpose of the current study was to identify divergence from the normative ASSET data. In doing so we create the potential to evaluate how construction professionals’ work environments and practices make them more susceptible to workplace stress than the general working population.

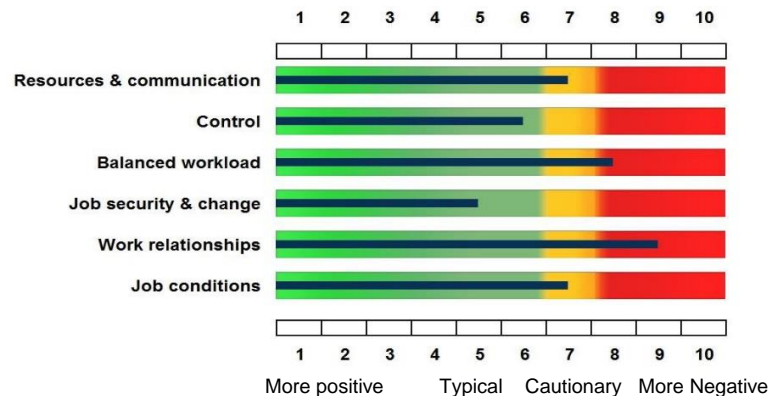


Figure 2: Overall ASSET sten scores for the 6 Essentials

Since feedback may act as an important moderator of stress (Bakker, Demerouti and Euwema, 2005), it is an aspect of construction professionals’ work practices that would benefit from intervention. Perceived lack of control over how people choose to do their work, or whether they feel unable to influence their situation by their ideas/suggestions about the job being taken seriously, can similarly be a major source of stress (Faragher et al., 2004). The converse is true; when people are empowered to attempt to resolve problems and are encouraged to approach their work positively (Karasek, 1979). Increased control can also be a safeguard against the negative effects of other pressures such as work-life imbalance and heavy workloads. It is possible that the long-standing working practices which result in lack of feedback and low decision latitude cannot easily be changed at the firm level, but industry associations and institutes could become powerful agents of transformation through the development of best practice guidelines for member firms.

Construction professionals were worse off than the GWP in terms of *Balanced workload*. This is consistent with previous research findings (Bowen et al., 2014b). Excessive travel time, technology overload and unrealistic deadlines are acute problems. Concerns about the impact of travel time could refer to the frequency of out-of-town business travel, daily commuting, or

frequent site visits. All three of these are potential stressors (Ivancevich, Konopaske and Defrank, 2003; Leung et al., 2005), which would be very difficult for firms to alleviate. Technology overload could refer to the pace and nature of new software development, electronic communication overload, or the latent fear of change felt by many workers regarding the use of new office technologies generally (Cooper, 2005; Leung et al., 2005). This is an area in which organisations and governments could intervene, as some have done. For example, Volkswagen stopped emails to off-shift workers in 2012, the French government introduced a law in 2017 requiring companies to define time periods in which emails may not be sent or answered, Atos banned all internal email from 2014, and Daimler deletes incoming emails while employees are on holiday (BBC News, 2012, 2014; Fortune, 2017). Tight or unrealistic deadlines have been shown to be common stressors in the construction industry (Bowen et al., 2014a; Yip et al., 2008). Impending deadlines put people under time pressure, which, although common in the project-based construction industry (Lingard, Francis and Turner, 2010), can be a major source of stress (Faragher et al., 2004; Irem et al., 2011). It is unlikely, though, that construction and project management organisations will voluntarily evolve into firms that generally apply less time pressure on employees. A good balance between people's work and non-work lives is an important contributor to their overall psychological well-being. An imbalance is thought to be the primary cause of occupational stress (Faragher et al., 2004). As work and work-related demands increase, people may experience a negative impact in their personal lives, leading to divided loyalties between work and family, and burnout (Bowen et al., 2014a; Lingard and Francis, 2009). The greatest potential to address both the time pressure and work-life imbalance problems lies in multi-stakeholder intervention strategies, rather than at the firm level (Lingard, 2004; Lingard and Turner, 2017).

The most acute problem regarding the atypical scores from the *Work relationships* scale was isolation at work, which refers to working alone and lack of social support from others. It is not possible to tell whether the responses reflect one of these aspects more than the other, but considering that lack of support from bosses and colleagues was also one of the highest risk items, it is assumed that the problem is more about the latter. This, taken together with a high level of concern over poor relationships with colleagues, leads to the inference that this is a complex problem. Good relationships at work can be energising and can contribute to the achievement of high levels of engagement and satisfaction. They can also help people to cope with work pressure and to maintain performance under challenging conditions. Conversely, poor relationships can cause strain and affect health and performance adversely (Faragher et al., 2004). The lack of social support problem can be addressed at firm level and would require organisations to evaluate their working practices to assess how best to intervene.

CONCLUSION

Overall, construction professionals compare unfavourably with the GWP 2015 norm group, with four of the 6 *Essentials* scales indicating areas that should be of concern to the construction industry. If work stress levels are to become better aligned with the general working population, analysis and interventions are required by firms, the industry and the government. Responsible organisations will need nothing more than knowledge of what the problems are, and the current study indeed provides such direction. However, problems that are widespread and deeply rooted in the culture of the industry will require more than the optional moral response of firms. Mental health promotion programmes will need to be formalised and designed using a multi-

stakeholder, multi-level approach.

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HEALTH AND SAFETY IMPROVEMENT AMONGST GHANAIAN COMMUNITIES AS A CORPORATE SOCIAL RESPONSIBILITY OF CONSTRUCTION COMPANIES

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Purpose –The purpose of this paper is to juxtapose construction site hazards with hazards present in typical Ghanaian communities to engender some safety knowledge transfer from construction companies to project host communities. **Design/Methodology/Approach** –Fifty-one volunteers who are health and safety professionals in Ghana partook in the survey to determine the common health and safety hazards present in most Ghanaian communities. The identified hazards were compared to typical construction site health and safety hazards identified from literature. The survey also sought to establish the general health and safety awareness levels among Ghanaian communities from the perspective of the safety professionals. **Findings** – Findings from the study confirmed the notion that H&S awareness in the Ghanaian community is poor, and therefore needs improvement. It also identified 26 construction hazards that are also common in the Ghanaian communities and established that H&S knowledge in the Ghanaian construction industry is more advanced than that of the Ghanaian community. **Originality/Value** –The poor state of H&S knowledge among Ghanaian communities has been recognised by various researchers, but this study is the first attempt to compare this state with the construction industry and to present wide-ranging lessons to be learnt from health and safety improvement in the construction industry.

Keywords: Health and safety, Hazards, Ghanaian construction industry, Safety performance.

INTRODUCTION

The poor state of health and safety culture among Ghanaian communities is well documented. This has generated a lot of debate among government, academia, religious bodies, opinion leaders and the media, all calling for an urgent action to improve upon the situation. The National Statistical Service Report (2016) and the Ghana National Fire Service Incident Report (2016) have both called for an urgent need to improve the state of health and safety in the country. Ignorance and negligence rank high as causes of most health and safety problems reported in the country. The responsibility of every nation is to provide good and safe environment for its citizenry devoid of risks, hazards, and diseases (Puplampu and Quartey, 2012). Therefore, there is the need to put in place measures that protect the Ghanaian public against avoidable health and safety hazards.

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CONTEXT

Construction health and safety

Occupational health and safety related issues at the work place, especially in the construction sector, continue to be of global concern (Albert et al, 2014). According to these authors, the construction industry in America for instance accounted for 16% of fatal occupational injuries while employing 4% of the total work-force in 2011. The U.K. construction sector also accounted for 22% of fatal injuries while employing 5% of the total work-force in the same year. This confirms the fact that, the construction industry is one of the most hazardous industries in the world.

Nonetheless, a number of studies have reported an improvement in the situation. According to Jaselskis et al. (1996) the improvements of construction H&S is as a result of increased adaptation of highly effective injury prevention strategies. Esmaeili et al. (2012) corroborated this statement after many years by arguing that, health and safety in the construction industry have improved significantly in recent years and these improvements are attributed to the increased implementation of good safety policies and strategies adopted by construction companies.

A large body of literature exists which reveals key factors driving better health and safety in the construction industry. Some of these factors are: safety regulations (Kartam et al., 2000), safety policies, safety training, incentives and worker attitude towards safety (Hinze and Wilson, 2000), increased formal safety meetings with supervisors, sub-contractors and suppliers (Esmaeili et al., 2012) and safety equipment usage, education and training (Abdelhamid and Everett, 2000). All these authors agree that the adaptation of these driving factors have helped in improving the state of H&S in the construction industry.

A hazard is any situation, substance, activity, event, or environment that could potentially cause injury or ill health. Some of the situations that can be hazardous in the construction industry includes: slippery or uneven walking surface, cramped working conditions, badly ventilated areas, fall from height, noisy locations, poorly lit areas, and confined space. Others are dangerous tasks, heavy lifting, repetitive work, interpersonal conflicts, bullying, intimidation, explosions, fires, collision, vibrations, leaks, falling objects, chemical reactions, toxic substances and excavation (HSE, 2011).

The Ghanaian health and safety situation

The need for health and safety improvement among Ghanaian communities has become paramount. This is because the Ghanaian society and its workforce is not exempted from daily exposure to hazards associated with the working environment such as; chemical hazards, physical hazards, biological hazards, psychosocial hazards and ergonomic hazards. According to Asumeng et al. (2015), Ghana is gradually becoming an industrialized nation and this change has exposed a large percentage of the workforce to various health and safety hazards. Annan et al. (2015) also opine that the increasing industrialization in Ghana is an indication of increasing number of Ghanaian population being exposed to workplace physical, chemical, biological and psychological hazards. As these authors have indicated, it is time for H&S to be taken seriously in Ghana, because as the nation gradually moves towards industrialization, people are also moving away from traditional manual labour based on service mechanization

in most of their daily routines. Puplampu and Quartey (2012) expressed the worrying nature of health and safety in the country, as employees complain about lack of effective policies, programmes and practices that protect their well-being. With all these concerns Ghana as a nation does not have any comprehensive national OHS policy (Annan et al., 2014). The few legal provisions in Ghana require huge modifications in order to meet international requirements and standards (Ghana Health Service Report, 2007). Recently there have been many avoidable domestic, industrial and institutional fire outbreaks coupled with vehicular collusion which have been attributed to ignorance and negligence on the part of the citizenry (G N F S I R, 2016; Addai et al., 2016; Annan et al., 2014). Alkilani et al. (2013) argue that health and safety awareness and performance in developing countries is low and therefore needs improvement.

Health and safety studies in Ghana have been on the ascendency in the country although not as much as expected. Some authors such as Laryea and Mensah, (2010), Kheni et al. (2008), and Addo-Abedi (1999) looked in the area of construction industry's health and safety improvement. Quartey and Puplampu (2012) also looked at health and safety improvement among workers in the shipping and manufacturing industry. Addai et al. (2016), Asumeng et al. (2015) as well as Annan et al. (2014) have all looked at general occupational health and safety improvement issues in the country. However, none of these studies looked at similarities between H&S hazards within the construction industry and typical Ghanaian communities and lessons that can be shared between the two. Therefore, this study which is an ongoing research tries to fill in this gap of transferring improved H&S knowledge from the construction industry to the Ghanaian community as a corporate social responsibility of the construction companies.

METHODOLOGY

A questionnaire survey is an effective method to gain data on attitudes towards issues and causal relationships. Also, it is a widely used method to describe general perceptions about health and safety practices (Albert et al., 2014). For this particular study, a questionnaire survey was selected as the method of data collection. A survey of health and safety professionals in Ghana was carried out to determine the common health and safety hazards present in most Ghanaian communities identified from literature. The identified hazards were compared to typical construction site health and safety hazards also identified from literature. The survey sought to establish the general health and safety awareness levels among Ghanaian communities.

An invitation was sent to health and safety professionals in the country to indicate interest. Interested respondents (75) were given questionnaire by email to fill. Out of this, fifty-one questionnaires were answered and returned. The respondents completed a structured demographics and perception questionnaire. Since none of the respondents had a missing value in their responses, there was no exclusion of respondents from the final analysis. The scoring of knowledge and practice questions run from non-hazardous (Strongly Disagree) through to hazardous (Strongly Agree) practices provided by each respondent. The demographic characteristics of the respondents captured for the study included gender, job position, years of experience in health and safety management and region of residence. The population consisted of health and safety officers with a post-graduate diploma in occupational health, safety and environmental management (DOSHEM) working in different professions, from Ghana institute of management and public administration (GIMPA). They were purposively chosen, due to

their in-depth knowledge and expertise in the subject matter, ease of accessibility and willingness to participate in the study. Statistical analysis was conducted using the statistical package for social sciences (SPSS) software. Comparison of mean value of identified health and safety hazards of construction industry also found in the Ghanaian community was carried out in order to rank them.

FINDINGS, ANALYSIS AND DISCUSSION

Table 1 shows the frequency and percentage distribution of the characteristics of respondents pertaining to their gender, job position, years of experience in health and safety and region of residence. The dominant work experience of the respondents surveyed is less than six years. On the other hand, a significant number of respondents have worked between 6 and 15 years. This implies that all the respondents have significant experience in health and safety to ensure reliability and accuracy of data.

Table 1: Characteristics of the Study Sample

Respondents' Characteristics	Frequency	Percentage
Gender		
Male	39	76.5
Female	12	23.5
Job Position		
Safety officers (Mining)	21	41.2
Safety officers (Building)	4	7.8
Safety officers (Health Service)	9	17.6
Safety officers (Project Mgr.)	8	15.8
Safety officers (civil)	0	0
Others	9	17.6
Experience in health & Safety		
Less than 6 years	25	49.0
6-10 years	13	25.5
11-15 years	12	23.5
16-20 years	1	2.0

The regions of residence of the respondents sampled for this study shows that, a significant majority i.e. 70.6% of the respondents are residents of Greater Accra region. This is expected since most institutional head offices in Ghana can be found in this highly populated region (Greater Accra). The remaining was distributed as follows: Volta 7.8%, Western 5.9%, Brong Ahafo 5.9%, Central 3.9%, Ashanti 2%, Upper West 2% and Upper East 2%. It is noteworthy that none of the respondents resides in the Eastern and Northern Regions.

Perception of Health and Safety Culture within the Ghanaian Community

This study describes frequencies of desirable answers (Agree and strongly agree) and undesirable answers (Strongly disagree, Disagree and Somehow Agree) provided for the perception questions. Generally, majority of the respondents (98.1%) provided desirable answers (Agree and Strongly Agree) that health and safety knowledge of the Ghanaian communities is poor and needs enhancement. Particularly most of the respondents (82.4%) strongly agree to the statement and 15.7% agree to that statement. However, 2.0% representing just one respondent do not agree to the same statement. This could be due to weak health and safety legislation and lack of serious sanctions for health and safety accidents and violations in Ghana. Although the society fears the hazards, there is not much awareness creation on health

and safety practices. Clearly, these results indicate that serious steps are needed to address problems related to poor health and safety policies and practices in Ghana.

Perception of Health and Safety Knowledge of the Ghanaian Construction Industry compared with the Ghanaian Communities

The perception of respondents on health and safety knowledge of the Ghanaian construction industry compared with that of Ghanaian communities. Generally, majority of the respondents (84.3%) provided desirable answers (Agree and Strongly Agree) that health and safety knowledge of the Ghanaian construction industry is better compared with that of the Ghanaian communities. This is matched against (15.7%) who did not agree. Particularly most of the respondents (49.7%) strongly agree to this position and 35.3% agree to same. However, 2.0% representing just one respondent strongly do not agree to same. This could be since health and safety management in the construction industry in Ghana is of major concern to stakeholders and government and also due to the risky nature of the industry and the proliferation of foreign contractors who have better knowledge in health and safety issues

Construction Hazards Commonly Found in Ghanaian Communities.

Respondents were asked to indicate the hazards in the construction industry which are common in the Ghanaian community. The mean score ranking was used to analyse the responses. These hazards were ranked based on a Likert scale of 1 to 5 where “1=strongly agree” and “5=strongly disagree”. A high mean relevance rating would mean that the construction hazard under consideration was not commonly found in the communities. From Table 2, it was observed that all the mean scores (26 out of 26 hazards) are less than 2.5 for all the respondents sampled in the study. The results revealed that “Dust” (mean = 1.31), “Equipment related injury” (mean = 1.59) “Manual handling” (mean = 1.59), and “Noise and vibration” (mean = 1.69) are the first four major hazards in the Ghanaian construction industry commonly encountered in the communities.

Table 2: Hazards of the Ghanaian Construction Industry

Hazards	Mean	SD	t-value	p-value	Mean Difference	95% CI of Difference		Rank
Dust	1.31	0.71	13.27	.000	1.314	1.11	1.51	1
Equipment related injury	1.59	0.85	13.30	.000	1.588	1.35	1.83	2
Manual handling	1.59	0.94	12.04	.000	1.588	1.32	1.85	3
Noise and vibration	1.69	0.79	15.30	.000	1.686	1.46	1.91	4
Slips and trips	1.80	0.87	14.77	.000	1.804	1.56	2.05	5
Clearance and excavation	1.88	1.01	13.27	.000	1.882	1.60	2.17	6
Fire	1.90	0.92	14.73	.000	1.902	1.64	2.16	7
Work place transport	1.90	1.06	12.78	.000	1.902	1.60	2.20	8
Falls from height	1.92	1.15	11.97	.000	1.922	1.60	2.24	9
Struck by objects	1.98	0.95	14.91	.000	1.980	1.71	2.25	10
Toxic substance in plant	2.08	0.94	15.88	.000	2.078	1.82	2.34	11
Vehicles collision	2.08	1.02	14.60	.000	2.078	1.79	2.36	12
Toxic substances (biological origin)	2.10	0.86	17.53	.000	2.098	1.86	2.34	13
Explosion	2.12	0.97	15.55	.000	2.118	1.84	2.39	14
Fumes	2.12	1.03	14.65	.000	2.118	1.83	2.41	15
Gases	2.14	0.96	15.91	.000	2.137	1.87	2.41	16
Exposure (contagious disease)	2.16	1.14	13.54	.000	2.157	1.84	2.48	17
Collision	2.18	1.01	15.33	.000	2.176	1.89	2.46	18

Hazards	Mean	SD	t-value	p-value	Mean Difference	95% CI of Difference		Rank
Mists	2.20	1.06	14.81	.000	2.196	1.90	2.49	19
Heat & cold temperature	2.20	1.15	13.65	.000	2.196	1.87	2.52	20
Radiation (ionizing & non-ionizing)	2.25	0.89	18.08	.000	2.255	2.00	2.51	21
Liquids	2.25	0.91	17.64	.000	2.255	2.00	2.51	22
Vapours	2.25	1.07	14.99	.000	2.255	1.95	2.56	23
Animal attacks (snake bites, etc.)	2.29	0.97	16.97	.000	2.294	2.02	2.57	24
Carcinogen (wood dust)	2.47	1.03	17.19	.000	2.471	2.18	2.76	25
Lung infection due to soil fungus	2.47	1.17	15.05	.000	2.471	2.14	2.80	26

Other equally common hazards included “slips and trips” (mean =1.80); “clearance and excavation” (mean =1.88); “workplace transport” (mean =1.90); “fire” (mean =1.90); “falls from heights” (mean =1.92); “struck by objects” (mean =1.98). The construction hazards which were found to be least prevalent in the communities were; “carcinogen from wood dust” (mean = 2.47), and “lung infection due to soil fungus” (mean =2.47).

Moreover, from table 2, mean scores of all the hazards evaluated were evidently much less than the neutral score of 3 (theoretical mean) at a 5% significant level when the t-test was applied (all p-values < 0.05). It is also clear that all the mean differences fell within the 95% confidence interval constructed for each hazard item. Thus, all the hazards listed in Table 2 are potential hazards found in the communities.

Respondents’ characteristics and their perception on health and safety in the Ghanaian construction industry compared to the community

Table 3, displays result from the chi-square test of association of the respondents’ characteristics and their perception on the knowledge of health and safety in the Ghanaian construction industry. The items that were significant at $p \leq 0.10$ are marked. It was observed that, respondents’ gender (p-value = 0.59), experience in health and safety (p-value = 0.51) and region of residence (p-value = 0.64) were not statistically significantly related to their perception that health and safety knowledge in the construction industry is higher as compared to that within the Ghanaian community. This implies that, the respondents’ perception that health and safety knowledge in the Ghanaian construction industry is higher compared to that of the community has got nothing to do with these characteristics.

Meanwhile, respondents’ job position was found to be statistically significantly related to their perception that health and safety knowledge in the construction industry is higher compared to that within the Ghanaian community (p-value = 0.09*). This means that there is enough statistical evidence to the fact that the job status of the respondents has a significant bearing on concluding that health and safety knowledge in the construction industry is higher compared to that within the Ghanaian community. In other words, respondents perceived that health and safety knowledge in the Ghanaian construction industry is higher compared to that within the community based on their job position. This implies that their job positions as safety officers has exposed them to deeper meaning and understanding of safety culture, therefore they are able to come to this conclusion, also this justifies why it was best to have these set of respondents’ to evaluate the safety culture of Ghanaian communities.

Table 3: Chi-Square Test p-values from the Cross Tabulation of the respondents' characteristics and the perception of Health and Safety Knowledge of the Ghanaian Construction Industry compared with the Communities

Respondents' Characteristics	Perception of Health & Safety knowledge of the Ghanaian construction industry compared with the communities
Gender	0.59
Job Position	0.09*
Experience in Health & Safety	0.51
Region of Residence	0.64

* Significant at 0.10

CONCLUSIONS

In conclusion, when it comes to the issue of H&S awareness in the Ghanaian communities, it can be concluded that:

The level of H&S awareness in the Ghanaian communities is low and therefore needs improvement. H&S knowledge in the Ghanaian construction industry is higher than that of the Ghanaian communities and therefore can be benchmarked in transferring H&S knowledge from the construction industry to the communities. When it comes to common H&S hazards in the Ghanaian communities, 26 construction hazards are found to be common in the Ghanaian communities and therefore all the already existing knowledge in identification, mitigating and possible elimination of such hazards in the construction industry can be transferred to the Ghanaian communities to help improve their awareness level of these hazards, keep them safe and to improve their wellbeing.

It is therefore recommended that further studies should be carried out to find out ways in which H&S knowledge from the construction industry can be transferred to the communities. Health and safety issues in the country should be a collaborative effort, involving government, academia, employers, as well as the entire citizenry. Construction activities cut across the whole country, whatever one does or wherever one goes in this country there is construction, and the industry also employs both skilled and non-skilled labour wherever it happens. Construction should therefore be a good channel or means of reaching out to the citizenry when it comes to creating awareness regarding H&S. A national policy to direct handling of H&S in the country, which provides strategies on how to identify, assess, manage or control hazards found to be present in the communities is recommended.

Although the findings of this study is based on 51 expert opinions of H&S professionals living in the Ghanaian communities, across eight out of the ten regions of Ghana, they are not representatives of the communities, but the right people with the expertise to assess rightly H&S situation in these communities., We therefore recommend that a further research be carried out on a larger scale in all the ten regions involving the community members to ascertain their perception and overall state of health and safety in the country.

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A DESCRIPTIVE STUDY OF HUMAN ERRORS PRODUCING UNSAFE ACTS IN CONSTRUCTION

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Human errors mean different things to different people in construction. To practitioners and scholars, human errors observed through unsafe acts and conditions remain significant threats to the health, safety, and well-being of people in construction operations. The reported research is interested in the elimination of human errors on construction sites, and where removal fails, ways of containing adverse effects should be a priority. The descriptive qualitative research that utilized interviews to obtain data on project sites discover the leading factors of unsafe working conditions and their impact on people in the industry. The study observed unsafe conditions on construction sites despite the fact that legislation and regulations prohibit them. Human errors that are associated with the performance of frontline operators (people in construction) have an immediate impact on task execution and organizational systems. Project actors should tackle the damaging potential of human errors and researchers should create awareness around the salient issues with their scholarship activities.

Keywords: Accidents, Construction, Errors, Safety, Site Work

INTRODUCTION

A study of distributed work uncovered that the assessed influence of human failure in the form of errors, mistakes, and violations on accident causations expanded fourfold between the 1960s and '90s (Reason, 1995). The study advances the notion that people are inclined to mistakes in the workplace as opposed to technology (hardware), which appears to be more dependable (Reason, 1995). The work of Reason further observes that the contributions of people to failures is not surprising considering that they design, build, operate, maintain, organize, and work within a system (Reason, 1998). Reason also informs that instances of human error are more a matter of chance than outcomes of imprudence, numbness, or rashness (Reason, 1990a; 1990b). Human error also goes beyond the "bad apple theory" to include problems that break down safety defence in a system (Dekker, 2006). Industrial accidents due to human error have major impacts on individuals and the society (Wiegmann and Shappell, 2001; Salminen and Tallberg, 1996; Wiegmann and Shappell, 2017). The accidents, inter-alia, produce injuries, disabilities (both temporary and permanent), reputational loss (individual and company) and other various forms of harm (Khan and Hashemi, 2017; Rasmussen, 1990).

The consequences of human error induced accidents are prevalent where exhaustion, poor housekeeping, misperceptions and misconceptions, mixed up needs, poor site layout, and poor site supervision predominates in the workplace (Dedobbeleer and Béland, 1991; Dekker, 2004;

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Dekker, 2014). The causes of human error also include vindictive acts, common confusion, misrepresentation and betrayal, carelessness and absence of care, failures of consideration, and intentional infringements (Dedobbeleer and Béland, 1991; Dekker, 2004; Dekker, 2014). In particular, accidents in construction cost lives, create widespread environmental damage and generate a poor public image for the industry. The reported research in this paper addresses the elimination of unsafe conditions induced by human errors on construction sites. It also went on to advance ways of containing adverse effects of human errors to ensure safety is maintained on site.

SUCCINCT LITERATURE REVIEW

An error is a set of human actions that exceed certain levels of acceptability in the workplace (Mitropoulos, Abdelhamid and Howell, 2005). Traditionally, the standard of judgment related to human error is the prescribed normative behaviour. From this perspective, human error is a deviation from a normative procedure. Causal factors for human errors include misjudgement, failure to check equipment, failed technique, inattention, haste, inexperience, communication problems, inadequate preoperative assessment, lack of appropriate control and monitoring, and insufficient preoperative preparation (Reason, 2016).

It is notable that human error occurs in several forms (Reason, 1990a; 1990b; 1995; Reason, 2008). These include intentional erroneous actions (mistakes and violations) and unintentional incorrect actions (slips and lapses). The fundamental difference between the two basic forms is that mistakes are planning errors (e.g., intentionally choosing an unsafe pathway through a worksite) while slips and lapses are the results of failed execution (e.g., inattentiveness, distraction). Mistakes are shortcomings in the judgmental and inferential process involved in the selection of an objective or in the specification of the means to achieve it. In contrast, slips and lapses occur during the mostly automatic performance of routine tasks, usually in familiar surroundings. They are related to some form of attentional capture, either distraction from the immediate surroundings or preoccupation.

In the construction context, unsafe acts often evolve from errors and violations as explained below (Reason, 2008):

- Errors in the form of slips and lapses are "skill-based" errors and occur with limited conscious thought. A slip is an unintended error in the execution of a correct plan. Mistakes (decision) errors involve the proper implementation of a wrong idea. In other words, mistakes are intentional behaviours that involve the wrong choice of action.
- Violations could be either routine or exceptional. Routine violations are customary departures from the rules that are tolerated by supervision and management. This may involve behaviours that are established practice as opposed to the specified practice. Exceptional violations are neither typical of the individual nor disregarded by management.

The highlighted unsafe acts are not easy to contain when compared to physical hazards. Physical hazards are containable with appropriate barriers and safety procedures. However, hazardous actions and behaviours violate prescribed method. It is for this reason that most safety programmes attempt to enhance compliance with safety rules, and maintain safe work behaviours at all times. In essence, management actions to reduce unsafe behaviours focus on training and motivating workers to comply with safety rules. Such practices include training in

rules and procedures, incentives and motivational campaigns such as safety culture (Cooper, 2000; Glendon and Litherland, 2001; Guldenmund, 2000; Guo, Yiu and González, 2016; Hafey, 2015; Holt, 2008). The main limitation of these practices is that they do not address the systemic forces that push workers near the edge. First, the dynamic nature of work does not involve conscious decision-making, workers immersed in the dynamic flow of work do not make decisions based on exact situation analysis but know-how, and a perception of active control and they cannot follow strict procedures prepared by experts (Rasmussen, 1997). Secondly, short-term conflicts between safety and production are usually resolved in favour of productivity as efforts for production have relatively specific outcomes that provide rapid and rewarding feedback (Reason, 1990). Thirdly, safety management needs to maintain continuous countermeasure for accident prevention, although the move journey toward safety by workers is a progressive one. Fourthly, in a complex and dynamic environment there are hazardous situations not covered by work rules (Hale and Borys, 2013; Hopkins, 2011; Mitropoulos et al., 2005).

METHODOLOGY

The research strategy was qualitative as it used face-to-face interviews to obtain primary data from site management and construction workers who have encountered accidents on various projects. The interviews were conducted on multiple construction sites in the economic hub of South Africa, which is the Gauteng province. Interviews were utilized in the study to discover perceptions formed through lived experiences of participants (Silverman, 2013; Yin, 2013). Before the interviews, meeting dates were set up with the professional teams in charge of each site by the students who collected the primary data. Focused group interviews were held as it is a proficient method for directing an exploratory dialog that is flexible and adaptable to the nature of the information (Grindsted, 2005; Gugiu and Rodriguez-Campos, 2007; Longhurst, 2009). The same method was used in engaging general workers on various project sites. The approved questions were composed in English, Sotho, and Zulu to draw in South African language speakers and English language speakers. While the sessions with professionals were mostly in English, the meetings with general workers mainly were executed with South African home languages (Sotho and Zulu).

Three building construction sites were used for the fieldwork that included 30 participants. The interview protocol had open- and close-ended questions. Table 1 sampled the questions used for management and workers in the study. Besides the questions in Table 1, the participants were urged to include additional remarks about working conditions where human contributions have a significant impact on the likelihood of accident causation.

Table 1: Sampled opened ended questions of focused interviews

Management	Workers
What does the term “human error” bring to mind in terms of construction work?	What are the working conditions concerning health and safety on site?
What were the most valuable learning experiences?	What are the working conditions in relation to human error?
In what way are you reducing accidents in your organization?	What factors of human error are most likely to happen on site?
According to you, can you boldly say there is a way of successfully preventing human contributions as a whole?	How do you feel about working on a construction site?

Management	Workers
In your experience, what impacts/factors of human error have you come across?	What do you feel are the reasons for mishaps?

The analysis of this data was done with Table 1 questions as guides in the next session. The views of site management have been used to provide a platform for highlighting the perceptions of the general workers on the three sites.

RESULTS AND INTERPRETATION

The textual data from the qualitative study that is exploratory focused on current human errors. The discourse outline several causes of human errors. The most cited causal factor pertains to on the job stress and work pressure in a very 'physical working' project site. The interviewees contend that construction work is demanding as the time frame to get the job done is always limited. Despite tight schedules, the interviewees were working in environments where workers could be injured and experience other forms of harm. With comments such as "it does not bring joy to our hearts when a co-worker is injured" and "fatalities and mishaps is a wakeup call to adhere to health and safety compliances," it can be argued that working conditions in relations to safety is essential to general construction workers.

In the focus interview sessions with site management, it was discovered that miscommunication on construction sites occur through excessive noise exposure and the diversity of languages on a site. Also, the managers interviewed suggest that mistakes are decision-making failures. Based on their explanations, rule-based and knowledge-based mistakes are prevalent on their sites. Their explanatory framework is consistent with the literature in that such mistakes arise "when we do the wrong thing, believing it to be right." A vivid instance cited by an interviewee is when an operator misinterpreted the sound of a machine breakdown and fail to switch it off immediately for safety reasons. Instead, the operator continued to work until an accident takes place. The interviewees, however, noted that mistakes happen on site when people do too many things at the same time, do too many complicated tasks at once, and ignore the effects of time (or work) pressures on the crew. From the three sites, the management highlighted common factors contributing to mistakes. The factors include:

- A work environment that is too hot or too cold. In some locations, there are poor lighting, noise, and restricted workspace.
- An inappropriate task is setting such as high workloads, boring and repetitive jobs, jobs that require a lot of concentration, working in the mist of too many distractions, working with inaccurate or confusing instructions and procedures related to plants and equipment.
- Social issues that involve peer pressure, conflicting attitudes to health and safety, conflicting views of workers on how to complete work, and too few skilled workers.
- Psychological stress and strains comprising of drug and alcohol abuse, lack of sleep, family problems, and ill health.
- Organizational issues such as failing to understand where mistakes can occur and implement controls through training, technology, and inspection.

One factor that stood out in the site management interviews is psychological stress and strains. One interviewee says,

"job strains are adverse reactions that employees have to job stressors.... Psychological strains are effective reactions including attitudes (job dissatisfaction) or emotions (anxiety or frustration). The results of unsafe human act reveal worker attitudes, anxiety and job dissatisfaction. This means if an employee works under any of this psychological strain, he/she is more likely to ignore the safety compliance and cause a mishap."

The interviewees, in general, perceive that a relationship exists job dissatisfaction and accidents on sites. The interviewees were of the view that perceived work pressure is associated with an increased tendency to engage in unsafe acts. As an illustration, they contend that workers who perceived a high degree of work pressure would focus their attention on task completions at the expense of the safe working procedure. The interviews also reveal that the supervisor who reported more anxiety reported more injuries and took fewer safety precautions.

To all the aforesaid contributory factors to mistakes, the majority of the interviewees agreed that they could be either prevented or reduced through increase worker situational awareness of high-risk tasks and the provision of procedures for predicting non-routine high-risk functions (to avoid rule-based mistakes). The mitigation strategies for knowledge-based mistakes require appropriate supervision of inexperienced workers with job aids and diagrams to explain procedures. These strategies are consistent with the recommendations of Reason (2008).

In general, the results of the study indicate that construction workers have knowledge of human errors on sites. The interviewees contend that human errors bring about unnecessary accidents, such as slippages, falls, and trips. For example, some workers recall that slippages happen when the surface is wet, or maybe a plastic or banana cover is left unattended on site. In addition, one may slip and fall from banana cover and break a leg because of poor housekeeping; which could have been prevented had the banana cover not left lying on the ground. The workers specifically cited instances where littering on site was rampant. While the managers recognized the role of poor housekeeping as a fertile ground for human error proliferation, they nonetheless flagged the miscommunications as a significant causality of human error as well.

When asked about how they think about working on a construction site, the workers gave mixed responses with sentences such as:

"It's just okay, as long as the food is put on the table" and "It is very challenging, especially when there's a delay and we are behind schedule."

"The stress during the delayed schedule is quite high." "Lot of pressure and stress."

"I love my job, and finishing my task for the day is a priority."

The above quotations reinforced the notion that workers are exposed to work pressure and stress, apart from other factors that foster human error.

CONCLUSIONS

The textual data presented in this paper show that workers were united in saying that it is hard to predict what a person is thinking or planning. Assessing working conditions in relation to human errors provides insights into the mind-set of workers in the subject area. In essence, people are prone to commit errors that produce unsafe acts. Unsafe acts must be reported to avoid accidents. The perception of the interviewees underlined this particular point because

one of them said: "A human act is unpredicted, there is bad mood, stress, pressure, and tiredness." The study also provides opportunities for general workers to air their views. The workers used their lived experiences to confirm that slips, mistakes, forgetfulness, lapses, and violations have all occurred on their sites.

With this confirmation, workers were then able to explain why these human failures and their causations occur in construction. In one interview session, the workers believed that most accidents in construction are due to miscommunication (this is consistent with the views of the professionals). Although English is the language that their superiors use for communication, the reality is that some workers misunderstand what is supposed to be done because of the communication barrier (use of Standard English Language as a communication medium). They also mentioned mistakes by machine operators. This includes misinterpretations of building designs and drawings from the professionals and by supervisors. All the reasons said above fall under human error, which brings to a conclusion that accidents on construction sites are profoundly influenced by the acts of people in the form of human errors. Future study should thus assess the extent that human errors that are associated with the performance of frontline operators (people in construction) impact on task execution and organizational systems.

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MANAGEMENT'S 'GENUINE BENEVOLENCE' & WORKER COMMITMENT TO HEALTH & SAFETY – A QUALITATIVE STUDY

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The engagement or disengagement of workers within their workplace involves the workers using different degrees of their physical, cognitive, and emotional selves during the performance of their roles. Previous research has consistently identified the significance of developing a highly engaged workforce and the construction industry seeks to enhance levels of engagement to influence greater worker commitment to Occupational Safety and Health (OSH). The significance of worker commitment lies in the perception of predicting positive performance and improvement of OSH at work. This phenomenological study reviewed extant literature by adopting an acceptable commitment theory; used focus group meetings and Delphi technique to agree on the proposed set of theoretical themes. Semi-structured interviews were conducted with workers to establish and validate the commitment themes. Three levels of worker commitment (conditional, compliance and citizenship) were operationalized to evaluate if workers truly perceive that their organization or management genuinely inspires them to work safely to achieve compliance or citizenship commitments. The findings identified no element of conditional commitment amongst the workers probably because it was challenging getting access to disengaged workers to speak to. It also revealed that some operatives perceive that their organization predominantly persuade them to commit to OSH to avoid fines and claims rather than being genuinely benevolent for the wellbeing of the workforce. Furthermore, the findings indicated a split in the number of workers performing OSH roles to attain compliance commitment (legislation driven) and citizenship commitment (going above-and-beyond compliance).

Keywords: Genuine benevolence, Commitment, Conditional, Compliance, Citizenship

INTRODUCTION

The importance of construction worker commitment to OSH lies in their perception of its significance in predicting positive performance at work and improvement of construction OSH (Cameron et al., 2006). Benevolence in the context of this paper is the perception of a positive orientation of the management toward the worker. Holste and Fields (2010) consider trust (encompassing benevolence) as affect-based and it is grounded in mutual care and concern between workers. Therefore, the concept of 'genuine benevolence' relates to the extent management genuinely cares for the OSH of workers. This is also related to an important element of reciprocity in trust (Scholefield, 2000). When an employer invests in a worker's wellbeing, there is tendency for the worker to feel valued and reciprocate directly with renewed employee loyalty through hard work and improved performance efficiency. This can lead to

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higher levels of engagement, greater focus on achieving organisational goals and increased motivation at work which can significantly improve mental and physical wellbeing (Meyer et al., 2012).

This study reflects on the **three-component model (TCM)** of worker perceptions and their commitment to their organisation/occupation based on the work of Meyer and Allen (1991) that all commitment mind sets have an implication for membership decisions (Tsoumbri and Xenikou, 2010). Although commitment is regarded as the subjective experience of dependence, research has categorised this concept into three broad groups of '*affective*' (**citizenship commitment**) - emotional attachment of workers caused by their identification with the objectives and values of their organisations; '*normative*' (**compliance commitment**) – attachment of workers to the organization based on loyalty or a moral obligation to the organization; and '*continuance*' (**conditional commitment**) - workers feeling a sense of commitment to their organization because they feel they have to remain or due to the perceived cost associated with leaving (Meyer and Allen, 1997; Meyer et al., 1993; Meyer and Allen, 1991; Meyer and Herscovitch, 2001; Weng et al., 2010; Meyer et al., 2015). In adopting the TCM theory, this study aligned the essence of worker commitment to behavioural based safety theories of citizenship (Hofmann et al., 2003); compliance; and conditional commitments.

Benevolence

The conceptual understanding of benevolence builds on the work of Mayer et al. (1995), Mayer and Gavin (2005), and Schoorman et al. (2007). It is believed that benevolence is a quality of a relationship and it is more influential (than integrity) as an antecedent of trust in a long-term relationship. Benevolence is the perception of a positive orientation of the manager toward the worker. It is the extent to which a supervisor or manager is believed to want to do good to the worker, aside from a self-centred profit motive and this is believed to be dependent on some sort of specific attachment e.g. the length of time and their relationship working together on projects. Some of the benevolent qualities include loyalty, openness, availability, caring, supportiveness, and demonstration of concern towards workers. This is because the manager or supervisor desires to help the worker, even though they are not indebted to be helpful, and there is no extrinsic reward for such a manager or supervisor.

Conditional Commitment

Conditional commitment can be viewed from two perspectives: as disjunctive goals, which makes the workers under-committed to the conditional goal due to the lack of connection or consistency, or as conjunctive goals which makes the worker over-committed, (Vandenberghe et al., 2011). This is when workers feel a sense of commitment (**mind-set of cost-avoidance**) to their organisation because they feel they have to remain (Meyer et al., 1993). The opportunity for work-based learning is an important precursor of worker-job-attitudes and behaviours and if the present job allows for the development of a range of job skills and OSH, then conditional commitment of the worker would presumably be high as there is potentially much to be lost by seeking a change of job. On the other hand, workers who perceive little professional development within their current job have little to sacrifice by leaving and are likely to exhibit low conditional commitment. This type of commitment occurs when certain conditions apply e.g. remunerations, pensions; seniority etc.; see (Meyer and Allen, 1997) e.g. fixing a safety problem or speaking to someone about safety results in loss of productivity and therefore

earnings.

Compliance Commitment

Compliance commitment refers to the worker's attachment to the organisation based on a moral obligation (**mind-set of obligation**) or a sense of indebtedness for benefits received from the organisation (Meyer et al., 1993; Meyer and Parfyonova, 2010; Meyer and Herscovitch, 2001; Herscovitch and Meyer, 2002; Somers, 2009; 2010). Workers with high compliance commitment tend to remain in the organisation because they believe it is morally right to do so. These workers have the mindset that they have an obligation to pursue a course of action of relevance to a particular target (Meyer and Herscovitch, 2001; Meyer and Allen, 1997). Organisations with workforce displaying compliance or **normative** commitment will get the job done with acceptable results, but their goal will not exceed satisfactory results or achieving exceptional outcomes. Studies have identified that compliance commitment of workers tend to correlate strongly with citizenship commitment (affective) and to share many of the same antecedents and consequences (Meyer et al., 2002). Cohen (2007) however, argued that commitment based on obligation or indebtedness (compliance) might best be considered as a commitment tendency rather than a constituent of commitment and that it can be viewed as a precursor to citizenship commitment.

Citizenship Commitment

Citizenship commitment refers to workers' attachment to their workplace caused by their identification (**mind-set of desire**) with the objectives and values of their organisations (Meyer and Parfyonova, 2010; Morin et al., 2011). This means, workers are loyal to and choose to remain with their company because they want to (Meyer et al., 1993) or due to the ability of workers to satisfy their OSH needs at work (Vandenberghe et al., 2011). Therefore, citizenship commitment will be higher for workers whose experiences in their organisation satisfy their OSH needs than for those with less satisfying organisational experiences. Workers who care about their work and their organisation tend to exhibit both emotional and citizenship commitment in terms of engagement. Their commitment is not driven by money or other incentives, but by the satisfaction at contributing towards the organisation's OSH goals. This type of commitment is more self-driven than any amount of money or tangible reward because it encourages the workers to invest a greater amount of time and energy in their role. Workers who exhibit citizenship forms of commitment go above and beyond compliance; they proactively promote safety messages; they exhibit affective commitment (Meyer and Allen, 1997) by enjoying their job and showing some level of satisfaction from their contributions to improved H&S standards. Research indicates that workers with strong citizenship commitment and compliance commitment to a change initiative tend to exhibit the highest levels of discretionary support for the initiative (Meyer et al., 2007; Herscovitch and Meyer, 2002; Hofmann et al., 2003).

METHODS

Phenomenological research design was implemented during the course of this study (Creswell, 2013; 2014; Creswell and Poth, 2017; Marshall and Rossman, 2016). A purposeful sampling strategy for construction sites and workers was utilised by selecting from a pool of site options made available by seven contractors. A total of 13 projects ranging from house building to large scale civil engineering were involved in the data collection phase. Eight projects were

used for developing the commitment framework and five projects for validation. This study conducted 28 semi-structured open-ended interviews with operatives and supervisors to develop the commitment framework until the themes being investigated reached saturation (Charmaz, 2014). The average timeframe for individual interview was 40 minutes. The workers involved were representative of the geographical spread of construction work across mainland Britain. Delphi technique was used for developing the framework by involving a team of six experts from the Steering Group with the aim of achieving convergence of opinions for grouping statements from the operatives and supervisors; see (Hsu and Sandford, 2007; Hasson et al., 2000). Three iterative phases of the ranking were carried out until consensus was established for worker commitment. Ethical issues such as personal disclosure, authenticity, credibility, role of the researcher and personal privacy were also addressed, see (Israel and Hay, 2006; Creswell, 2014). The validation of commitment and genuine benevolence (on five projects) involved 22 additional workers that volunteered to participate. The contractors were encouraged to involve their engaged workforce within the operatives and supervisory level. The criteria for engaged operatives were workers deemed as showing interest in OSH issues; contributing to H&S and regularly attending H&S meetings; whilst engaged supervisors were those who encourage engagement within and outside the workplace and regularly discuss OSH issues with other workers.

FINDINGS, ANALYSIS & DISCUSSIONS

The findings, analysis and discussions of this study present the results of commitment and benevolence in the context of OSH within the construction industry.

Benevolence: The validation exercise for genuine benevolence indicated that trust between workers and the organisation is the extent to which the workers are willing to ascribe good intentions and have confidence in the words and actions of other workers, supervisors, managers and the company. The results show that workers perceived elements of lack of genuine benevolence in some cases while others perceive genuine benevolence from management, managers and supervisors regarding H&S (compliance or citizenship). Extracts from the validation regarding *'why do you think management wants to keep you safe and healthy'* were categorised by associating lack of genuine benevolence with conditional commitment; genuine benevolence associated with compliance and citizenship commitment:

LACK OF GENUINE BENEVOLENCE (CONDITIONAL)	GENUINE BENEVOLENCE (COMPLIANCE)	GENUINE BENEVOLENCE (CITIZENSHIP)
<i>'I work for an agency, so you are treated differently, I've found that everywhere'</i>	<i>'Because if they didn't they will have a lawsuit in their hands; they will comply with the rules and regulations; they have a duty of care to the workers.'</i>	<i>'I am been treated very well, they look after me, I'm enjoying it. That's how they want to be treated, they want to be going home safe every day and they want workers to do the same'</i>
<i>'The general consensus among men is they feel the management are H&S focused to keep the insurance cost down'</i>	<i>'It's in the management interest to keep you safe and healthy and I am here to do my own job and do it right and to go home safely; they don't want to have bad record with HSE and they will need it for bidding for other jobs'</i>	<i>'I don't struggle for anything, everything is put in place. They don't want any accidents on their job; you don't want to be going home and say to your wife I had a man killed on my site today'</i>

The extracts from workers show their perceptions in relation to the benevolence of management regarding their OSH. It indicates that some workers perceive the management as lacking genuine benevolence because they are treated differently and with the focus of H&S specifically due to cost cutting and insurance purposes; i.e. their organization predominantly persuade them to commit to OSH to avoid fines and claims rather than being genuinely benevolent for the wellbeing of the workforce. Other workers perceive the organisational benevolence is aligned to elements of managements' compliance with the regulations. However, some workers perceive elements of managements' genuine benevolence because they care about the welfare of workers and also their responsibility to train the workers in OSH. This study observed that just as perceptions about benevolence will have an impact on how much trust the worker can garner, these perceptions affect the extent to which the workers trust their organisation. The works of Scholefield (2000), Schoorman et al. (2007) and Berwick (2003) indicate that the development and sustainment of trust in the management can considerably lead to competitive advantage. Therefore, nurturing higher levels of genuine benevolence would be a worthy goal for management to pursue. This is relevant as research shows that trust within the workplace can increase organisational effectiveness (Bussing, 2002). The result from this study indicates that the relationship between genuine benevolence and workplace performance may operate primarily through workers engaging in discretionary behaviour which can be identified in workers that display citizenship form of commitment.

Commitment: Workforce commitment was grouped into three broad categories founded on the work of (Meyer and Allen, 1991): **conditional commitment**; **compliance commitment**; and **citizenship commitment**. The validation of worker commitment revealed that none of the workers showed perceptions of conditional commitment but rather, displayed compliance and citizenship forms of commitment. It is pertinent to clarify that employers were not deliberately asked for 'disengaged' workers as this could lead to prejudice and discrimination within the workplace. Eleven workers discussed issues related to 'compliance commitment' while the other 11 discussed issues above and beyond compliance i.e. citizenship commitment.

Compliance Commitment: Organisation with a workforce that display compliance commitment are obliged to work to the rules due to training opportunities, rewards or a need to remain with the organisation and other benefits (Meyer and Parfyonova, 2010). Workers that display compliance commitment stay in the company because they believe it is the right and moral thing to do. A worker that the company has contributed to his/her career growth (e.g. education, mentoring) will feel a moral sense of obligation to give back to the organisation in return by been compliant. The validation interviews identified some attributes of compliance based on the perceptions of workers when asked to '*describe what you do when you see something unsafe?*'

'If I see something unsafe I'll need to report it; if it's something you won't like to see.'

'If I see anything unsafe and I was stood next to somebody in authority, I will tell them directly.'

'I'll go over and say something, the boy might tell me to f-off; and then you can go to the line manager.'

Eleven workers displayed compliance form of commitment relevant to OSH issues. These set

of workers conform and do what is required of them but no more than the legal requirement. This study identified that operatives majorly fitted into this group but however, some also perceived genuine benevolence from the management. Typically, the operatives tend to undertake just enough to keep their role but with their compliance commitment; it could be considered as an important motivational force that has influenced and benefited both employers and workers. Therefore, workers should perceive it as a sense of moral duty rather than an indebted obligation. Workers with a strong sense of moral duty tend to perceive the organisational OSH ideology and therefore commit to its meaningful objectives and support the organisation in its efforts.

Citizenship Commitment: Workers that demonstrated citizenship commitment showed a sense of attachment to their company as a result of their identification with the objectives and values of their company. This reflected their loyalty to the company and their ability to fulfil and satisfy their OSH needs at work. These workers tend to go above and beyond compliance; proactively promote safety messages and derive some level of enjoyment and satisfaction from contributing to improving the OSH standards within their company. The validation interviews revealed some of the attributes of citizenship commitment based on perceptions of the workers when asked to *‘describe what you do when you see something unsafe?’*

‘When I see something unsafe I’ll fix it. I will act on it right away.’

‘I will sort it out, I’ll try not to walk by but it’s difficult sometimes when it’s not your area of expertise.’

‘If I can rectify it myself then I will, if not I will try and get hold of somebody, a supervisor or whoever is in charge of that area and get it to their attention, it will have to stop until its sorted.’

‘If I see something unsafe I’ll action it immediately by stopping and sorting it, but depending on the scale, if it’s on a bigger scale then it will be directed up the line to managers. If it’s a subcontractor then I’ll find a way to action it.’

Eleven workers displayed citizenship forms of commitment and these were mostly workers on supervisory roles. It would be expected that these workers would also perceive higher levels of genuine benevolence within their workplaces but the validation indicated that some supervisors felt there was a lack of genuine benevolence from senior management in some H&S situations. Supervisors that have experienced career growth tend to be positively associated with displaying citizenship organisational commitment. However, the validation identified that although citizenship commitment might be higher for supervisors because their employers satisfy their needs, their perception of genuine benevolence might not always be same. Similarly, workers that have been with their employer over a period of time tend to show higher citizenship commitment than workers that have been with the organisation over a shorter period of time. Therefore, workers will display high levels of citizenship commitment when they truly believe in what they and their organisation are doing; believe they are making a difference and believe it is genuinely reciprocal.

CONCLUSIONS

This study adopted the three-component model approach to assess workforce perceptions

regarding genuine benevolence and worker commitment. The study reveals that majority of workers that displayed compliance commitment were operatives and this is not in any way unexpected. The demands of high productivity versus safety; time pressure and performance within the industry are potential reasons why most operatives tend to function more within the sphere of compliance commitment rather than operatives reflecting a strong citizenship commitment to their organization. However, it is suggested that there may be substantially greater benefits for both employers and operatives when compliance commitment is experienced as a moral duty rather than an obligation. The benefits derived from compliance commitment experienced as a moral duty can in some ways lead to citizenship commitment which was majorly displayed by supervisors. Although this study assessed various operatives and supervisors, the result indicated that there were differentiations across the profiles with supervisors accounting for mostly citizenship commitment behaviours to their organization and occupation. Although conditional, compliance and citizenship forms of commitment were expected to tie workers to the organisation and reduce turnover, one of the major reasons for distinguishing among them was the belief that they can have different implications for on-the-job behaviour. This study can infer that citizenship commitment is most strongly associated with job performance and OSH, followed by compliance commitment and conditional commitment.

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TOWARDS AN UNDERSTANDING OF CONTRACTOR - SUBCONTRACTOR RELATIONSHIPS IN THE SOUTH AFRICAN CONSTRUCTION: EXPERIENCES FROM SITE

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There is a strong correlation between project success and a good contractor-subcontractor relationship. Although the term “contractor” is ascribed to main contractor and their subsequent supply chains, the broad generalization has somewhat distorted each supply chain’s role and interaction with the principle contractor. The purpose of this paper is to provide an understanding into the influences of various aspects of management that have a bearing on contractor-subcontractor relationships and their overall performance on site. By means of three case studies, 31 semi-structured interviews were conducted with various project teams. The in-depth qualitative approach highlighted collaborative practices that influence the contractor-subcontractor relationship. Notably, client requirements, procurement strategies, project sum and size were found to influence the operational structures on-site as well as relationships between the principal contractor and subcontractors. Also, the duration of site occupancy was found to impact the relationship dynamic among the principal contractor and subcontractors as relationship built over time were viewed as beneficial for project alliance. The role of government and regulatory bodies in influencing policies and procedures in South African construction is paramount to reconciling the tensions that exist between principal contractor and subcontractors. Finally, creating and managing time-sensitive stakeholder relationships effectively that are built on communication and information sharing, irrespective of the selection processes employed remains a key element in successful collaboration as this encourages a shared vision among project participants.

Keywords: Case studies, Collaborative practice, Subcontracting, Supply chain, South Africa.

INTRODUCTION

South Africa has undergone significant change over the past 20 years. The societal transformation has had great effect on sectors such as construction where the democratic dispensation has produced professionals, construction companies owned and managed by historically disadvantaged individuals (Martin and Root, 2010). The majority of these construction companies reprise the role of subcontractors and suppliers generally known as SMEs. Further structural change in the country’s construction industry has been accredited to the increase of contracting activities funded by both private and public divisions of the economy (Emuze and Smallwood, 2014). Although a major contributor to the country’s

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economy, the industry is not without its challenges. Challenges, which include: public-sector capacity; mismatches between available skills and required skills; procurement practices and the capacity for sustainable empowerment; availability of infrastructure; high rate of enterprises failure/ delivery capacity and performance; increases in the costs of building materials; statues and regulations affecting tender and procurement processes to include previously disadvantaged groups (Windapo and Cattell, 2012). These challenges directly impact on the performance, growth and development in the industry (ibid). Over and above these challenges, Emuze and Smallwood (2014) bring to the fore a challenge that South African construction industry shares with the rest of the international construction community, that of fragmentation and specialisation as response to the growth as well as free-entrants to the field.

In this paper, we seek to add to existing research on collaborative working on construction sites by presenting the analysis of high priority case studies where contractor-subcontractor relationships were paramount to successful execution and completion of work. The aim of this research is to develop an interpretative understanding of the relationship dynamic between principal contractors and their supply chains, in this case the subcontractors. To enable the conceptualisation of collaborative practices (CP) to resonate with practitioners, each element of collaborative working are explored deeply through the development of narratives (Pablo and London, 2017). The sequential format followed in this paper begins with a brief background into CP in the South African construction industry and the challenges it grapples with which ultimately influences the contractor-subcontractor dynamic. Thereafter, the research methodology and the analysis of data is presented to provide an interpretation of the findings. The discussions in this paper are organised under three areas, namely: government influence on project structure and outcome; creating and managing time-sensitive stakeholder relationships; and subcontractor selection and competency of contract teams.

COLLABORATION IN THE SOUTH AFRICAN CONSTRUCTION

Notably collaborative practice (CP) is not an emergent concept in construction, in the South African construction industry however, researchers have only recently explored this concept as a means to improve project performance and other related issues by promoting the application of supply chain management (SCM) through collaboration (Emuze and Smallwood, 2014). Owing to the fact that a supply chain works as one team for the project duration, the benefits presented by collaboration are copious. Shakantu et al. (2007) make reference to one crucial benefit of collaboration that of ensuring that no unnecessary risk is passed on from one member of the supply chain (SC) to the next. Collaboration is further seen as a problem solving or win-win means to avoid and or reduce risk for the client and members of the SC (*ibid*).

In the wake of said challenges and issues encountered in the construction process, Towey (2012) tasks principal contractor as the enablers of productivity on construction sites. They therefore oversee the coordination and collaboration of the SC. A study conducted by Emuze and Smallwood (2014) affirmed the participation of contractors in collaborative arrangements in the South African construction industry within the last ten years. Establishing the existence and practice of collaboration in construction. Contractors in South Africa however face numerous challenges that hinder their abilities to ensure effective collaboration. One of the critical issues affecting the construction industry in South Africa is structural issues which are evident in the transient nature of work and the resulting temporary organisations involved (CIDB, 2011., cited by English and Hay, 2015). The transient nature of work and subsequent

establishment of temporary organisations further expose problems as brought out by the Construction Industry Development Board (CIDB, 2011) report which includes:

- A lack of skills on the part of contractors – many contractors lack the business and financial management skills, project management and technical skills specific to construction;
- Financial constraints and limited access to funding, trade credit, guarantees and performance bonds and high interests when these are available;
- Late payments by clients impacts on contractor cash flows and causes delays in the completion of the project, erodes profit margins, ties up working capital and encourages corruption;
- High turnover among skilled workers owing to uncertainties in job opportunities;
- Short term nature of the work which makes it hard to develop and implement long-term strategies and growth plans;
- Bureaucratic, overly complicated contract award and contract administration procedures;
- Intense competition, especially in the lower scales of construction enterprises, and difficulty in competing with larger construction firms;
- Insufficient resources to provide a safe and decent working environment such as protection equipment and attire;
- Lack of professional advisors and consultants, and where these are available the reluctance to use them to perceived fees, lack of finance or awareness;
- Lack of capital equipment such as vehicles, heavy machinery and scaffolding and;
- Uncertainties in supplies and prices of materials, allied with generally non-existent or poor relationships with suppliers.

In an exercise to explore remedial actions, Emuze and Smallwood (2014) proffer the following collaborative-working related recommendations to mitigate these and other challenges surrounding short-term objectives, strict and inflexible forms of contract, unfair allocation of construction projects risks and fragmentation:

- Ensure early involvement of key project team members who have expert knowledge so that an appropriate level of client satisfaction and value can be defined;
- Establish stable subcontractor and supplier relationships by selecting teams based on value rather than lowest price;
- Manage project parameters of cost, schedule. Quality and H&S harmoniously;
- Work together as a team to agree mutual goals and devise dispute resolution mechanisms;
- Develop and monitor continuous improvement programmes;
- Develop and implement sound risk management processes;
- Deal with risks and rewards equally by using modern commercial arrangements such as collaborative contract forms, target cost and open book accounting;
- Use non-adversarial forms of contract and ensure that contractual relationships are appropriate for expected project objectives;
- Mobilise and develop people to ensure employee satisfaction through integrated teams;

and

- Embrace the Latham (1994)/Egan (1998) collaborative working principles.

As a deduction of the aforementioned, the successful execution of construction projects or lack thereof is greatly influenced and dependent on the contractor and their respective subcontractors involved in the project (Alzahrani and Emsley, 2013). Furthermore, CP as a core feature of SCM in construction is becoming an important part of management paradigms in effort to ensure that the industry remains in the global competitive market and fulfil the growing demand for better performance from clients (Bouchlagen and Shelbourn, 2012). This paper advocates the correct interpretation of the contractor –subcontractor relationship. Understanding the relationship dynamic each subcontractor has with the principal contractor, a narrative can be developed that sheds light on barriers and enablers of collaboration in construction (Pesamma et al. 2009).

METHODOLOGY

To achieve the objectives outlined in the introduction of this paper, a qualitative case study methodology is used to analyse three construction projects that comprise of various subcontractors each undertaking work on behalf of the principal contractor. The rationale of utilizing case study is in line with conducting a pragmatic inquiry that investigates modern-day phenomenon in depth and within real-life context (Yin, 2009). As is the case of CP in South African construction, the boundaries between phenomenon and context are not clearly evident thus requiring an inquiry to bridge the gap. The data collected was gathered through semi-structured interview questions. The analysis of the interview followed an abbreviated guideline of analysing qualitative data development by Taylor-Powell and Renner (2003). The analysis process followed a five-step plan to describe the basic elements of the narrative data analysis and interpretation thereof. Figure 1 outlines the analysis process followed. The themes are colour coded to allow ease of allocating similar themes across every participant response.

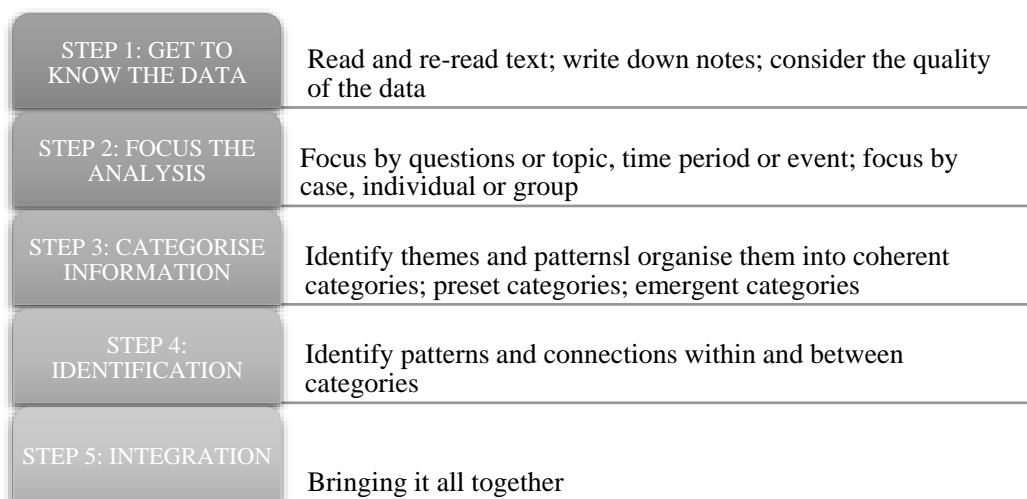


Figure 1: Qualitative Analysis process (Developed by Taylor-Powell and Renner, 2003)

The engagement with the interview transcripts initially produced 72 sub-themes which were further organized into thirteen primary themes from which three of those themes are explored in this paper. The respondents' responses to the seventeen questions posed during the 30

minutes' interview session were thus framed around the thirteen primary themes. Thus, as the discussion section will indicate, the data gathered from the case studies follows three concurrent flows of analysis namely (Miles et al., 2013):

- i. Data condensation – the process of selecting, focusing, simplifying, abstracting, and/or transforming the data that appear in the full body of written- up filed notes, interview transcripts, documents and other empirical materials;
- ii. Data display – an organised, compressed assembly of information that allows conclusion drawing and action. Data displays provides an understanding of what is happening in order to inform the remedial actions, and;
- iii. Conclusion drawing/ verification – the qualitative analyst interprets what things mean by noting patterns, explanations, causal flows and propositions

FINDINGS, ANALYSIS AND DISCUSSION

Findings and analysis of the collected data is presented in this section. In addition, a critical discussion of the analysed data is undertaken in light of relevant literature.

Government influence on project structure and outcome

The influence of the Government and local governments is evident in most South African construction projects. This is not only limited to contracts awarded but also includes policies and regulations that are established and implemented by the authorities. Thus the supply chain in construction projects is directly affected by such decisions. Interviewees expressed concerns about the lack of efficient strategies to improve project supply chain integration. Some participants called for direct involvement from the Government to help improve relationships between main contractors and subcontractors. Approaches that were suggested included '*redefining existing partnerships roles*', '*better regulatory aids in the form of revised contract suites*', '*standardisation*' and involvement of independent professional parties. In essence, the interviewees believed there was a lack of clarity on the roles of the various construction parties i.e. a clear demarcation of remits and limits of roles and responsibilities.

With respect to regulations, there were ambiguities in required codes of practice. Issues ranged from industry standards to approaches to costing. Some of the findings are as follows:

“For example the waterproofing... we use the conventional type but the Engineers have specified this new type so we comply” – CS03SA

“There must be legislated rates... improvement on government development programmes such as the EPWP programmes” – CS01PM

“There needs to be industry determined rates” – CS01SA

As highlighted, the industry professionals appreciate a systematic and transparent method of carrying out projects. Their suggestion would eliminate numerous project ambiguities and misunderstandings which often lead to cost overruns and project delays. Shakantu et al. (2007) also emphasize the importance clarity and transparency in the supply chain as described above.

Creating and managing stakeholder relationships

The cohesion of parties involved in a given construction project often gains strength over a period of time particularly if they have never worked together before. Since relationships are

built over time, it is widely accepted that earlier formed relationships are more beneficial for the longevity of the project alliance. However, since main contractors are often required to bring on board 30% of local SMEs as subcontractors, the cohesion and trust building process needs to be developed quite rapidly. Getting to know one another may be done through various methods but the face-to-face meetings are preferred by most main contractors. A brief, daily meeting among main contractor representatives and subcontractors has been the main method of creating and maintaining this relationship. However, subcontractors have found this practice to be insufficient. This approach to forming the project team has been described as '*poorly formed relationship dynamics*'. This is partly because the subcontractors believe the main contractor monopolises the direction of information flow; a practice which clearly goes against recommendations from Egan (1998). It was described as a meeting for the main contractor to brief other stakeholders instead of an opportunity for all parties to voice their opinions and concerns where possible. For instance, subcontractors believed holding such meetings offsite or in site offices (which are detached from the actual construction site) made it impossible for the main contractor's team to appreciate the predicaments of the subcontractors. It was also revealed that the contracts managers often chaired the briefings/meetings and did most of the talking during the assembly with subcontractors giving yes/no answers to matters raised. Thus there were often communication issues among the project parties.

Although the main contractors believed that they needed a better relationship with subcontractors, they also identified that their topmost priority was a practical project completion within a reasonable time. Based on this, project managers were pressed for time and wanted to offer a prescriptive approach to the project execution. They often tried to automate the project activities as much as they could in order for their ideas to be carried out exactly. However, this meant that subcontractors could not inform them of genuine project errors or inaccuracies thereby leading to more project delays and cost overruns.

With many project relationships, conflicts may arise from time to time. When conflicts occur, it is important to resolve them swiftly and efficiently so as not to have the situation spiral out of control. Key personnel are often consulted on practices to be employed whenever a conflict arise. This then leads to improved practices e.g. fair allocations of work. One of the main triggers of conflicts was incompatibility of strategies particularly from representatives of main contractors and this was often attributed to late entrants to the construction team. PRCMP02 emphasised that "*communication is key in dispute resolution*".

Subcontractor selection and competence of contract teams

There is a competitive tendering process for subcontractor roles. This often includes '*competitive quotations*' in order to select the most suitable subcontractor for the role. The evaluation process includes the subcontractors' costs in addition to their experience. Main contractors described their means for subcontractor selection as follows:

"We use a close tender system and negotiate the costs and partnerships" – PRCMP02

Following the selection of specific subcontractors, the main contractor then supports the subcontractors with project necessities including funds and documents. The main contractor "*assumes managerial role [and] provides financial assistance to commence subcontractors' work*" (PRCMP03). In order to ensure that the subcontractors work in a competent manner PRCMP03 explained that there are "*incentive programmes for well-performing teams*". It was

also added that main contractors had to inspire subcontractors to work effectively by “*encouraging soft skill development*”. Thus although they are competent at their trades, their soft skills (e.g. effective communication) needed to be stimulated as such skills are imperative for any successful project.

Even though a fair method of subcontractor selection was adopted, the specialist subcontractor pool is often limited. This is due to the government restrictions on subcontractor selection. The following was revealed:

“[The Government] clients imposed a clause in our agreement of 30% of project sum to local SMMEs, but it’s a challenge because specialised trades require experience at the same time we can face hefty penalties if we ignore this clause” – PRCPM01

By referring to the clause as being imposed on them, there is an obvious negative connotation assigned to the procedure. As bemoaned by the interviewee, the whole process is riddled with challenges, especially with respect to specialised tradesmen. This thus leads to a forced relationship between the two parties. In order for specialist subcontractors to be employed, the government clause and restrictions may need to be revised or relaxed for specific subcontractor roles.

CONCLUSIONS

The aim of this paper was to provide an understanding into the influences of various aspects of management that have a bearing on contractor-subcontractor relationships and their overall performance on site. In an effort to add to the existing research on collaborative working in construction sites, an analysis of high priority construction projects where the contractor-subcontractor relationship was paramount to successful completion of work was undertaken. To that end, the answers to understanding the contractor-subcontractor relationship was discussed under three areas of collaborative practice, namely: government influence on project structure and outcome; creating and managing time-sensitive stakeholder relationships; and subcontractor selection and competency of contract teams.

The role of government, in its capacity as project client and regulator of policy cannot be understated. As the findings of this research show, stakeholders in construction rely on government to help improve relationships between principal contractors and their subcontractors. Understandably, as issues regarding production and remuneration require legislated standardised rates. In addition, government imposed requirements on procurement strategies (i.e. 30% project sum allocated to local SMEs) should include training and skills development initiatives to circumvent any challenges associated with this method of procurement. Stakeholder relationships are time-sensitive due to the fragmentation of the construction industry. This is particularly true in South African construction. Early entrance to site with relation to project commencement has shown to contribute to better working conditions between principal contractor and subcontractors. The unavoidability of construction’s transient nature should prompt a new line of thought that of working to create relationships as presented in each project awarded. This can be steered by effective communication and information sharing in real time. Respect for both man and trade and courteousness is imperative in building lasting relationships as the current status quo of monopolising information is contributing to the tensions experienced on construction sites.

This study provided insight into the contractor-subcontractor relationship. It is one with opportunity and challenges. It is therefore the understanding that an amalgamated approach to governing the contractor-subcontractor dynamic requires a twofold objective. That of maintaining and supporting the principal contractor as the enabler of production as well as establishing subcontractors' crucial contribution to the supply chain both contractually and by including them in operational structures. There is therefore a need to define and reconcile the intra – and interdependencies of all SC contributors specific to construction activity undertaken. This should not only validate collaboration but effective integration of processes that contribute to an effective SCM model.

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FACTORS CONTRIBUTING TO DISABLING INJURIES AND FATALITIES IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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The South African construction industry is seen as a dangerous workplace, recording a high number of injuries and fatalities from accidents on a yearly basis. It is based on this observation that this study assessed the factors that contribute to these fatalities and disabling injuries within the industry. A survey approach was adopted, and questionnaire was used to gathered data from construction professionals in public and private organisations in Gauteng, South Africa. Data analyses were done using appropriate statistical tools. Findings revealed that the major factors contributing to fatalities and disabling injuring in the industry are mostly contractor related and the effect of these accidents include loss of production time, quality being compromised, negative effect on staff morale, pain and suffering for the family of the victims, and incurring of high medical costs. Contractors are therefore advice to strive towards being knowledgeable of construction regulations and risk planning management. Training on health and safety should also be a priority for all construction participants. The study contributes to the body of knowledge as it brings to light the major factors contributing to injuries and fatalities in the South African construction industry, and its perceived effect on construction works.

Keywords: Construction industry, Disabling injuries, Fatalities, Health and Safety, South Africa.

INTRODUCTION

The construction industry is important to the uplifting of the economy of any nation. Although the industry faces many challenges, it makes a huge contribution to the growth of the economy of South Africa. It is largely regarded as being important economically as it delivers the foundations and infrastructure for the economy and provides employment in large scales (Ofori, 2007; Windapo and Cattell, 2013). Thus, it is imperative that this industry runs smoothly, and accidents free so as to affect the economy in a positive light. Despite the significance of this industry, it remains one of the most dangerous workplace in the country. The industry records the highest occurrence of injuries and fatalities, from number of accidents reported on a yearly basis (Brace et al., 2005; Ramutloa, 2010). Construction in underdeveloped and developing countries has been adjudged to be performing very badly in the area of quality by international standards. Poor material and non-conformance to safety lead to site accidents, collapsing of buildings, as well as costly repairs having to be made.

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Construction sites are known to be dangerous places to work in. Workers are constantly handling heavy equipment and hazardous substances, and working in risky situations. Although there are many health and safety regulations and Acts that are meant to protect workers, accidents still occur. The industry has higher rate of injuries and fatalities compared to other industries. Industry statistics from industrial insurance company Federated Employees Mutual (FEM) indicates that in South Africa, fatalities that are due to construction total about hundred and fifty yearly. It is further claimed that four hundred accidents are suffered yearly. While it is a given that construction sites are dangerous, there is a health and safety policy to reduce these incidents (FEM, 2016). It is based on this knowledge and the need to provide a safe working environment within the construction industry in the country that this study investigated the factors that contributes to disabling injuries and fatalities on construction sites. Also the impact of lost time injury on construction projects and individuals were assessed.

LITERATURE REVIEW

Construction workers are constantly exposed to safety hazards because of the dynamic nature and conditions that changes all the time (Hinze and Applegate, 1991; Lipscomb et al., 2006). Fatalities and injuries on construction sites are attributed to several causes worldwide, the most common being falls from a high level, struck by a falling object or equipment, electric shock, and caught in between equipment or fixed objects. Fatalities and injuries in the industry do not only lead to social and financial loses for the affected workers, it also affects the employers. Haslam et al. (2005) affirmed that when accidents occurs, it impact substantially in term of cost to employers, workers and the society.

Kartam and Bouz (1998) noted that safety regulations are often cited as crucial to minimizing construction work accidents. It was observed that a major factor contributing to the bad record of safety in construction industry is the lack of accredited health and safety officers to ensure enforcement of safety regulations. In addition to this is the unavailability of health practitioners active in industry, due to the little priority place on occupational health and safety by employers. In South Africa, the occupational health and safety (OH&S) Act No. 85 of 1993 is the legislation which all companies have to abide by in terms of achieving acceptable healthy and safety standards. Managements in every organization are therefore bound by law to enforce OH&S in order to ensure the safety of their work force.

Aside regulation issues other issues such as lack of risk assessment has been noted to affect safety in construction. Generally, risk analysis in health and safety consists of identification of hazard, evaluation of measures of safety, and their consequences. Also, it determines whether the identified risk can be tolerated, since the assessment serves as a basis for managing intolerable risks. Lind et al. (2008) observed the lack of risk assessment techniques specifically meant for construction activities, and this has led to workers relying on their own knowledge and experience, which can be risky. Adding to this is the fact that most workers are not given adequate training on how to perform hazard identification and risk assessment (HIRA), for them to be knowledgeable in health and safety issues. In South Africa, one major reason for this can be attributed to the fact that constructions workers are hired on temporarily basis as unskilled labourers from project to project. They are hired for sometimes on a single project and may spend few weeks or months at different projects. This leads the contractors providing little or no job training as well as health and safety training before they begin with work.

Another important observation is the hazard associated with excavation works on site. Excavators used for excavation present severe safety hazards such as contact with live electricity underground cables, as well as the collapse of trenches. Also, excavators normally connected to ancillary equipment such as buckets or breakers, present possible hazards of being unstable during operation (Edwards and Holt, 2008). It is therefore the duty of employers to ensure that their employees are adequately catered for when handling these types of equipment, so as to ensure their safety.

Arguments has also been put forward by Loosemore et al. (1999) that contractors gain no competitive advantage from having a good health and safety record. In fact keeping their price low through elimination of health and safety related cost, serves as a way to be awarded work. Smallwood (2004) indicated that contractors find themselves in unfair positions as they may lose tenders or negotiations to competitors that are less committed to health and safety by making provision of cost for health safety, since the overall costs will increase by doing so. This is a problem for site safety as it gives room for contractors to relinquish the proper implementation of safety measures for the award or wining of construction projects. This can lead to a poor safety culture within the contractor's organisation. Bandura (1977) stated that in many cases, company's poor safety culture leads to unsafe behaviour of workers which invariably leads to site accidents. Heinrich et al. (1980) stated that majority of construction accidents involved unsafe acts. However, this does not necessarily mean that unsafe behaviours is the main cause of site accidents, but it is one of a numbers of factors and in most cases, it is the final cause that leads to the accident.

Abdelhamid and Everett (2000) carried out a study aimed at identifying the main causes of construction accident in the United States of America. The study classified the causes of construction accidents into physical and human factors. In China, Tam et al. (2004) identified the elements of poor construction safety management in the country and observed 25 major causes. Some of them include; poor awareness of safety measures, lack of training, reluctance to invest in safety, reckless operation, poor equipment, lack of first aid measures, lack of enforcement of safety regulation, poor safety conscientiousness of workers, lack of personal protective equipment, excessive overtime work for labour, lack of innovative technology, and poor information flow. Hamid et al. (2008) carried out an assessment of the causes of construction site accidents in Malaysia. The study observed that workers' negligence, failure to follow work procedures, working at high elevation, lack of safety devices for operating of equipment, poor site management, and poor skill and knowledge of workers, are some of the principal culprits. Kadiri et al. (2014) carried out an assessment of the causes and effects of accidents on construction sites in Nigeria, and observed that the main cause is negligence, while the labourers are the major victims when these accidents occur, and loss of construction time is the major effect of these accidents. The study further suggested that in order to ensure site safety, management of construction firms need to implement safety policies within their activities, ensure the use of safety equipment, conduct safety training and accident prevention methods for their workers, and ensure safe working environment and enforcing safety rules.

RESEARCH METHODOLOGY

A survey design was adopted for this study, with quantitative data gathered from construction professionals both in consultancy, contracting and government organisations in Gauteng, South Africa. Questionnaire was adopted as the instrument for data collection. The questionnaire used

was designed in sections; the first section gathered information on the respondent's background. In the second section, the factors that can lead to disabling injuries and fatalities on construction sites were ranked by the respondents based on their level of significance. A Likert scale of 1 to 5 was employed, with 5 being very high, 4 being high, 3 being average, 2 being low and 1 being very low. A total of 60 questionnaires were conveniently distributed to these identified professionals with 48 retrieved out of which 44 were deemed fit for analysis. This represents a 73% response rate from the total questionnaire distributed. Data collection was done through self-administering of the questionnaire and the data collection span a period of one month.

Data analyses were done using percentage, frequency and mean item score (MIS). To ascertain the normality of the data gathered, Shapiro-Wilk normality test was adopted since the sample size of the study is less than 2000 as suggested by Ghasemi and Zahediasi (2012) and Pallant (2005). Result revealed that all the assessed factors have a significant p-value of 0.000 which is less than the 0.05 required criteria for normality. Hence the data gathered cannot be examined using normal parametric statistical techniques as they are non-parametric in nature. Kruskal-Wallis H-test which is a non-parametric test was used in determining consistency in the opinion of the different professionals sampled. The reliability of the questionnaire was tested using Cronbach's alpha test which gave an alpha value of 0.879 and 0.871, thus implying high reliability of the questionnaire used.

FINDINGS AND DISCUSSIONS

Biographical Data and Results

Findings from the 44 workable questionnaires revealed that 59% of the respondents were Black, 18% were White, 9% were coloured and 14% were either Indian or Asian. For the respondent's highest qualification, 25% had Grade 12 certificates, 9.1% had trade test, 50% of the respondents had Diplomas and 15.9% had Degrees. Furthermore 4.5% indicated that they were Quantity surveyors, 13.6% were Civil Engineers, 31.8% were Project Managers, 22.7% were Construction Managers and lastly 25% were General Site Workers. Thirty-four percent (34%) of the respondents were employed by consultants, 54% by contractors, and 12% were employees of the government. Findings relating to number of projects the respondents were involved in revealed that 25% indicated that they were involved in 1 to 2 projects, 15.9% were involved in about 3 to 4 projects, 6.8% in 5 to 6 projects, 15.9% were involved in 7 to 8 projects, 6.8% in about 9 to 10 projects and 29.5% in more than 10 projects. In terms of the number of disabling injuries and fatalities in projects the respondents were involved in, shows that 13.6% indicated that 3 to 4 projects had either a fatality or disabling injury, 34.1% indicated about only 1 to 2 projects whereas 52.3% indicate that disabling injuries and fatalities did not occur in projects they were involved in. This result indicates that the different professions from the different organisation types are ably represented, with adequate academic background to answer the questions in the structured questionnaire. In similar vein, they have been involved in considerable number of projects; hence the response gotten from them can be relied upon.

Contributing Factors to Fatalities and Disabling Injuries

Result of the Kruskal-Wallis H-Test conducted as seen in Table 1 shows that out of the nineteen assessed factors, ten has a significant p-value of less than 0.05, while the remaining nine has a p-value of above 0.05. This result implies that at 95% confidence level, there is no significant

difference in the view of the different construction participants (contracting, consulting and government) as regards nine of the identified factors. However, a significant difference exists in their opinion as to the degree of impact of the other ten factors. This disparity in their response can be attributed their view and the importance they attached to these factors.

Result also shows that all the assessed factors have a mean score of above average of 3.0 which means that to considerable extent, they all have the tendency to contribute to the occurrence of fatalities and disabling injuries within the construction industry. Chief of these factors include contractors working long hours, contractor's safety culture, contractors taking short cuts, not adhering to safety standards, lack of training of contractors on how to perform HIRA, ineffective use of safety management plan practices, and more focus on production and less on safety with a mean value of 4.41, 4.20, 4.17, 4.16, 4.11 and 4.11 respectively. The least factor is poor site establishment and management with a mean value of 3.18. This result shows that the most significant factors contributing to fatalities and disabling injuries within the construction industry are mostly contractor related. Working long hours will most likely lead to tiredness and wiriness, which can lead to lose of concentration. The resultant effect of this will be accidents on site. In the same vein, a poor safety culture among contractors, their desire to take short cuts and not adhering to safety standards, and their lack of training have crucial influence on the occurrence of site accidents which can be fatal or even lead to disabling injuries. Thus, a critical assessment of contractors' safety standards and monitoring of their site operations is necessary.

This finding is in line with Bandura (1977) submission that in many cases, unsafe behaviour by workers is a sign of the company's poor safety culture, and these does result in accidents. Kartam and Bouz (1998) has also stated that a major contributing factor to the bad record of safety in construction industry is the lack of enforcement of safety regulations, and lack of consultants and practitioners active in construction sector, due to the little priority that employers put on occupational health and safety. This is a pointer to the lack of importance placed on safety within the industry. Loosemore et al. (1999) linked this poor safety culture to contractor's competition for jobs within the construction industry. It was observed that contractors gain no competitive advantage from a good health and safety record. Smallwood (2004) further opined that contractors find themselves in unfair positions as they may lose tenders or negotiations to competitors that are less committed to health and safety by making provision of cost for health safety. Findings of this study also agrees with Tam et al. (2004) who noted that lack of training, reluctance to input resources for safety, reckless operation, lack of rigorous enforcement of safety regulation, excessive overtime work are part of the critical factors affecting health and safety in China.

Table 1: Factors contribution to fatalities and disabling injuries

Factors	Mean	Rank	Chi-Sq.	Sig.
Contractors working long hours	4.41	1	3.589	0.166
Contractor's safety culture	4.20	2	5.212	0.074
Contractors taking short cuts, not adhering to safety standards	4.17	3	4.715	0.095
Lack of training of contractors on how to perform HIRA	4.16	4	11.784	0.003**
Ineffective use of safety management plan practices	4.11	5	4.729	0.099
More focus on production and less on safety	4.11	5	4.129	0.104
Equipment not being inspected for safety use	3.91	7	7.375	0.025**

Factors	Mean	Rank	Chi-Sq.	Sig.
Lack of proper communication plan to warn workers of potential hazards	3.77	8	8.923	0.012**
Lack of understanding of construction regulations and OH&S Act	3.77	8	16.407	0.000**
Inadequate workplace space	3.75	10	3.745	0.154
Poor house keeping	3.75	10	10.166	0.006**
Shortage of trained personnel, i.e. first aiders, fire-fighters on site	3.73	12	19.584	0.000**
Immediate supervision by authorised personnel	3.70	13	11.263	0.004**
Effective risk management plan	3.68	14	4.548	0.103
Lack of knowledge of the safety processes	3.60	15	1.195	0.550
Worn out and incorrect fitting of PPE	3.52	16	6.339	0.042**
Improper safety file on site	3.45	17	6.600	0.037**
Lack of funds by contractors for safety management	3.34	18	8.296	0.016**
Poor site establishment and management	3.18	19	5.735	0.064

Effect of Fatalities and Disabling Injuries on Construction Projects and Individuals

Result of the Kruskal-Wallis H-Test conduct as seen in Table 2 shows that under the effect of fatalities and disabling injuries to construction projects, 5 out of the 7 assessed possible effects had a significant p-value of above 0.05. The remaining 2 have a p-value of below 0.05. This result implies that there is no significant difference in the view of the different construction participants as regards the 5 possible effects. However, a significant difference exists in their opinion as to the degree of impact of the other 2. The result also shows that all the assessed factors have a mean value of above average of 3.0, thus implying that they all have significant effects of fatalities and disabling injuries. However, the most significant of them all are loss of time in production, compromise in quality, and negative effect on staff morale, with a mean value of 4.05, 4.00 and 3.95 respectively. This means that when accidents occur on sites, works tend to slow down there by leading to loss in time of production. When they are fatal in most cases there is a stoppage of work on site, and by so doing, the delivery date of such project is extended, thereby leading to time overrun. Also quality might be compromised as a result of these fatalities as workers morale may be reduced and their desire to undertake more tedious and rigorous work might be hampered. Thus the expected quality for such project might not be attained.

Under the effect on individuals, result reveals that only 1 effect have a significant p-value of below 0.05, while the remaining 3 have a significant p-value of above 0.05. This means that there is a significant difference among the respondents with regards to one of the assessed effect of fatalities and disabling injuries to individuals. A look at the table shows that all the assessed 4 possible effect of fatalities and disabling injuries on individuals have a mean value of well above average. This implies that all when accidents occur and they are fatal; it is bound to have these effects on individuals. First and foremost it will lead to pain and suffering not only to the individual but also to the family of the victim. Also high medical bills are involved in treating these accident victims, which sometimes might be way over their health insurance cover. These accidents victim might not be able to work again, thus leading to loss of income and even future earnings for them. Thus it can be said the occurrence of fatal accidents on construction sites has dire effect on individuals, hence optimum care must be taken during construction process.

Table 2: Effect of fatalities and disabling injuries on construction projects and individuals

Effect	Mean	Rank	Chi-Sq.	Sig.
Effect on Project				
Loss of time in production	4.05	1	0.261	0.878
Quality being compromised	4.00	2	0.035	0.983
Negative effect on staff morale	3.95	3	3.209	0.201
Cost overruns	3.84	4	16.384	0.000**
Claims and disputes by injured personnel	3.82	5	4.028	0.133
Perceived loss in the ability to comply with future tender stipulations on health and safety	3.80	6	2.801	0.246
Negative industrial relations consequences	3.55	7	10.587	0.005**
Effect on Individual				
Pain and suffering to the family	4.57	1	2.864	0.207
High medical costs	4.52	2	5.252	0.064
Loss of income	4.48	3	7.589	0.022**
Loss of future earnings	4.05	4	3.881	0.158

This findings is in line with Endut et al. (2009) submission that the impact of time overruns include, reduced expected profits, increase in costs and bruised reputation. There could also be a damaged reputation of the contractor due to poor safety records. Hinze (1997) has earlier stated that health and safety is crucial to project success as a project is termed unsuccessful when a worker is permanently disabled or killed during the course of construction. A successful project is delivered on schedule, within budget and reflects exemplary health and safety. The finding of this study is also in line with that of Kadiri et al. (2014) who carried out an assessment of the causes and effects of accidents on construction sites in Nigeria, and observed that when accidents occur, and loss of construction time is the major effect of these accidents.

CONCLUSION AND RECOMMENDATIONS

This study set out to assess the factors contributing to disabling injuries and fatalities on construction sites. Using a survey approach with questionnaire administered among construction professionals in Gauteng, South Africa, the study has been able to ascertain the most significant factors responsible for disabling injuries and fatalities on construction sites, and the effect of these incidents on construction projects and individuals. Based on the findings, the study concludes that, the key factors contributing to disabling injuries and fatalities within the South African construction industry are contractors working long hours, contractor's safety culture, contractors taking short cuts, not adhering to safety standards, lack of training of contractors on how to perform HIRA, ineffective use of safety management plan practices, and more focus on production and less on safety. When these incidents/accidents occur they lead to loss of time in production, compromise in quality, and negative effect on staff morale. Their effects on individuals include pain and suffering to the individual and their family, high medical bills, loss of income, and loss of future earnings.

It is therefore recommended that since the major factors contributing to fatalities and disabling injuries in the industry are mostly contractor related; contractors should strive towards being knowledgeable of construction regulations and risk planning management. Contractors should take the initiative in training and educating their workers on health and safety matters. Training and education on health and safety should also be a priority for all construction participants and not just the contractors alone. The study contributes to the body of knowledge as it brings to light the major factors contributing to injuries and fatalities in the South African construction

industry, and its perceived effect on construction works.

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LINK BETWEEN CULTURAL DIFFERENCES AND TEAM PERFORMANCE ON CONSTRUCTION PROJECTS

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Construction projects are influenced by various factors ranging from technical, financial, physical and institutional factors. Due to the number of stakeholders involved in construction projects, cultural differences pose major limitations on team performance and in turn, the success of projects. The current study therefore investigates the influence of cultural differences on team performance on construction projects. An initially pilot-tested questionnaire was distributed among 109 participants drawn from construction projects across South Africa using Survey Monkey. Purposive sampling was used to include built environment practitioners including construction managers, engineers, project and engineering managers, foremen, and quantity surveyors, contractors, clients and client organisations in South Africa. Data were analysed using EXCEL to output descriptive and inferential statistics. Findings revealed that age, educational background and organizational culture background influence on communication, knowledge sharing/exchange and integration among teams, which in turn influenced project performance. On the other hand, it was found that trust was not importantly influenced by cultural differences among the sampled respondents. The study was focused on construction professionals. Future studies may include another sample of construction workers such as craft workers to determine what cultural factor influence project performance. The study focuses on individual cultural dynamics as opposed to organizational culture which is mostly studied. Findings from the study inform construction stakeholders of individual cultural elements which have a bearing on project performance outcomes. This allows for development of strategies to accommodate these differences and improve rather than hamper team and ultimately, project performance.

Keywords: Construction industry, Culture, Performance, South Africa

INTRODUCTION

The Construction Industry in South Africa alone contributes about 8.6% into its GDP, and the total investment from government is about R110 billion. Thus, there is a continual interest in ensuring success of projects in terms of time, quality, safety, budget and productivity. Many projects struggle in the delivery of the final product with the benefits that it was initially implemented for (Stare, 2011). On average, Stare (2011) contends that only about 26% of initiated projects are completed successfully. This can be seen from the many projects that, more often than not, encounter problems which lead to schedule slippage, cost overruns, as well as some defects in quality (Chevrier, 2003). It is not a secret that the construction industry has performed poorly when compared to other industries. It has been noted that the construction

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industry is slacking and needs to improve its efficiency.

Despite an in-depth growth in the understanding of project success criteria and project management as a whole, as well as an increase in maturity, project failures still persist and continue to rise. One of the ingredients to a successful project is an effective, high-performing project team (Jumba, 2013). Project success can be achieved through great team relationships, and team culture. Team dynamics including communication, trust, integration and knowledge sharing are in turn influenced by cultural differences of the team members in terms of ethnicity, race, gender, age and educational background. Even with joint ventures and partnerships, culture and cultural differences seem to be important issues that need to be dealt with and managed properly if projects were to be successful (Kivrak et.al, 2009).

Studies have been conducted on the influence of culture on project performance. Ankrah (2007) conducted a study on organisational culture and its impact on project performance. Likewise, Jumba (2013) conducted his investigation on corporate culture and its impact on project performance; Amponsah (2012) investigated the effect of culture on project management; while Zuo et al. (2009) has investigated the role of culture and its influence on project performance. Ankrah (2007) and Ochieng and Price (2010) focused on single aspects of culture such as organisational culture or factors to improve team performance. Ankrah et al. (2009) investigated factors influencing culture of a project team, but did not focus on demographic variables or cultural differences of the individuals who make up a project team. According to these studies, culture has an impact on team and project performance. However, although studies have been conducted on culture and team and project performance, few studies have investigated the contribution of culture on team performance, which contributes to project success. The current study therefore aims to investigate the influence of cultural differences on team performance.

LINK BETWEEN CULTURE, TEAM PERFORMANCE AND PROJECT SUCCESS

Every construction project is undertaken by individuals and most likely than not, these individuals are from different cultures and background (Loosemore and Lee, 2002). This difference in cultural backgrounds has some kind of impact on how the project performs.

Culture is defined as “values, beliefs and systems of meaning that are shared among a group of people and provide a guide for their interpretation of various aspects of life and the world around them” (Stahl et al., 2010). Culture emerges as a result of a society’s need of answers to problems that are common to all groups (Tukiainen et al., 2003) and determines who talks to whom about what and how the message is encoded from one party to the next (Loosemore and Lee, 2002).

Culture can change over time, depending on its characteristics, which could be learned (through experience; not inherited or biological); shared (People as members of a group, organisation, or society share culture; it is not specific to single individuals); Trans-generational (cumulative, passed down from one generation to the next); symbolic (based on the human capacity to symbolise or use one thing to represent another); patterned (has structure and is integrated; a change in one part will bring change in another) and adaptive (based on the human capacity to change or adapt, as opposed to the more genetically driven adaptive process of animals) (Tone, 2005; Kivrak et al., 2009). Different people therefore have differing feelings, opinions, levels

of understanding and tolerance, ways of doing, perceiving or interpreting things, experiences, competences, languages, and modes of survival and these affect integration, knowledge sharing, communication, and trust (Stare, 2011; Loosemore et al., 2012; Schermerhorn et al., 2012). In a study conducted in Singapore by Pheng and Alfelor (2000), it was found that even things such as construction tools and equipment, the format and layout of drawings were an issue and created conflict between the American and Singaporeans consultants. This can be correlated to the belief that culture influences even the way people approach work (Schermerhorn et al., 2012). Notwithstanding, diversity should be something to value as Schermerhorn et al. (2012) argue, rather than it being something that needs to be managed.

Cultural differences relate more on values than practices and may over time influence organisational/corporate culture (the beliefs and values that govern behaviour in an organisation) (Pheng and Alfelor, 2000; Stare, 2011). Corporate culture has a strong influence on project performance (Jumba, 2013). It helps to increase mutual understanding and trust between parties from different cultural backgrounds, and helps define effective and ineffective performance (Jumba, 2013). But even with different culture types, culture as a whole has been found to be a hindrance to the efficient execution of construction projects if any gaps are found to exist (Ankrah, 2007). Amponsah (2012) found from cross-cultural management research that Western management concepts may entirely or partially be irrelevant and non-applicable to other cultures because the values portrayed in the work environment are culturally based. Cultural differences lead to people not perceiving certain scenarios and approaching situations the same way and therefore making it difficult for organisations to predict and understand the behaviour of their employees and this affects performance of projects (Schermerhorn, 2012). Cultures materialise and evolve in response to social cravings for answers to a set of problems common to a group such as in a project team (Ochieng, 2012). Thus, in order to survive and exist as a social entity, every project group, regardless of size, has to find solutions to problems of cultural diversity.

Cultural differences affect project teams in terms of the following:

- Communication: The exchange of information (ideas, perceptions, feelings) in a verbal or nonverbal way;
- Trust: The ability of everyone in the team to have confidence, firm belief, assurance in the ability, reliance and strength of someone or something;
- Integration: The combination of people from various cultures put together to become one team with one goal/vision – which in this case is to deliver a project successfully; and
- Knowledge Sharing: The exchange/sharing of information, skills or expertise related to a particular subject, in this case, construction/engineering, i.e. lessons learned

In the construction industry, encoding of messages could be detrimental to the project if vital information is not communicated to the relevant people. Information and knowledge sharing plays a critical role in projects. Knowledge sharing is not just for a 'lessons learned' session, but also for innovation purposes which essentially leads to successful projects. Consequently, people involved in construction projects, working in teams composed of multi-cultural team members may need to bend a little and be willing to modify and compromise their cultures in order to accommodate the other cultures present and be able to share responsibilities and authority shared amongst them (Ochieng, 2012). The project team dynamics in construction

projects therefore needs to be investigated to ensure that even though teams are made up of people with different views, they can still work together to achieve one common goal, which is to deliver a successful project. Therefore, cultural diversity within construction projects needs to be managed effectively as it can impact health, safety, welfare and productivity of the workforce, as well as the organisation's performance (Loosemore et al., 2012).

METHODS

A 5-point Likert questionnaire was developed from literature review and pilot-tested to 10 construction contractors. The pilot survey served to ensure that the questions were structured correctly and the right questions were asked. Thereafter, the main study was conducted. The main survey was conducted using Survey Monkey as a data collection tool. Foremen, Engineers, Construction Managers, Project and Engineering Managers and quantity surveyors working for Consultants, Contractor (including Sub-Contractors) and Client organisations were identified as potential respondents using

purposive sampling. It was important to include in the study, individuals who had worked on a construction project and within a project team, throughout all the phases of the project. A link was created in Survey Monkey which was distributed to all the participants using 'Outlook' email software in order to complete the survey. 109 participants responded (a response rate of 35.16%). 100 of the questionnaires were valid (completed) and used for analysis. Data were analysed using EXCEL to output descriptive statistics.

FINDINGS AND DISCUSSION

Demographic Characteristics of the Respondents

88% of the respondents were male and 12% were female. 50.5% of the respondents were from the white community; black people made up 38.3%, and Indians were 5.6%. Respondents who indicated 'coloured' accounted for 3.7%, while 1.9% of the respondents chose to indicate 'other', representing the Chinese or Arabic respondents. With regard to organization, consultants represented 50.9% of the respondents, clients made up 30.6%, contractors 17.6% and "other" 0.9%.

Findings on Perceptions of Construction Professionals on Link between Cultural Differences and Team Performance

Table 1 presents findings on the influence of culture elements on team performance. One of the elements evaluated as forming part of team performance was communication. The respondents were asked if they easily communicated with all team members within the projects, and the results showed that 55.2% and 32.4% agreed and strongly agreed, respectively, to easily communicating with all team members; while 5.7% neither agreed nor disagreed, and 6.7% 'disagreed' with the statement. For the statement, there is free flow of communication between us, despite the difference in age among team members, 51.5% and 19.4% agreed and strongly agreed, respectively, with the statement. On the other hand, 12.6% disagreed with the statement. With regard to the third statement under the communication element, the respondents were asked if they easily reach consensus on many issues on the project despite different backgrounds, 11.4% strongly agreed, 54.3% agreed, 15.2% disagreed and 19% neither agreed nor disagreed with the statement. When asked if all team members easily communicate with other team members regardless of cultural differences including race, gender, age and ethnicity, 32.4% and 14.3% of the respondents agreed and strongly agreed, respectively, with the statement; whilst 21% neither agreed nor disagreed, and 32.4%

were disagreeable.

Another element evaluated relative to team performance was trust. The statement trust exists among the team even with difference in organisational culture background had a mean score of 2.74, with 44.2% of the respondents in agreement with the statement. Likewise, with the statement trust exists among the team even with cultural differences in terms of race, gender, age and ethnicity, only 10.7% and 47.6% of respondents seemed to strongly agree and agree, respectively, on the statement. It is notable that the mean scores for the statements in this category were below the average (3.0) and therefore it can be deemed that the respondents tended to disagree with this statement.

Respondents were asked to rate the extent to which they share information with all project team members without hindrance from gender differences. The results show that 52.4% and 41.7% agreed and strongly agreed with the statement, while only 2.9 disagreed. On the statement, I share information with all project members without hindrance from age differences, 47.6% and 39.8% agreed and strongly agreed, while 3.9% disagreed and 7.9% were neutral.

With regard to information sharing, the respondents strongly agreed that they share information easily with all project team members without hindrance from gender (ranking 1, mean score, 4.31), age (ranking 2, means score of 4.21) and ethnicity (ranking 3) with mean score of 4.18.

Integration was also an element evaluated relative to team performance. The respondents were asked if a good project team was formed in projects despite differences in background and cultural differences. When asked to rate the influence of cultural background differences on team integration, 47.6% agreed and 6.8% strongly agreed with the statement there is integration as a team, despite our cultural background differences.

Table 1: Influence of cultural elements on project team culture

My experience on construction projects is that:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Weighted average	Rank
Communication							
I easily communicate with all team members on the project	0.0	6.7	5.7	55.2	32.4	4.13	1
There is free flow of communication between us, despite the difference in age among team members	1.0	12.6	15.5	51.5	19.4	3.76	2
We easily reach consensus on many issues on the project, despite our different	0.0	15.2	19.0	54.3	11.4	3.62	3
All team members communicate with other members irrespective of race, gender, age and ethnicity	3.8	28.6	21.0	32.4	14.3	3.25	4

My experience on construction projects is that:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Weighted average	Rank
Trust							
Trust exists among the team even with difference in organisational culture background	2.9	26.0	20.2	44.2	6.7	2.74	1
Trust exists among the team even with cultural differences	2.9	22.3	16.5	47.6	10.7	2.59	2
Knowledge sharing							
I share information with all project members without hindrance from gender differences	1.0	2.9	1.9	52.4	41.7	4.31	1
I share information with all project members without hindrance from age differences	1.0	3.9	7.8	47.6	39.8	4.21	2
I share information with all project members without	0.0	5.8	4.9	55.3	34.0	4.18	3
All team members share their knowledge with other project members regardless of gender	0.0	19.0	14.3	48.6	18.1	3.66	4
All team members share their knowledge with other project members regardless of educational background and qualification	1.0	20.6	21.6	43.1	13.7	3.48	5
Integration							
We have formed a good project team despite our differences in background	1.0	7.6	9.5	61.9	20.0	3.92	1
There is integration as a team, despite our cultural background differences	4.9	23.3	17.5	47.6	6.8	2.72	2

The findings showed that respondents perceived that communication, integration, knowledge and information sharing within the project teams are influenced by cultural differences. These findings are consistent with the views expressed in similar studies like Loosemore et al. (2012) and Ochieng (2012), which informed that extra efforts have to be made in order to accommodate the different views, opinions, interpretations and so on, of members of a construction team, who are varied and come from diverse backgrounds. As Loosemore et al. (2012) emphasised, to deliver a successful construction project, cultural diversity needs to be managed effectively as it can impact health, safety, welfare and productivity of the workforce, as well as the organisation's performance.

The findings also showed that the sampled respondents deemed that trust was not influenced by their cultural differences or background. This could mean that cultural differences and organisational culture background do not influence the trust existing among the sampled respondents. This finding does not really align with the views captured in Ajmal (2015) which

stated that cultural difference may hinder trust building among team members. The difference in results could however, be the focus or population sampled in the current study and Ajmal's, which focused on international stakeholders, who may not be acquainted with one another and therefore the issue of trust become significant in that scenario. In other words, in the current study, trust may not have been considered an issue that could affect project performance due to cultural differences.

CONCLUSION

The study was conducted to investigate the role of cultural differences on team performance, which could contribute to project performance. Findings revealed that age, educational background and organizational culture background influence on communication, knowledge sharing/exchange and integration among teams, which in turn influenced project performance. On the other hand, it was found that trust was not importantly influenced by cultural differences among the sampled respondents. The study was focused on construction professionals. Future studies may include another sample of construction workers such as craft workers to determine what cultural factor influence project performance. In addition, the study focused on individual cultural dynamics as opposed to organizational culture which is mostly studied. Findings from the study inform construction stakeholders of individual cultural elements which have a bearing on project performance outcomes. This allows for development of strategies to accommodate these differences and improve rather than hamper team and project performance.

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WOMEN AT CONSTRUCTION SITES: SHORTCOMINGS, DIFFICULTIES AND GOOD PRACTICES

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On average only 10% of the workers at construction sites are women, meaning the male workforce is predominant at civil constructions. This index, however, is not related to the lack of interest or capacity of this group, but to gender discrimination, sexual harassment and work safety. Companies in the sector have started to understand the benefits carried by social responsibility at construction sites and, therefore, to implement the gender-inclusive policy. The purpose of this work is to identify the main shortcomings and current difficulties of women workers in construction sites, as well as good practices that might provide a better environment for them. For this purpose, an analysis of construction site conditions of the city of Salvador is carried out, as well as interviews with workers of these sites, in accordance with the existing norms and policies of social responsibility. It is hoped that the results of this work contribute to raising awareness of the benefits of gender mainstreaming in construction sites and to promoting the healthy and safe presence of women in these environments.

Keywords: Women, Construction sites, Gender, Work safety, Civil construction.

INTRODUCTION

Less than 10% of construction jobs in Brazil are occupied by women (Ministry of Labor, 2018). Although women's participation in the formal labor market is constantly growing, their employment in positions seen by society as male's is still very small.

The concept of social responsibility promotes the insertion of women in the labor market, especially in the sectors in which they are a minority. Oliveira (1984) indicates that social responsibility goes beyond simply fulfilling legal obligations. It is represented by the company's ability to collaborate in some way with the society, given its norms, values and objectives. In the modern world, the interest of companies to provide social improvement attitudes becomes clear, either in the attempt to self promote the company, ending in financial profits, or motivated by a truly ethical and beneficiary attitude.

On the one hand, it is possible to see the evolution of society on these aspects through recognitions and guidelines, as the CBIC Social Responsibility Award, CBIC itself following ISO 26000, that determines guidelines for organizations to operate in an ethical and transparent manner, contributing to the health and well-being of society. On the other hand, it is still part of women's daily life all the prejudice, devaluation, discrimination and sexism, which holds

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off the equality on the opportunities between genders in the work environment, more specifically, in construction sites, within the civil construction sector.

This article analyses the partial results obtained through a diagnosis carried out in construction sites in Salvador, Bahia, to identify the specific needs of female workers in these work environments. The analysis seeks to identify what led the construction industry to have such a low number of women working on construction sites; the importance that women workers give to this labor; the difficulties experienced by workers; and good practices that can be implemented to improve this work environment for women.

CONTEXT

Historical Context

IBGE reports that, in 1950, only 13.6% of women took part in the labor market in Brazil, but with the constant growth of this index, in 2010 it reached 49.9% (Andrade, 2016). Even though there was a clear evolution of the insertion of women in the economically active population, many difficulties women face today while trying to enter labor areas predominately occupied by men are due to cultural and historical issues.

According to Blay (2001), discrimination strongly marks the historical trajectory of women in the workplace, where sexual differences are a pretext for hierarchizing social relations, in which men exercise the position of domination and women, of subordination. This gender hierarchy is reproduced with each generation, and it is still present in contemporary societies.

Calil (2000) emphasizes that in the nineteenth century it was believed that women should not work, they should focus exclusively on domestic and reproductive functions.

Sexual Labor Division

The historical factors mentioned above, such as discrimination, devaluation and precariousness of women's work, along with factors that the society believes to be biological, attribute different characteristics to the work perceived as masculine and to that perceived as feminine. The sexual division of labor attributes to men the role of family financial provider and to women the domestic and reproductive responsibilities, functions that are not considered work (International Labor Organization, 2012).

For Hirata and Kergoat (2007), the sexual division of labor is modulated historically and socially, resulting from social relations between the genders. Men are called the productive sphere, which concentrates the functions with the highest social value, and women are the reproductive sphere. The concept has two principles: separation, in which male and female jobs are divided, and hierarchy, which values the work of man above that of woman.

The principles of sexual division of labor are justified mainly by the biological differences between the genders, seen by society as weaknesses and impediments of the woman, depriving her of occupying more important and recognized positions. However, Blay (2001) indicates that there are only four aspects of biological difference between the two: the man's ability to fecundate and the woman's ability to gestate, breastfeed and menstruate. In addition to these reproductive functions, the author explains that there are no other characteristics so different between the sexes that makes the man capable of practicing some activity and the woman incapable, or vice versa.

A World not so Modern

In the 1980s, Brazil suffered an economic crisis while some changes were taking place in the political, economic and social spheres of the country (Bruschini, 1992). In the midst of these changes, female participation in the Brazilian labor market began to grow, since women began to work to support their families, and many of them became the primary providers of their homes (but still earning very little for that).

According to the Brazilian Government, in 2016, 44% of formal job market places belonged to women, a higher number than 41% of places in 2007 and much higher than the participation of women in the late twentieth century. The source also reports that women study and qualify more than men. Yet by 2015, men earned 16% more than women, and held 90% to 95% of management positions in companies and organizations.

These data show that women are formalizing their work and gaining space in the active economy of the country, but the roots of the sexual division of labor, prejudice, discrimination and devaluation are still present.

Women and Construction Sites

In Brazil, between 2000 and 2010, the number of men employed in construction grew more sharply than the number of women (DIEESE, 2012). Within the civil sector, in the mentioned period, the growth of employed men was approximately 39%, while the growth of employed women was 32%.

The common living areas of construction sites should receive special attention, since they impact on the satisfaction of the worker in performing his duties. They must be adjusted for the needs of women employees. NR 18 and NR 24 are quite specific with the separation of facilities by gender, and with the necessary care and measures to turn the construction site environment minimally pleasant. Unfortunately, there is no clear way in which the comfort of workers will be guaranteed and there is also a lack of specifications to direct the well-being of women in the site.

METHODOLOGY

This research seeks to collect and analyze data in a qualitative and consistent way to create subsidies that allow a discussion around the gender gap in construction sites. For that, interviews are being made with workers and engineers of both sexes, making it possible to assess the work environment both in women's and men's views.

Since this work aims to increase awareness of gender discrimination and inequality at the construction site, interviews with male workers and engineers may be seen firstly as a bias of judgment and hierarchy of man towards woman. The intention of the interviews with male employees is, however, to collect different perceptions of the problem, show the importance of a problem that is often not perceived by the opposite sex, and, with a simple conversation, bring issues that will trigger reflections on them, might influence their way of dealing with gender issues and improve their attitudes towards women at work and at their personal life.

It is important to emphasize the difficulty of finding construction works that employ women. From the 40 contacts carried out in the beginning of 2018, only two sites were identified, until the present moment, containing female workers in their staff, simply because the buildings

were going through their finishing phase of construction. The data collection activities, however, will continue to be carried out throughout this year, and it is estimated that it will be possible to conclude the study with a larger number of interviewees.

So far, the sample of the research is composed by seventeen persons, all of whom work in two different sites in Salvador, Bahia (Site A and Site B). This sample is not large enough to make generalizations about the gender issue at construction sites. However, it exemplifies common daily situations and thoughts that can be used to prove assumptions and facts studied in other articles and references.

The interviews were based on a structured script. The respondents should agree or not with some statements that were asked, justifying their choice afterwards. Some questions were made as well. The answers were recorded with the consent of the interviewees and then transcribed. An observation guide was also structured, and some notes were taken based on the conditions of the sites.

The statements and questions were developed and analyzed from the following topics: Acceptance, Good Practices, Installations, Well-being and Perception about genders. **Acceptance** is related to the insertion of women in the civil construction, the benefits of this insertion and their adaption at the construction site; **Good Practices** approaches improvements in the work experience and issues about the entrance of women in the construction environment, such as the adaption of the site and the instructions received by workers. **Installations** analyses gender segregation at the site and adequacy, comfort, hygiene and safety on the premises. **Well-being** introduces topics about satisfaction, comfort, safety and respect at work, conciliation of work with domestic tasks, coexistence between workers at the site and how open the administration is upon communication of insecurities experienced at the site. At last, **Perception about genders** brings comparisons between genders in the positions occupied, in training, evaluation, promotion, performance and productivity. Figure 1 presents the profile of the interviewees.

Interviewee	Site	Gender	Formation	Function	Civil status	Age	Children
SA-W1	A	Female	1 st degree	Servant	Married	27	1
SA-W2	A	Female	1 st degree	Servant	Single	27	1
SA-W3	A	Female	2 nd degree	Servant	Single	34	1
SA-W4	A	Female	3 rd degree	Engineer	Single	26	-
SA-W5	A	Female	3 rd degree	Intern	Single	23	-
SA-M1	A	Male	2 nd degree	Bricklayer	Single	26	-
SA-M2	A	Male	2 nd degree	Assistant	Married	26	-
SA-M3	A	Male	3 rd degree	Engineer	Married	35	-
SB-W1	B	Female	2 nd degree	Servant	Single	27	1
SB-W2	B	Female	2 nd degree	Servant	Married	36	1
SB-W3	B	Female	1 st degree	Painter	Single	36	1
SB-W4	B	Female	3 rd degree	Intern	Single	21	-
SB-M1	B	Male	2 nd degree	Carpenter	Married	38	1
SB-M2	B	Male	2 nd degree	Bricklayer	Married	41	2
SB-M3	B	Male	1 st degree	Assistant	Married	32	1
SB-M4	B	Male	2 nd degree	Technician	Single	23	-
SB-M5	B	Male	3 rd degree	Engineer	Married	33	-

Figure 1: Profile of the interviewees in the construction sites visited

ANALYSIS AND DISCUSSIONS

The first point analysed was the unavailability of women working in the construction sector and the limitation of the positions of those who work. A reasonable number of women was found working in the management sector, however, in the production field, it is common that

there are none. On the sites visited, an average of 7% of the employees in the production field are women and, in management, this number grows to 33%.

According to the engineers who were consulted, the hiring of women usually occurs at the end of the construction of the building, during the period of grouting, finishing and cleaning. This fact brings the concept of sexual division of labor. All the interviewees agreed that the role of women in construction is precisely to exercise more detailed and fragile activities, caring more about the service done and, therefore, delivering higher quality services.

Acceptance

The lack of female workers at construction sites is related with the hiring of the staff. The manager usually feels insecure when hiring women, knowing that it is an extremely sexist environment. The engineer SA-M3 revealed that when a few women are allocated inside a site that has 100 men, they will probably suffer harassment. He considers that women also suffer discrimination when placed in positions normally occupied by men or in positions of high hierarchy, since he has experienced such cases. The intern SA-W5 agrees and explains that if the manager is to choose hiring a male or a female worker in a position usually occupied by men, they will hire the man. This happens because the manager values the satisfaction of the male workers already allocated in the site, and when a woman enters their work environment, they think that a male workmate, friend or family member is losing their position to her.

To adapt to the masculinized environment, suffer less discrimination and gain respect at the construction site, the engineer SA-W4 said she is much more tough and rigid. She transforms herself a little at work. According to her, female workers with masculine behaviors have an easier and quicker adaptation to the work environment, receiving respect from both women and men at work. This confirms the statement indicated by Silva and Honório (2011), that, to be recognized and respected professionally, women are more patient when searching for opportunities, adopting masculine characteristics when necessary.

Good Practices

Most of the interviewees of both sexes that approached harassment and provocation issues during the interview stated that the male workers are to blame for that. However, both companies consulted adopt the same system of instructions for when women enter the site: they instruct the newcomers, not the male workers that were already there. In addition, it is possible to find etiquette manuals at construction websites targeted only to women, even though the men are the ones to blame for the abuse.

The bricklayer SB-M2 said that most of the men at construction sites think women should work at home, because if they attend an environment like that, then men can use them, do what they want with them. The servant SB-W1 stated that, in another site, she tried becoming friends with some of the male workers, but it did not end in a good way, since everybody else started rumors about her dating guys in there. Since then, she restricts any contact with male workers.

The technician SB-M4 declared that the instructions given to female workers entering the site aims to avoid annoyances with them. Along the instructions, he asks the women to always focus in the service being done, not to talk much with the men working there and not to care about what they say. He also claimed that when there are many men around a few women, they feel the need to tease the women just to show and magnify their masculinity, and that the

instructions about behaviour are done to men only in case women bring up a good number of complaints. According to Rios, Chong and Grau (2017), female workers in nontraditional occupations avoid reporting workplace harassment, because they fear losing their jobs. In another part of the interview, the technician also cited that he does not know if the women feel insecure or disrespected, since they do not complain about it and they might think they will lose their jobs if they do.

Finally speaking of actual Good Practices, some male and female workers suggested reunions, or, as they call, DDS, to encourage respect among genders in the field. Since the lack of respect comes from men, the management should start giving *them* instructions, not only to women, who are the actual victims in this situation.

Installations

Regarding the norms NR 18 and NR 24, the engineer SA-M3 reported that the construction sites only guarantee the basic standards in the common living area, always according to the regulations. The construction sites visited have sanitary facilities and locker rooms separated by sex, which are sanitized every day.

For the administration of one of the sites visited, the installations represent a huge disadvantage on the hiring of women. The intern SB-W4 stated that the insertion of women in this market is not planned and that it is very convenient for the administration to maintain the predominantly masculine environment. When women enter the site, the management has got to resize the installations regarding the division of genders and to worry about the adaptation of workers to this new reality, which, to them, represents more costs, and are not worth it.

Well-being

Some female workers reported that they work in the construction sector only as a matter of necessity, which is accentuated by the fact that they have to support a child. They work harder than in their previous jobs, but one element that encourages them to stay in the construction sector is the financial return, in addition to the desire of new opportunities in the area, specifically in the administrative sector. When asked if they prefer an easier activity that pays less, they did not hesitate to answer that they do not.

When responding if they feel respected, safe and comfortable, the female workers agreed that because it is a masculinized environment, they search for their own place and do not relate much with others. SB-W1 claimed that there is still a lot of judgement in the construction environment, intensified by moral and verbal sexual harassment. The same question was asked towards the male workers. The assistant SA-M2 referred to disrespect among production workers of different levels of hierarchy and the bricklayer SA-M1 referred to the insecurity related to work instability, arising from the crisis that the country is going through. It is notorious, by those speeches, the contrast between the thoughts of men and women in the sites visited, regarding their comfort and safety in the workplace.

Cavazotte, Oliveira and Miranda (2009) claim that the judgement suffered by women has its price: negative consequences are suffered not only by the female workers but also to the company, since the perception of discrimination causes disengagement within women, which increases the turnover and generates high costs for the company.

The engineer SA-W4 reported that she wanted to hire women for a job and her former boss replied that he did not want a pretty woman. He declared that she must hire an ugly woman, since beautiful ones go along with pick up lines. This is another example of women being blamed for men's actions in the field.

Regarding the gender relations in the construction site, when talking about the coexistence of workers in general, the men declared that there was a good relationship between both sexes, that they chitchat once in a while, because women now have equal rights. In spite of that, the speech of the servant SA-W1 was different: she said they talk as little as possible, they play very little with them, and have to be cautious. It portrays the difficulties of conviviality that, in their intrinsic way, the male workers also see, proved by citing that women should work in a quieter area, because there are too many men for just a few women and there is a lot of mess at construction sites.

Perception about genders

It is an obstacle for the number of women who work in construction sites to expand upon other occupation areas, since the posts reserved to them are always within the finishing phase of constructions, to exert grouting and cleaning functions, as mentioned above. They also find it difficult to grow professionally in constructions companies, since this small range of positions does not open possibilities for promotions.

Cavazotte, Oliveira and Miranda (2009) explain the expression *glass ceiling* as a phenomenon in which a subtle but strong barrier blocks the promotion of women to higher levels of hierarchy in organizations, distancing them to professional advancement. The technician interviewed confirms the statement, as he says promotion at construction sites are retrograde, since women do not have opportunities to grow yet. Silva and Honório (2011) also confirm that jobs considered more formal and stable, especially those linked to managerial positions, are usually occupied by men, while jobs with lower responsibilities are relegated to women.

Regarding productivity, most of the workers interviewed stated that men and women produce in a similar way, each in their respective sector. The bricklayer SB-M2 said women produce even more than men, and that, even noticing the inequality between genders in the construction sector, the only thing that differentiates men and women is the sex.

Even along all these difficulties, the women are proud of their work, mainly because it is a decent job and because they feel courageous about habituating that environment. They see themselves as warriors in the construction industry: SA-W2 states that it is not all women who have the courage, there are people who are ashamed, especially if they are young like her. She says most of the people out there wants something easy, and she would rather be there, fighting.

The servant SB-W1 adds that women entering construction sites symbolize the gain of space not only at the construction sector, but also in the marketplace and in society, breaking taboos and judgements as well.

CONCLUSIONS

For the hiring of women to be expanded, some standards must be broken. Contractors must change their views regarding hiring women, and the unemployed and active female population must see the construction sector as a less intimidating environment. Engineers must stop

thinking that women are the cause of harassment and male workers must be trained and instructed, acknowledging that respect must be always present in the field.

Another factor that promotes the insertion of women in the civil construction sector is their participation in unions and in politics, in order to encompass the vision about the issue and to stimulate the implementation of projects such as those mentioned above. In public works, there is a minimum proportion of women that has to be hired, regulated by law. Female workers must also recognize their legal rights to equality and safety at the workplace, being aware that the challenges and risks they handle are common to other women in similar situations, knowing, therefore, that they are not alone.

In this context, it is important to emphasize that there are some projects in Brazil that aim to incorporate women labor in construction, whether through hiring or through promoting trainings. In addition to providing opportunities for women to raise their incomes, they empower them, opening space for them in a typically male labor market. *Mão na Massa* project, for example, selects women in Rio de Janeiro to take professional civil construction courses and promotes better work opportunities for them in the sector. *Mulheres na Construção* project offers professional training courses with guaranteed temporary contracts for the participants.

Besides that, some steps made by CBIC (2018) to support the process of hiring women in construction sites should be highlighted. It is necessary to identify jobs that can receive female labor force, to understand the profile of the collaborators, also mapping the expectations of the candidates, and to implement changes in the infrastructure, since the regulations demand some specifications for female workers. Current employees should be prepared through meetings, with instructions or booklets that address the equity of treatment towards women and emphasize mutual respect. Lastly, women should be welcomed and integrated, to avoid polarization among workers, closely following the first weeks of the workers. It is very important that the management of the work is always available, so that employees can report any insecurity or nuisance they feel throughout the work.

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MINIMISING RAPE INCIDENTS IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY - A GAUTENG CASE STUDY

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Rape remains a social crisis that faces almost every industry within a nation's economy and the construction industry is no exception. This study presents the findings on the assessment of the possible ways of minimising the occurrence of this unpleasant act within the construction industry in South Africa. The study adopted a quantitative approach whereby questionnaire survey was conducted among construction professionals in Gauteng, South Africa. Data gathered were analyzed using percentage, mean item score and standard deviation. The study revealed that the most significant measures of minimising rape in the South African construction industry are paying attention to sexual violence by persons in charge of workplace safety, adequate training for persons in charge of sexual misconduct in the workplace, educating employees, proactive policies in work place, creating rape prevention programmes, and continuous evaluation of the work environment. The study further recommends the adoption of a uniform policy by construction organisations on the handling of rape cases. Guidelines stated in the South African Employment Equity Act (No.55 1998) can also assist organisations in the effective management of sexual harassment and violence issues in their organisation.

Keywords: Construction industry, Rape, Sexual harassment, Sexual violence, South Africa.

INTRODUCTION

The construction industry is amongst the biggest industries worldwide. The industry's impact on economic development of any nation has been observed over the years. The crucial role it plays in the socio-economic development of any nation has also been highlighted (Giang and Pheng, 2011; Ofori, 2007; Olanrewaju and Rashid-Aziz, 2015). However, this obviously important industry is not free from the numeral existing social issues that affect the sustainability of its contribution. One major social issue is rape which has over time become a menace to the delivery of a safe and sustainable environment.

According to Stange et al. (2011), every formal environment has its own legal definition of rape and this tend to cause a conflicting understanding of what exactly makes up rape. However, in current legal usage, rape commonly refers to unwanted sexual intercourse that includes the use of force and the lack of consensus. In the construction industry, Duggan et al. (2014) stated that almost nine out of ten of women in construction have been targets of sexual harassment. Engineering News-Record (2016) stated that sexual harassment in any industry

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typically happens on women between 25 and 45 years of age and the perpetrators are mostly men who have higher positions in a company whether on-site or in an office. If this harassment is not taken into consideration, it can lead to rape. Abeid et al. (2015) observed that the number of rape incidents that were reported to the Department of Home Affairs in Tanzania between 1995 and 2007 escalated from 1000 to 4500. In South Africa, Abrahams and Gevers (2017) stated that a total of 62,649 sexual offenses were reported in the Western Cape to the police in the years 2013 and 2014, and out of that 73.8% (46,253) were rape cases. Embedded in this huge figure are cases that occurred within the construction industry. This shows that the issue of rape is a very sensitive issue, which needs to be handled with proper caution and appropriate actions.

Considering Duggan et al. (2014) submission that nine out of ten women in construction have been targets of sexual harassment, and this sexual harassment can lead to rape if not properly curtailed; the fate of the construction industry being able to retain its female skilled workers is bleak. If this persists, the industry will most likely experience unpleasant results such as victims leaving the industry. This implies that the industry will lose skilled and trained professionals and this will lead to an unstable condition within the industry, and a decline in productivity (Willness et al., 2007). It is therefore imperative that construction companies adopt strict measures to curb the occurrence of this barbaric act, and develop policies for rape cases to ensure that rape incidents are handled in a proper manner, and that victims get justice. It is based on this theoretical background that this study was conducted to assess the possible measures for minimising or eradicating completely the incidence of rape within the South African Construction industry, with a view to providing a safer and healthier working environment for construction workers.

LITERATURE REVIEW

The definition of rape keeps on changing from time to time and all governmental organisations, health providers and professionals, legal professions and law enforcement bodies define it differently. Kolivas and Gross (2007) noted that most researchers on sexual assault and legislative laws defined rape as an act of sexual penetration on either mouth, vagina, or anus that has no consensus and is done using force. According to Lee et al. (2015) adolescents are at high risk to experience this kind of sexual assault. Rape is mostly referred to as a gender-based crime according to the international criminal law, as it is bound to happen to either a woman or a man. It is a serious offense as it humiliates, degrades and brutally invades the privacy and dignity of the victim (MacKinnon, 2016).

MacKinnon (2016) submitted that men are likely to be the perpetrators of sexual violation and women are likely to remain the victims. A national study conducted in the United States revealed that male perpetrators were held responsible for 99% cases of female rape cases, while they were involved in 79.3% cases of male rape. A national survey was also conducted in Cleveland and it was found that 60.4% of female and 69.2% of male adult victims experienced being raped for the first time at the age of 18 (Lee et al., 2015). Rape is a crime based on gender inequality as the Supreme Court of the United States embraced this during its ruling in 1986 that sexual harassment is a form of sex-based discrimination in a case of a man raping a woman (MacKinnon, 2016). According to Hildebrand and Najdowski (2014), sexual assault of women by men is a major problem in the United States due to one in five women being victimised in their lifetime. Rape against women is viewed as a health problem in Tanzania which affects the public as a whole and 20% of women in the urban areas were estimated to have been raped (Abeid et al., 2015).

To prevent the occurrence of this unpleasant act, the first thing to do is to prevent the things that can eventually lead to rape such as sexual harassment. Kim and Kleiner (1999) observed that sexual harassment can be defined as a term relating to certain behaviours that are sex-related and can make women not to feel welcome and comfortable at work. Smolensky and Kleiner (2003) further stated that to avoid sexual harassment in the workplace measures such as educating employees, evaluating the present work environment, choosing the right resource person, and follow-up are necessary.

If a company is on a mission to eradicate harassment, Petrocell and Repa (1998) recommend certain steps in order to determine if harassment currently exists in the company. One of the steps is to first look out for hostility, for example, incidents such as jokes, posters or any other things that indicate disrespecting any boundaries. A person accountable for implementing company policy must have the ability to listen, investigate, mediate and counsel. Once a policy has been introduced and in place, employees will take note of it and realise that if they do something that is unlawful disciplinary actions will be carried out. Furthermore, the policy put in place should be presented to the employees every now and then so that they can see it as the commitment of the company to create a safe working environment for every individual. Söchting et al. (2004) noted that rape prevention programmes can help to minimise rape incidents. These programmes include attitude change programmes, which are based on the idea that a reduction in the attitude that support rape will result in the decrease in the rape incidence, and also self-defense programmes such as resistance strategies that prepare women to be fully alert in case a sexual threat takes place.

Lee et al. (2015) put forward the idea of Rape Crises Centers that give victims of different ages that have experienced sexual assault, the necessary support structure, and counselling sessions, as well as promoting the prevention of sexual assault through educational programmes. Abeid et al. (2015) stated that preventative education can also help. It was stated that during a study in Tanzania communities poor knowledge was discovered, and the level of education was linked with the knowledge and attitude people within the communities have towards sexual violence. The issue of sexual violence has almost become a normal occurrence to individuals in these communities as a result out of lack of knowledge. The prevention strategies of sexual assault can include educational outreach to decrease rape and the chances of rape myths being accepted. According to Banyard et al. (2007), one innovation is the use of bystander approach to prevent the widespread of sexual violence. This approach includes teaching bystanders how to interfere in situations of sexual violence. This model takes next steps towards a broader community approach to prevention. The bystander model gives members of the community a specific role which they can identify and adopt to prevent the problem of sexual violence in their respective communities. The role of the members in the community includes stopping situations that could lead to sexual assault before it happens, speaking out and not supporting sexual norms that support sexual violence, and also having the skills to give moral support to the rape victims and survivors.

Turchik and Wilson (2010) stated that strict screening of people being recruited is necessary in a bid to ensure the safety of workers and in minimising rape incidents within the work place. University of Minnesota (2003) stated that reporting early signs that can lead to rape such as sexual harassments can minimise its occurrence. Furthermore, Yeung (2015) believes that it is the job of state labour to ensure that all workers are safe at their workplaces and these persons have the authority to tackle any violence that may occur in the workplace. The South African Employment Equity Act no.55 (1998) provides a guideline as regards management of sexual harassment cum violence in organisation. The Act states that organisations must consult their

stakeholders with a view towards developing and communicating policies that will ensure that their work environment is free of sexual harassment and violence.

RESEARCH METHODOLOGY

This study set out to assess the possible measures for minimising the issues of rape within the South African construction industry. The study was carried out in the Gauteng Province, and a quantitative survey method was employed. The research instrument adopted was a structured questionnaire administered to construction professionals within the study area. These professionals include Architects, Engineers, Quantity Surveyors, Construction Managers, Construction Project Managers, Health and Safety officers, and other allied professionals. Using a convenience sampling approach, a total of 60 questionnaires were distributed, with 53 retrieved and deemed fit for analyses. This represents an 88% response rate, which is considered adequate for the study based on the selected study area. It might, however, not be enough for generalising the proceedings within the entire South Africa.

The questionnaire adopted was designed in sections with the first section seeking data on the background information of the respondents. The second section sought the respondent's view regarding possible measures for reducing rape within the construction industry. A 5 point Likert scale was adopted for the study. The data gathered were analysed Statistical Package for the Social Sciences (SPSS) computer software. The method of data analyses include the use of percentage to analyse the background information of the respondents, while Mean Item Score (MIS), and Standard Deviation (SD) were employed in analysing the possible measures for reducing rape within the South African Construction industry.

FINDINGS AND DISCUSSIONS

Biographical Data and Results

The result of the study showed that 57% of the respondents that took part in the study were male and 43% were female. The respondents' age group showed that 25% of them were between the age of 21-25 years old, 32% of them were between the age of 26-30 years old, 19% of them were between the age of 31-35 years old, 11% of them were between the age of 36-40 years old, 8% of them were between the age of 41-45 years old, 4% of them were between the age of 46-50 years old, and 2% of them were above the age of 55 years old. The result also revealed that 87% of the respondents were black, 8% were white, and 6% were coloured. Furthermore, the finding clearly showed that the highest educational qualification obtained was a post-matric certificate or diploma (40%), this is followed by bachelor's degree with 25%, honour's degree with 23%, and matric certificate (grade12) with 13%. The professionals that participated include 8% Architect, 19% Quantity Surveyors, 15% Engineers, 13% Construction Managers, 17% Construction Project managers, 11% Health and Safety Officers, and 17% being other allied professionals. In terms of years of experience, 53% have 0-5 years of experience, 28% have 5-10 years of experience, 9% have 10-15 years of experience, 8% have 15-20 years of experience, and 2% have more than 20 years of experience. This result implies that the respondents are matured both in age and working experience to understand issues concerning good ethical conducts within the industry. Also, they are knowledgeable in terms of academic qualification to understand the concept of rape in a work environment and the possible measures for curbing same. Therefore the response garnered from these respondents can be relied upon base on the result attained.

Measures to Minimise Rape in the South African Construction Industry

In determining the measures for minimising rape within the South Africa Construction Industry, certain measures were identified through the review of related literature and were presented to the respondents to rate based on their level of agreement. A 5 point Likert scale was adopted, with 5 being strongly agree, 4 being agree, 3 being neutral, 2 being disagree, and 1 being strongly disagree. Result in Table 1 shows the ranking of the identified measures. From the table, it is clear that all the 18 assessed measures are perceived to have a significant impact in reducing the occurrence of rape within the industry as they all have a mean value of above average of 3.0. However, the most significant of these measures are: persons in charge of workplace safety must pay attention to sexual violence (MIS= 4.34; SD= 0.732), training for persons in charge of sexual misconduct in the workplace (MIS= 4.28; SD= 0.769), educating employees (MIS= 4.19; SD= 0.856), proactive policies in place (MIS=4.15; SD=0.841), rape prevention programmes (MIS=4.13; SD=0.761), and evaluating the present work environment (MIS=4.13; SD=0.878). These were the most highly recommended measures to prevent rape incidents in the construction industry.

These findings show that management and authorities within organisations have a significant role to play in the quest to minimise rape within the work environment. Persons appointed to be in charge of workplace safety have the onus of paying attention to issues relating to sexual violence within the organisation. This result is in line with Yeung (2015) submission that the job of those responsible to ensure safety, and ensure that all workers are safe at their workplaces, and if these set of people have not been paying attention at all it is time that they start. Petrocell and Repa (1998) also recommended persons accountable for implementing company safety policies must have the ability to listen, investigate, mediate and counsel. In order to achieve this feat, proper training of people charged with the responsibility of ensuring a safe and sexual violence-free workplace is necessary. Also while training these set of people, creating avenues for proper enlightening and educating of workers as regards sexual violence issues is important in the reduction of issues of rape within the industry. This finding further confirms Smolensky and Kleiner (2003) submission that educating employees is important in reducing rape cases in organisations. It also agrees with Abeid et al. (2015) submission that preventative education can also help reduce rape incidents.

Creating proactive policies that will curb sexual violence act is also necessary as observed from the findings of this study. This is in line with Willness et al. (2007) submission that putting pro-active policies in place can minimise rape incidents. Petrocell and Repa (1998) have earlier noted that once a policy has been introduced and in place, employees will take note of it and realise that if they do something that is unlawful disciplinary actions will be carried out. Furthermore, the policy put in place, as a point of emphasis must be presented to the employees every now and then, so that they can see it as the commitment of the organisation to create a safe working environment for every individual.

Söchting et al. (2004) strongly suggest the adoption of rape prevention programmes that will help minimise rape incidents. Lee et al. (2015) further affirmed this suggestion by putting forward the idea of Rape Crises Centers that give victims of sexual assault, the necessary support structure, and counselling sessions as well as promoting the prevention of sexual assault. Findings of this study further corroborate these submissions as the use of rape prevention programmes was seen to be a significant measure that can help minimise rape. While these suggestions are crucial, it is imperative to also evaluate the working environment from time to time. This will give a vivid view of happenings within the organisation and the possible identifying and curbing of sexual violence before they occur. This submission is in

line with Smolensky and Kleiner (2003) that evaluating the present work environment is an important factor in reducing sexual violence in the workplace.

Table 1: Measures to minimise rape incidents

Measures	Mean	SD	Rank
Persons in charge of workplace safety must pay attention to sexual violence	4.34	0.732	1
Training for persons in charge of sexual misconduct in the workplace	4.28	0.769	2
Educating employees	4.19	0.856	3
Proactive policies in place	4.15	0.841	4
Rape prevention programmes	4.13	0.761	5
Evaluating the present work environment	4.13	0.878	5
Taking sexual pressure seriously	4.08	0.874	7
Attitude change programmes	4.08	0.805	7
Being alert to patterns, not just actions	4.06	0.663	9
Proper follow-up	4.06	0.795	9
Preventative education	4.06	0.691	9
Self-defence programmes	4.04	0.759	12
Reporting early signs such as sexual harassment	4.04	0.876	12
Rape crises centres	4.00	0.784	14
Choosing the right resource person	3.96	0.831	15
Bystander approach (developing a role to identify and to prevent rape incident before it happens)	3.94	0.745	16
Strict screening procedures	3.89	0.751	17
Resistance strategies	3.89	0.751	17

CONCLUSION AND RECOMMENDATIONS

This study set out to assess the possible measures for minimising the issues of rape within the South African construction industry. Using a survey approach, the study has been able to ascertain the most significant measures of minimising rape within the construction industry. Based on the findings, the study concludes that the most significant perceived measures of minimising rape in the South African construction industry are paying attention to sexual violence by persons in charge of workplace safety, adequate training for persons in charge of sexual misconduct in the workplace, educating employees, proactive policies in work place, creating rape prevention programmes, and continuous evaluation of the work environment. It is therefore recommended that construction organisations adopt a uniform policy on handling rape cases. Guidelines stated in the South African Employment Equity Act (No.55 1998) can also assist organisations in the effective management of sexual harassment and violence issues in their organisations. Also, to be able to protect the reputation of these companies, construction organisations should organise forums whereby issues of rape and challenges are addressed as this will create adequate awareness among workers. Employees should be encouraged to talk and report any sexual misconduct in the workplace, and management should be readily accessible to provide support and counselling for victims.

This study contributes to the body of knowledge as it has brought to light the significant measures for minimising the occurrence of rape within the South African Construction industry, with a view to providing a safer and healthier working environment for construction workers. The study provides possible directions for further studies, as its major limitation is the few sample size used in the analyses and its restriction to a specific region in the country. Further studies can, therefore, be conducted in other areas of the country with a view to getting a larger sample and comparing results within regions. Also, the study was limited to the

measures for minimising rape. Further studies can be carried out in ascertaining the effect of these occurrences on both construction organisations and their service delivery.

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WOMEN AS CONSTRUCTION PROFESSIONALS: MODERN DAY CHALLENGES

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The ratio of men to women in the construction industry is one that has often attracted great concern for all stakeholders. Although the UK construction sector has enjoyed a significant rise in the number of women, there is undoubtedly more room for improvement. Numerous schemes have been initiated by government and other professional bodies to encourage more women to join the industry. On the surface, many issues such as lack of workplace flexibility and looming discrimination prevent many more women from joining. Using the glass ceiling and the leaky pipeline theories, an in-depth exploration of experiences of female construction professionals is undertaken in this research. A total of six semi-structured interviews were carried out. Although the respondents acknowledged the industry had improved significantly, they nevertheless expressed concerns on many issues that they believed needed to be addressed. It was identified that many women struggle to re-enter the industry after embarking on maternity leave. Furthermore, the respondents believed that some workplace progressions were only due to senior managers' attempt to demonstrate a level of inclusivity rather than due to merit. Finally, it was revealed that sexism is still rife in the industry and many women are left in very uncomfortable environments with fear of voicing out this horror. This research merely offers a peek at the ordeals that some women have to endure when working in the construction industry. Hopefully by addressing such issues, more women will be encouraged to take up professions in the sector.

Keywords: Equality, Glass ceiling theory, Inclusive practice, Women.

INTRODUCTION

The UK construction industry contributed to the economic output by £103 million (6.5% of the total) in 2014 (Rhodes, 2016), comprising of over 280,000 businesses (Waters, 2017) and employment figures of 2.1 million jobs (6.2%). This covers 10% of the UK's total employment figure in 2015 (Rhodes, 2016). Skills shortage in the UK construction industry continues to grow and there is an urgent need to plug this gap. One method of plugging this skill gap is the recruitment of women into the industry. The industry lacks great numbers of women participation and this could be one of the solutions to the skills shortage. Unfortunately the construction sector has been known to be less attractive women due to the stigma attached to

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the industry e.g. sexism (Construction Industry Training Board (CITB), 2015).

This research explores the current challenges faced by women in the UK construction industry in order to identify barriers that can be eliminated in order to encourage more women to join the industry.

WOMEN AND THE CONSTRUCTION INDUSTRY

The UK construction industry has always been dominated by males (Gurjao, 2017). The recruitment of workers in the industry has been homogeneous, with a marked propensity for companies to attract, recruit and select men (Dainty et al, 2001: 297). Understandably this has led to women being significantly under-represented (ibid).

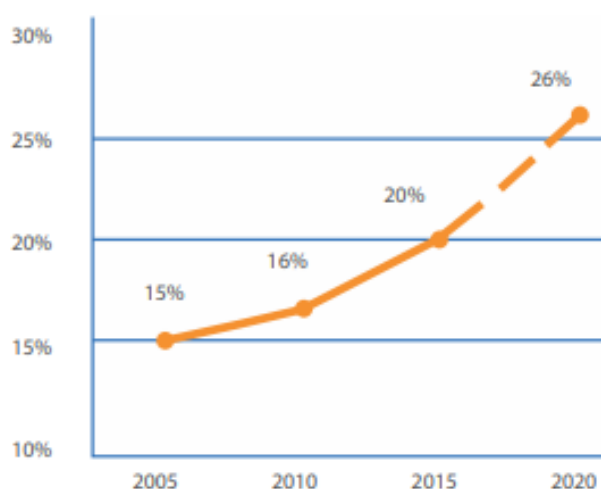


Figure 1: Proportion of female employees entering the UK construction industry (Randstad, 2016)

Figure 1 shows an upward trajectory of women entering the construction. By 2020, the industry could witness a quarter of its workforce being females. A great deal of effort has been made by professional bodies including the Chartered Institute of Building (CIOB) and Construction Industry Council (CIC) to encourage more women to join the industry in recent times. However, such initiatives still receives some resistance. This is partly due to the recruitment trends and the perceived image of the sector.

Perceived image of the construction industry

The industry is perceived as a masculine, hostile, challenging and dangerous environment (Fielden et al., 2001). Unfortunately, the construction industry fosters a male only image, entrenched in a culture that undermines women (Gurjao, 2017). Within certain areas of construction, sexist behaviour towards female colleagues appears to have become normalised. As many as 40% of women in the construction industry have admitted to being bullied or harassed by managers, while 30% revealed they were too afraid to make a complaint about the treatment they suffered (Union of Construction, Allied Trades and Technicians (UCATT), 2014). Often women will be exposed to forms of sexual harassment, seen by male co-workers as a way of reasserting control, refusing to adapt to a culture that allows women to manage teams (Waters, 2017). A staggering 51% of women said they were treated poorly purely because of their gender (UCATT, 2014). It is imperative to acknowledge that the issues raised

here are not as a result of women being incapable of executing the jobs to which they are tasked, but purely for their gender. Based on their gender, women believe there are significant barriers that prevent them from staying in their roles and also from rising above certain levels in the industry.

The next section presents some theories that have risen as a result of women's concerns in the workplace.

The glass ceiling and leaky pipeline theories in construction

The 'glass ceiling' theory depicts the challenges experienced by women when trying to grow within their sectors (Weyer, 2007). The theory establishes the difficulties women face with lack of internal promotion, thus preventing career progression (Bass and Avolio, 1994). It can be described as the invisible, artificial barriers that prevent qualified individuals from advancing within their organisation and reaching their full potential (Morgan, 2015). The term originally described the point beyond which women managers and executives, particularly white women, were not promoted. Today it is evident that ceilings and walls exist throughout most workplaces for minorities and women. For the scope of this study, race will not be the main focus. These barriers result from institutional and psychological practices, and limit the advancement and mobility opportunities of men and women of diverse racial and ethnic backgrounds (Gurjao, 2017). The 'glass wall' theory represents the traditional gender split in various sectors of the industry. The segregation of women in traditional administrative or secretarial roles in comparison to men in manufacturing and production sectors (ibid).

In addition to the glass ceiling, women face the leaky pipeline whereby change in career, career break to have a family and other personal decisions see them exit the industry and subsequently struggle to re-enter (see figure 2).

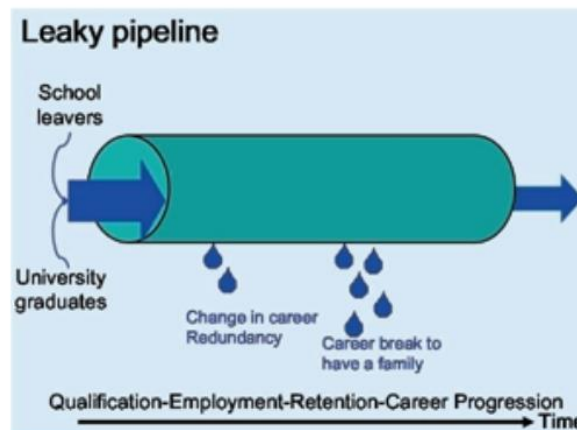


Figure 2: 'Leaky pipeline' theory (Gurjao, 2017)

The leaky pipeline describes the lack of women able to remain within the industry (Worrall et al, 2010) after entering through education. It is acknowledged that once temporarily leaving the construction industry it becomes increasingly difficult to re-enter (Gurjao, 2017). The theory further depicts the issues that surround women throughout their career, the poor work-life balance, lack of internal promotion and continual lack of respect including instances of poor behaviour women are exposed to throughout their time in the construction industry. An important situation that would also force women to leave the industry temporarily or

permanently could also be the harassment and abuse suffered by women in the workplace (see UCATT, 2014)

Having identified the existence of the glass ceiling (as opposed to hierarchical or occupational segregation) as a social phenomenon of many different communities as a real situation rather than a figment of women's imagination, the actual problem is that men above cannot see it as an institutional barrier faced by the women below (Morgan, 2015: 11).

Both the glass ceiling and leaky pipeline are identified to be barriers that prevent women from succeeding in the workplace. Cabrera (2009: 40) goes further to emphasize that: "*The glass ceiling is not what prevents most women from rising beyond certain levels in organizations. Most women are leaving their organizations voluntarily long before hitting the ceiling. A "leaky pipeline" is a more accurate description of what is occurring*". Thus the leaky pipeline supersedes the glass ceiling in the case of female construction workers.

In order to understand the barriers faced by female construction professionals with respect to employment retention, an in-depth understanding of the issues faced is required. The research method is presented next.

RESEARCH METHOD

Using a qualitative research approach, semi-structured interviews were conducted with six construction professionals. A purposive sampling approach was used to identify the interviewees. Previous researchers document the importance of gathering information regarding people's perceptions, opinions and experiences collected with the use of semi-structured interviews (Worrall et al, 2010). The semi-structured interviews were deemed appropriate to acquire the in-depth information.

From the critical literature review, the following areas were identified to be explored in the development of the interview guide:

1. Everyday sexism in the workplace
2. Societies' perception of industry, in terms of image
3. The gender pay gap
4. Retention issues, including maternity difficulties and progression issues
5. Educational impacts and awareness

Ethical considerations included anonymity and confidentiality of the interviewees. All interviewees were nicknamed Jane Doe (JD). Furthermore, there was a potential of sensitive matters being revealed and as such standards of the Social Research Association were strictly adhered to in order to ensure the interviewees were never in an uncomfortable situation.

FINDINGS, ANALYSIS AND DISCUSSION

The findings and analysis from the interview data are presented in this section.

Background of interviewees

Table 1: Profile of interviewees

	JD1	JD2	JD3	JD4	JD5	JD6
Years of experience	22 years	16 years	22 years	4.5 years	26 years	24 years
Job category	Management	Senior Management	Senior Management	Management	Senior Management	Senior Management
Job title	Knowledge Manager	Director of SH&E	Former Director	Diversity and Social Program Manager	Technical Director	Project Manager
First role in construction	No	No	No	Yes	No	No

A range of roles and time of experience of interviewees were included in the study. All interviewees had managerial roles. The years of experience and managerial positions were chosen with the hope of capturing the barriers the interviewees face or have had to overcome during their time in the industry. Furthermore, having managerial roles meant the interviewees had some ‘power’ or ‘control’ in their respective organisations. JD4 had the least experience (4.5 years) and this was her first role in construction. Her role was not a technical construction role but more aligned to managing diversity in the organisation. As such her role may not be considered as the traditional construction role.

Joining the industry

The interviewees had different reasons for entering the construction industry. Some of the reasons included simply wanting to contribute to the built environment. Reasons for entering the industry seemed to be as a result of genuine interests. However, they had all expressed there were challenges when trying to get into the industry and more importantly rising to their current roles. JD2 described the industry as an aggressive one. She stated:

‘...working in a gruff atmosphere, in a man’s world’.

Unfortunately her response demonstrates that she does not feel as though she is a part of the construction world if she describes it as a world belonging to the opposite gender. JD3 also referred to the industry as *‘a man’s world’*. JD4 believed she was *‘only able obtain a job because [she] knew somebody there’*. She did not believe her educational qualification(s) enabled her to gain the employment opportunity. JD2 was explicitly told that she was being employed to *‘meet a gender equality quota’*. From the above findings, it can be deduced that some women may already feel inadequate when entering the workplace. Although they may be competent to undertake their role, they may be intimidated from the point of entry into the industry and the situation may frighten them throughout their careers i.e. if they do not leave. This can then lead to the individuals suffering from the imposter syndrome – a psychosomatic pattern in which people doubt their accomplishments and have a persistent fear of being exposed as a fraud (Reis, 1987).

Treatment of women in construction

A clear pattern about unhappiness with respect to how the interviewees felt at work emerged.

They believed that there was unequal treatment and lack of [appreciation] from senior managers.

JD2 stated: *'the more senior you get the worse it is, the old men just won't let us have a say'*.

Although she had risen high enough to become a senior manager, she believed other senior managers wielded more power. When probed further about the above comment, she added:

'men in senior roles have worked through the ranks since an early age and believe that women should do the same, educational certificates are not worth the paper they are written on if you haven't been there and done that' you are not welcome'.

Evidently, she was intimidated by the behaviour of the other senior managers [men] that she worked with. She had been made to believe that working your way through *'the ranks'* was more important than educational certificates.

JD3 explained that women in the industry often feel patronised by men and added that *'if [some] men will not accept change, they should retire'*. In essence JD3 acknowledges that treating women unequally is an archaic practice and should be phased out. It was also revealed that *'younger managers are extremely welcoming to both genders'* (JD6). Poor treatment identified by the interviewees clearly pointed at male (older) senior managers. It was also uncovered that women believed they were overshadowed by male colleagues of similar positions as themselves.

Leaky pipeline and glass ceiling in practice

There are many reasons that drive women to leave the industry. Women had to change roles continuously if they wanted to gain promotion or climb the corporate ladder. JD2 explained that it was *'easy for men to be hired or promoted... not acceptable for women'*. Thus she had witnessed both the leaky pipeline and glass ceiling in the workplace.

JD5 added that since women are often less confrontational, *'men show an unconscious bias and underestimate women'*. Women have been known to leave the construction industry due to frustration of being treated poorly or being overlooked for promotion. Furthermore, it was identified that gaining entry into the industry is not always based on merit and as such, females leaving a particular job are not guaranteed of gaining another role.

One key problem that enhanced the occurrence of the leaky pipeline for the women was issues relating to maternity. Three of the interviewees had had children. JD2 used her annual leave as a maternity break. She states: *'didn't really have a [maternity] leave, I took six weeks'*. JD5 had to change roles because having children meant there was no work for her when she expected to return. JD6 recalls the difficulty in returning to work and had to assure her employers that she would not be taking a maternity leave anytime soon. From the above, it is evident that the interviewees struggled to return to work. Without a stronger will they could have all decided to leave the industry for good and become victims of the leaky pipeline. Considering the situation from another perspective, if the employees feel they have to choose between their newly born babies and their work, they may then leave the industry. This concept is confirmed by Carbrera (2009) where it is noted that many women leave the industry before even reaching the supposed glass ceiling.

JD6 stated she took a maximum of three months at home and continued to work throughout the

time where possible. *'It's hard to come back, even after a short time, they expect you to prove yourself'*. The law states that a woman is entitled to 39 weeks paid maternity leave (UK Government, 2018), whereas research indicates that very little maternity leave is taken due to the lower chances of companies taking women back post maternity on a more flexible basis. JD4 recalls that she *'left the industry to cut back long travel hours'*. Unless a more flexible approach is made accessible women will not be enticed to pursue a career, or return.

Recommendations for the eradication of the leaky pipeline

In order to eliminate the current barriers faced in the construction industry, Carbrera (2009: 45) highlights five areas that need to be improved in order for females to be adequately accommodated:

- Flexibility – rethinking when, where, and how work is done;
- Care-giving support – providing more support for the care giving needs of working women;
- Maintaining contact – maintaining ties with past (and intermitting) employees
- Welcoming re-entries – recruiting or rehiring ex-employees as they also possess key knowledge that will be useful to the organisation
- Supportive organisational culture – reinforcing the legitimacy of new ways through organisational culture

JD2 stated that in order for the industry to eliminate the leaky pipeline, male employees needed to be retrained in order to change their perceptions about the role of women. JD4 added that promoting flexible working conditions was the way forward and would encourage more women to join the industry. Other comments on improving the industry were as follows:

'Wait for the dinosaurs to retire' – JD3

'Make companies aware of the positives when recruiting young people' – JD4

JD3's comment reflects an earlier revelation that the older males in the industry were the most problematic therefore upon their retirement, the industry will improve. JD4 also echoes the thinking that younger people (males) embraced all genders in the workplace equally. All the recommendations are somewhat in line with suggestions from Carbrera (2009), i.e. introducing new working practices and changing the overall culture of construction firms.

CONCLUSIONS

The problems faced by females in the construction industry are still present and may be one of the main issues limiting the sector from plugging some of the skills shortage. The industry is one of the largest contributors to the nation's GDP and yet is not being encouraged to evolve for the better. Beyond the discussion of plugging the skills gap, the industry has a serious problem of women being treated badly. This situation not only discourages women from joining but also forces the women in the industry to leave and not return. Sexism is widely accepted practice in the industry according to women who work in the sector.

The industry will require a major overhaul if it is to eradicate this negative culture. At present, women are worried about taking career breaks for crucial circumstances such as starting a family. It has been recorded that the Statutory Maternity Pay is not implemented and women

can face redundancy when/if they decide to take their entitled maternity break. Some women have thus resorted to using their annual leave to have children and return to work thereby losing out on very important time they could have spent with their newly born babies. Such practices make the industry rather unattractive and hence critical steps need to be adopted in order to make the sector flourish.

The industry has often been labelled as being resistant to change but this is one change that must be embraced. The issue at hand is not particularly one of change but one of unfair treatment and an irrational exclusion of key people who can contribute significantly to the industry. Furthermore, the unfair treatment of women in the construction industry can also make it less attractive for males who believe in equality and therefore are unhappy with the stigma attached to the industry, thus an additional loss of new entrants. With current skills shortage, BREXIT uncertainties and the government's encouragement for the expansion of housebuilding projects, the need for more workers in the construction industry is definitely set to grow. For this reason, recruitment and fair treatment of everyone in the construction industry is a definite priority!

Recommendations for future study

Although this paper offers a unique contribution in its own right, there are a few critical recommendations for further research that will undoubtedly help advance the discourse initiated here. These are as follows:

- Having identified situations where women have faced barriers of their retention or progression in this study; a quantitative study using questionnaire surveys should be carried out focusing on variables such as age, qualifications, industry experience and family and marital status juxtaposed with the attitudes and behaviours that women have witnessed and/or experienced in the workplace. A larger sample from this approach will give an opportunity to establish representative findings for the industry.
- In numerous cases of gender discrimination, the perpetrators may not be aware of the effect of their actions (see Goldberg, 1968). Thus a research to ascertain how men feel about the treatment of women in construction would offer a very valuable perspective. This will ultimately help identify and subsequently address unconscious biases that exist amongst men (and some women) in the industry.

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SAFETY, HEALTH, AND WELLBEING IN CONSTRUCTION: A WORK PSYCHODYNAMICS APPROACH

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Civil construction is one of the most important segments of Brazil's economy. Its activities generate millions of jobs a year. However, contrary to technological advances, the reality of construction sites is very precarious regarding the health and safety of its employees. Labor accidents (LA) rates are high, showing an unsafe environment and high risk of accidents. On the other hand, the psychodynamic of the work is presented as a scientific approach developed in the 1980s, whose objective is to study the workers' mechanisms of defense, in the face of suffering situations due to the work organization. An approach that is very interesting for application in the environment of work sites, considering its environmental conditions and its craftwork production. The article presents an extensive and structured literature review about the work environment in the construction industry, in the light of the psychodynamic of the work, emphasizing the relation of this with the health, safety and dignity of the worker. The results indicate the importance of conducting a qualitative analysis of workers' perceptions in studies related to the theme.

Keywords: Safety, Health, Wellbeing, Construction sites, Psychodynamics of work.

INTRODUCTION

Civil construction in Brazil, even though it is a fundamental sector in the national economy, is still marked by building methods that depend on the labor force of a low-skilled workforce from the most vulnerable classes in society. It is not surprising, therefore, that the sector stands out due to the high number of work accidents and the precariousness of the construction sites. In the period from 2003 to 2005, the National Institute of Social Security (INSS) registered 83,842 occurrences in the sector.

In order to aggravate the situation, Brazilian safety standards at the construction site are restricted, focusing only on safety installations and not on prevention as a whole. In addition, engineering companies, for the most part, are limited to complying with legislation and the safety of workers is considered secondary.

Workers usually don't comply with technical safety instructions on the work sites and there is still difficulty in understanding such behaviors that are harmful to both the safety of the worker and the work environment.

Thus, this interdisciplinary work aims, through a bibliographical review, to study the harmful behaviors of the workers themselves and the work in the light of the psychodynamic of work

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considering the worker as subject in order to identify the variables necessary for a future study of case on this topic.

CONTEXT

The Psychodynamics of Work

The study of the relation between the work and the psychic aspects of the subject began to gain strength in the early twentieth century with the emergence of the Taylorist system of work organization. This system was based on the rationalization of work, which caused damage to workers' physical and mental health due to excessive work hours, intense rhythm, high pressure, fatigue and automation (Mendes, 1995). In face of this situation, researcher Dejours sought to understand the relationship between working conditions and mental illness.

In his field research, the author realized "a strange silence" in work environments where people would necessarily be psychically unbalanced. This state of normality left him perplexed and this question became his object of study. Thus emerged the Psychodynamics of Work (Lancman and Uchida, 2003).

In this bias, work is seen as a source of pleasure, when it favors appreciation, admiration, recognition and the possibility of expressing creativity; and suffering, when there is division and standardization of tasks with underutilization of technical potential and creativity, as well as hierarchical rigidity, with excessive bureaucratic procedures, centralization of information, non-participation in decisions, non-recognition and the low perspective of professional growth. (Martins and Oliveira, 2006)

Dejours (1987) states: "The organization of work exerts on man a specific action whose impact is the psychic apparatus." Under certain conditions emerges a suffering that can be attributed to the clash between an individual story, bearer of projects, hopes and desires, and an organization of work that ignores them." In order to understand the normality previously cited, Dejour (1987) focused on the study of suffering and pleasure in the work and identified possible strategies of individual and collective defenses for the preservation of the psychic balance by minimizing a reality of suffering.

The "Self" and Suffering

The subject, according to psychoanalysis, is a being endowed with subjectivity, living a unique experience and consciousness and also having an unconscious side. In short, this subject, according to Freud, always goes in search of an intense experience of pleasure or absence of suffering and displeasure. Pleasure is associated with the satisfaction of needs in a high degree by the subject. Suffering, in turn, is characterized by unpleasant sensations arising from the non-satisfaction of needs. Both pleasure and suffering are of unconscious origin and are related to the deeper desires of the subjects, often revealed to the conscious in the form of projects and expectations of life (Mendes, 1995).

In this way, every subject, in this journey between the search for pleasure and the diminution of suffering, will mean his experiences in a unique way forming his own identity - interface between the subject (internal questions and personal history) with reality. It is in the incompleteness of identity, that is, where one cannot transcend and experience inner longings in reality, that suffering arises (Darwiche, 2016).

Figure 1 illustrates schematically the construction of identity where, on the one hand, there is the subject, his personal history and his yearnings; on the other, the reality, the social order, the work and its constraints. Identity is constantly changing to balance these two forces (Darwiche, 2016).

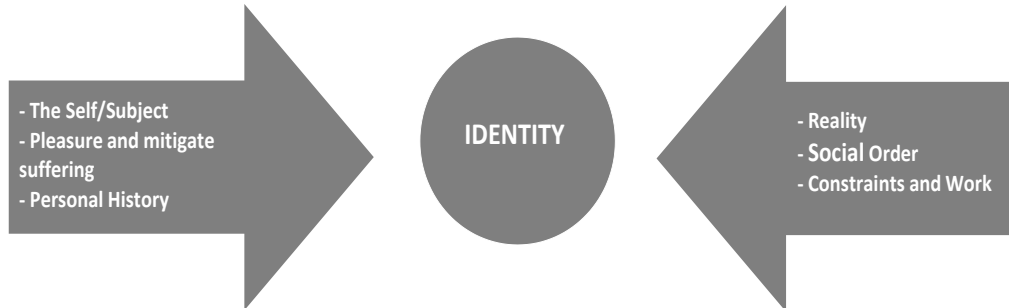


Figure 4: Scheme of the confrontation between the subject and the Real in the formation of the identity.

Civil Construction and The Psychodynamics of Work

Civil construction is one of the most important segments of the Brazilian economy and represents approximately 6% of the national GDP. Its activities imply, in particular, the generation of millions of jobs a year. However, contrary to technological advances, the reality of construction sites is very precarious regarding the health and safety of its employees.

The current context characteristic of the construction sites of Brazil involves a set of conventional and handmade techniques of construction with mechanized methods where the machine replaces the man in the heavier operations.

Labor accidents (LA) rates are high – the segment occupies the second position in the ranking of accidents, according to Araújo (1998), showing an unsafe work environment and high risk of accidents. A construction worker in Brazil is three times more likely to die in accidents than in developed countries. It is also observed that this segment is still very informal and lacks appropriately qualified professionals, further aggravating the risks of the trade.

Analyzing the environment of the construction site in the light of the psychodynamics of work, it is important to emphasize that when the subject is submitted to pressures and constraints in the work, the need to defend either individually or in a collective way arises. In this way, these defenses are defined as a way to mitigate, modify and transform their perception of the reality that makes them suffer. Such transformation, for the most part, leads to the euphemization of this perception of reality with the purpose of masking, containing and hiding suffering, articulating itself as a way of adapting the pressures of an organization of work (Cruz, Souza and Lisboa, 2007).

To illustrate the above, Molinier (2013) analyzed the purpose of some dangerous games in civil construction, such as challenges in which workers expose themselves to risks without any apparent reason or in a "free" way. The act of putting oneself at risk, of creating one's own risk - distinct from the real risk that may arise from the profession and not from one's own will - is a way of creating a collective illusion of the realm of risk. This illustrates how the collective elaboration of defense for the reduction of fear comes from a risky job. Similarly, there is a

strong resistance of construction workers to the use of personal protective equipment (PPE), which also shows a certain pleasure in taking risks. Thus, Tejeda (2001) assumes that the psychology of construction workers is characterized by a pleasure for danger and physical performance through behavior characteristic of pride, rivalry, virility, bravery, but also recklessness (unconsciousness of reality, absence of discipline, individualism).

According to the same author, the acute awareness of risks would oblige the worker to take so many precautions that this would make him unproductive. Mendes (2003) states: "The fact that the worker cannot go wrong, as this would endanger his life and other people; having to do the job with quality, at the risk of being fired or being forced to retake it and having to undergo the precarious working conditions entails certain insecurity and vulnerability in these workers. "

In a similar way, Dejours (1987) states: "In civil construction, ideology is functional at the group level, its cohesion, its courage, and it is functional at the level of work, in fact, it is the guarantee of productivity. The apparent "unconsciousness" of the workers (absence of fear, recklessness) has another meaning, because, truly, it is the price that must be paid in order to overcome the burden of fear that labor presupposes." That is, there is a defensive ideology that implicitly denies the fear of this profession, so the workers develop the common sense that these conditions are normal and this is transmitted from work to work. Another example that illustrates this ideology is the consumption of alcohol as a tool to face the precarious working conditions. Therefore, if the labor cannot overcome the apprehension of performing a risky job, in general, he is not accepted by the group, which makes him stop working (Medeiros and Rodrigues, 2002).

According to Dejours (1987), the last characteristic of this ideology is that for its elaboration it is necessary the participation of a working group, that is, not only a community that works in the same place, but with a work that demands a division between the members of a team.

METHODOLOGY

The present research was developed in two stages. The first stage consisted of a bibliographical research about the theme, gathering all the knowledge both in the historical and general context about the psychodynamics of work and in the context related to the physical and organizational structures of the construction sites. For the bibliographic review carried out in this present study, articles of journals, theses, dissertations, monographs and course completion papers were used.

As a result, we defined the analysis variables that were used in the next step, whose objective was to perform a structured analysis of specific bibliographies related to studies of organizational environments of construction sites, with a focus on the psychodynamics of work.

This stage involved the characterization and comparison of the selected works in order to identify the variables and practices of greater relevance for the elaboration of methodology for the diagnosis of the environment of the construction site in front of the approach of the psychodynamics of work.

For this stage, 8 national works were selected, based on a set of 20 references identified in the bibliography, due to their direct relationship with the theme and the industry sector analyzed.

Selection was limited to the national context, since the Brazilian cultural and social dynamics of civil construction may differ significantly from what exists in other countries. Social relations as well as the profile of the proletariat have a direct influence on the socio-cultural context of the country.

Table 1 shows the papers analyzed, relating the authors, the year of the research, the city where it was developed, the type of work and the code that will be used to identify the papers in this article.

Table 1: Selected Researches

Author/ year	City	Research Type	Codification
Darwich, 2015	São Paulo	Final paper	SR1
Saurin e Ribeiro, s.d	Porto Alegre	Paper	SR2
Medeiros e Rodrigues,2002	João Pessoa	Paper	SR3
Barros e Mendes, 2005	Brasília	Master's thesis	SR4
Tejeda, 2001	Porto Alegre	Master's thesis	SR5
Borges, 2012	São Carlos	Master's thesis	SR6
Menezzi, 2013	Belo Horizonte	Master's thesis	SR7
Gil, 2017	Santos	Master's thesis	SR8

It is worth mentioning that each work has a specific object, but all make an analysis of construction sites from the perspective of the psychodynamics of work identifying the suffering and pleasure of the proletariat.

ANALYSIS OF RESULTS

Table 2 presents the results of the comparative analysis of the research methodologies adopted in the selected papers (SR) for the specific bibliographic review stage.

Table 2: Comparative analysis of the research methodology

Selected research	Research Method	Type of analysis	Number of sites analyzed	Sample amount	Sample typology
SR1	Structured Interviews	Qualitative and quantitative	5	131	Leadership and workers
SR2	Semi-structured interviews	Qualitative	1	9	Leadership and workers
SR3	Observations / Bibliography research	Qualitative	-	-	Workers
SR4	Semi-structured interviews	Qualitative	4	20	Workers
SR5	Semi-structured interviews	Qualitative	4	15	Workers
SR6	Semi-structured interviews / Observations / Documentary research	Qualitative	1	12	Workers
SR7	Semi-structured interviews	Qualitative	1	15	Workers
SR8	Semi-structured interviews	Qualitative	3	12	Workers

Regarding the scope of the surveys, the lowest number of interviews was the SR2 work with 9

interviewees in 1 work site; followed by SR6 with 12 interviewees in 1 work site; SR8 with 12 interviewees in 3 work sites; SR5 with 15 interviewees in 4 works sites; SR7 with 15 interviewees in 1 work site; SR4 with 20 interviewees also in 4 works sites; and finally, SR1 with the largest number of interviews, 131 interviewed in 5 works sites. It is worth mentioning that the SR1 and SR2 surveys involved the top leadership (engineers or managers) and the workers (masons, servants, carpenters, etc.) while the others researches focused only on the workers.

SR1 performed individual structured interviews with mixed questionnaire between quantitative and qualitative. SR2, SR4, SR5, SR7 and SR8 performed semi-structured interviews with a qualitative questionnaire - not very common in engineering studies.

Of all the works only SR4 held collective interviews while all the others preferred individual interviews so that the interviewee did not feel constrained to say anything. The justification for the collective interviews is the fact that the public space for discussion among workers is a means by which phenomena can be identified and the dynamics involved in them, as well as valuing the socialization of knowledge among individuals (Mendes, 2005).

The work SR3, in turn, stands out as not consisting of a case study but rather experimental observations. The author points out that there is an ignorance about the risks and processes in the construction due to a discontinuous knowledge of the constructive methods. Thus, there is no consolidated knowledge about the process and functioning of the facilities due to the lack of training for workers, and knowledge is restricted to leadership. From his observations, he reports that, because of unsatisfactory instructions, workers end up interfering in the stages of the production process in their own way, that is, the practical and operational form of worker's knowledge. The author points out that from this worker knowledge, creative solutions can emerge and are unnoticed by the higher levels of leadership, a fact proven in his field observations. In conclusion, therefore, the difference between predicted labor and real work leaves room for innovations and that worker knowledge enters into this context and allows the emergence of creativity, participation and consequent increase in the motivation and transformation of suffering.

SR6 research also stands out for presenting direct observations and documentary research as complementary methods of analyzing workers' behavior.

It can be seen in table 2 that all the papers opted for qualitative analysis leaving the interviewees free to express individual opinion about the topics asked. This shows the importance of using such type of methodology when the study involves a complex subject.

Table 3 presents the results of the comparative analysis of the topics adopted in the selected papers (SR) for the specific bibliographic review stage.

Table 3: Comparative analysis of the topics of analysis

Topics of analysis	Selected Research							
	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8
Basic socioeconomic profile	X					X		X
Relationship with work	X	X	X	X	X	X	X	X
Relationship with the leadership			X	X	X	X	X	

Topics of analysis	Selected Research							
	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8
Relationship with colleagues			X	X	X	X	X	
Satisfaction		X		X	X	X	X	X
Productivity	X							
Idleness	X					X		
Safety	X	X	X			X		X

In relation to the topics covered in the interviews, the SR1 study contemplates the following topics: basic socioeconomic profile; relation to work; productivity; idleness; safety. Work SR2 prioritized the following topics: main cause of accidents; suggestions for improving safety at work; job satisfaction; training; activities at greater risk; work load; main priority of the work; frequency of accidents; level of awareness of the workers. In SR4, the themes of greater focus were: activities developed; difficulties faced at work; ways to overcome difficulties; organization, conditions and social relations of work; work-related feelings and coping strategies. The SR5 study evaluated the following: personal aspects about the profession; relationships with peers of the same class; relationship with senior leadership; perception of fear; possibility of proposing something new. The SR6 research analyzes labor relations, working environment conditions and susceptibility to accidents. The SR7 research focuses its analysis on the satisfaction and suffering of the collaborator. Finally, SR8 study prioritized the following topics: socioeconomic profile of the interviewee, sense of suffering and safety, and relationship and commitment to work.

Through the analysis of the variables proposed in each study, it is possible to note the importance of the worker's perception regarding his relationship with work, colleagues and leadership.

CONCLUSIONS

It was observed difficulty in obtaining academic papers in the national literature related to the subject and with case studies focused on civil construction, which indicates the need for more studies related to the theme.

Mendes (1995) states that the study of work psychodynamics can bring beneficial contributions to the companies since it demonstrates that the collective management of the work organization allows the transformation of the suffering allowing the engagement of the worker without harm to his mental health.

Most of the studies analyzed included research methodologies focused on worker perception, based on data collected from structured or semi-structured interviewees.

The importance of a qualitative questionnaire focusing on the interpretation of data rather than simple quantification is emphasized here, since a quantitative questionnaire - such as the Likert scale - would preclude a comprehensive analysis of the subject. Regarding the scope, although the focus is the worker, it is relevant to collect data from management since to propose improvements it is necessary to understand how relationships and work are seen by both parties. Regarding the variables, we identify the need to understand the social relations in the work environment, the worker's perception about work and its risks and safety.

It is expected that this work would contribute to disseminate research related to the theme and, in this way, contribute to promote a culture of prevention against accidents in construction sites, both by workers and employers, in order to reduce the numbers of LA and to increase the quality of life of the workers.

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EMPOWERMENT AS A CONSTRUCT OF WORKER ENGAGEMENT AND WELLBEING

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This qualitative study evaluated empowerment as a construct of worker engagement. Research within the construction industry has not concisely grouped, developed and validated workforce empowerment based on the four cognitions of **knowing; doing; decision-making** and **influencing**. These emphasize workers' experiences of empowerment; with measures of the construct requiring the workers to discuss what has made them feel empowered in relation to their work activities. The criticality of the issues identified; the impact on workers; and their relative perception of such issues e.g. 'knowing' the value of a work goal; 'doing' a given task with some level of capability; 'decision-making' about work activities and methods; and 'influencing' certain work or organizational outcomes were all captured. Previous research suggests that engagement is positively related to good health, and that engaged workers are better able to perform well. Given the significant contributions of workforce empowerment (positive job attitudes, higher degrees of performance, motivation, job satisfaction, commitment, and reduction of job-related stress) to organizational success, it is essential to grasp how it improves worker engagement and wellbeing.

Keywords: Empowerment, Engagement, Knowing, Doing, Decision-making, Influencing

INTRODUCTION & BACKGROUND

The concept of worker engagement (WE) is "*a process where every worker on a construction site is motivated and empowered to participate in improving health and safety through meaningful discussions with workers in advance of decisions being taken, influencing others, and is committed to sharing their experiences and knowledge; and managers positively encourage workers to identify and resolve health and safety problems in a culture of trust, leading to every worker on site benefiting from safe and healthy working conditions*" (Lawani et al., 2017). There are both legal and ethical reasons for management to engage with the construction workforce for the improvement of Occupational Safety, Health and wellbeing. The HSE Construction Division's 'worker involvement and engagement' initiatives encourage the industry to rise above the minimum legal requirement, moving towards 'best practice'. Research shows that worker engagement has many positive job outcomes such as job satisfaction and performance (Gruman and Saks, 2011; Schaufeli and Salanova, 2007), active coping style (Storm and Rothmann, 2003) and creativity (Bakker and Xanthopoulou, 2013). Empowerment has also been vital in many positive job attitudes (Shockley-Zalabak et al., 1999; Fedor and Werther, 1996; Scholefield, 2000); making significant contributions to

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organisational success. Therefore, it is crucial to understand the factors and the contributory role of empowerment on construction worker engagement.

Although Conger and Kanungo (1988) defined empowerment as the motivational concept of self-efficacy, it was Thomas and Velthouse (1990) who argued that empowerment is complex and its principles cannot be captured by a single concept. They offered a broader definition of empowerment as increased intrinsic task motivation manifested in a set of four cognitions which reflects an individual's orientation to his or her work role - *meaning, competence, self-determination and impact*. Spreitzer (1995; 1996); Spreitzer et al. (1997) developed a measure of psychological empowerment capturing these four sets of essential cognitions which this study aligned with and redefined into four levels for characterising workforce empowerment from preliminary interviews conducted: **knowing, doing, decision-making, and influencing**; Table 5 and **Error! Reference source not found.**

Table 5: Developed cognitions of construction worker empowerment from preliminary interviews

Empowerment Level	Description
1.Knowing	Knowing the value of a work goal judged in terms of a worker's own values, beliefs or standards (important to the individual).
2.Doing	Worker's belief in his/her capability to successfully perform a given task or activity (capable and resourced).
3.Decision-making	Worker's sense of choice about activities and work methods (autonomy over working methods).
4.Influencing	The extent to which workers believe they can influence certain work or organisational outcomes (on wider organisational decisions).

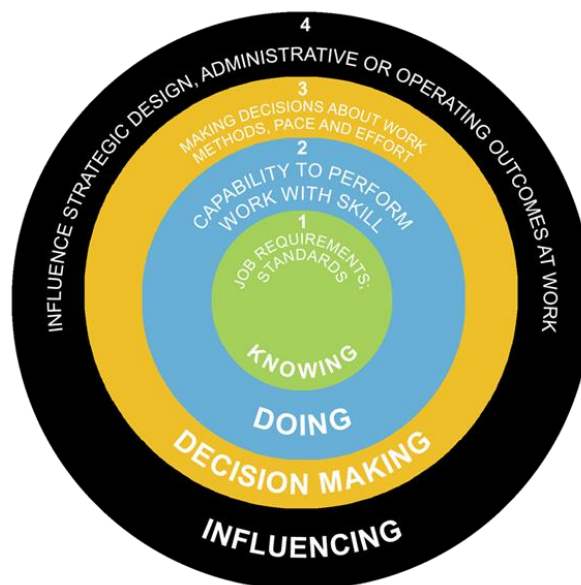


Figure 5: Developed Empowerment framework from preliminary interviews

These four levels combine additively to form empowerment; and lack of any single level will decrease the empowerment scale but not eliminate the overall degree of empowerment experienced by the worker (Spreitzer, 1995); and items measuring worker empowerment focuses on their subjective experience. Linked to this is ‘psychological safety’; the ability to

raise concerns without fear of negative consequences, (Edmondson, 1999). Previous studies identified three arguments regarding the importance of including the workforce in decision-making and planning for OSH. These include potentially improving psycho-social and organisational development; improving productivity and efficiency; and, ethical and legal requirements (Shearn, 2004). This is in contrast to Bowen and Lawler's (1992; 1995) analysis of empowerment trends in the private sector where it is assumed that the key constituent is power sharing and decision-making authority with lower level workers.

Further to the direct effect of empowerment on worker engagement, it is expected that empowerment could moderate the relationship between trust and engagement in such a way that workers who are psychologically empowered will be more engaged irrespective of the level of organisational trust. For example, trust has been found to explain why some workers effectively complete their jobs and also go above and beyond their job description with no notable reward. This effect is very close to the concept of 'workers going the extra-mile' which is representative of engaged workers (Schaufeli and Bakker 2010). Workers that are psychologically empowered through engagement are more likely to have higher degrees of performance, motivation, job satisfaction and commitment, and this can reduce job-related stress; see (Thomas and Velthouse 1990; Quinn and Spreitzer 1997). Empowering leadership in which leaders allow workers to make decisions and pursue objectives on their own tend to facilitate worker performance and satisfaction, and to suppress dysfunctional worker resistance (Vecchio et al., 2010). Therefore, the drivers of worker empowerment can be related to managements' sincere interest in the wellbeing of workers; and the extent to which workers believe that they have improved their skills and capabilities over the course of time. These are related to a strong and transparent organisational leadership; engaging managers; an effective and empowered employee voice and organisational integrity, (MacLeod and Clarke, 2009).

OBJECTIVES

The objective of this paper is to qualitatively validate a construct of workforce empowerment in relation to WE and OSH based on the four cognitions of *knowing*, *doing*, *decision-making* and *influencing*.

METHOD, DESIGN & INTERVIEW

This paper adopted phenomenological research inquiry (a qualitative research approach) useful in obtaining adequate data that captures the context of workforce empowerment; their wellbeing and engagement. This specific type of research inquiry can adequately describe the empowerment, engagement and wellbeing experiences of the workforce; see (Creswell, 2014). Phenomenological research design is deeply reliant on strong philosophical foundations and it involves conducting interviews, see (Giorgi, 2012). These involve interview questions asking participants 'what and how' in order to convey an emerging theme where the operatives and working supervisors describe their experiences (Creswell, 2013; Giorgi, 2012). This enabled the building of themes that were constantly checked against the literature. A purposeful sampling strategy for construction sites and engaged workers was utilised, selecting from a pool of site options made available by the research Steering Group.

A total of 28 'engaged' workers were initially interviewed using semi-structured questions to develop the framework; and characterise the empowerment cognitions until saturation of themes was reached (Creswell, 2013; 2014; Marshall and Rossman, 2016; Creswell and Poth,

2017; Charmaz, 2014). Engaged workers are those who are involved in OSH initiatives, contribute to health and safety discussions, and are proactive about OSH behaviours, and influence their colleagues. Furthermore, 22 workers were interviewed during the validation phase of the empowerment framework which this paper focuses on. Interview data were transcribed and analysed by highlighting significant statements (thematic analysis) or quotes that provided an understanding of how the operatives and supervisors experienced the empowerment phenomenon. These statements were categorised and ranked in line with the four theoretical cognitions of empowerment; and validated by an expert Steering Group using **Error! Reference source not found..** This was an iterative process using the Delphi method (Hsu and Sandford, 2007; Hasson et al., 2000), where all significant statements were allocated to each of the four indicators in hierarchical lists. Each list went through three reviews before consensus was reached. These four cognitions developed from the literature into the empowerment framework were matched to practical data from validation interviews. The interview process collected data from eight construction projects across mainland Britain, covering housebuilding, commercial and civil engineering sectors.

VALIDATION, FINDINGS & DISCUSSIONS

The four levels of hierarchical criteria for WE were developed based on comparisons between the validation interview data and the theoretical constructs from the preliminary interviews. The items measuring empowerment were consistent with this conceptualization by focusing on the workers and their subjective experience of workplace empowerment. Although empowerment perceptions reflect the characteristics of a workplace, these perceptions emerged from a psychological process in which workers ascribe meaning to the structures and practices in place within their organisation.

The empowerment’s four cognitions were validated using data from additional 22 workers. The development of empowerment criteria was adopted by assigning levels of issues perceived by the workers that have empowered them in relation to their work activities. The criticality of the issues identified; the impact on workers; and their relative perception of issues such as ‘knowing’ the value of a work goal; ‘doing’ a given task with some level of capability; ‘decision-making’ about work activities and methods; and ‘influencing’ certain work or organisational outcomes were all captured in the empowerment validation; **Error! Reference source not found..**

Table 6: Validation of empowerment levels from interviews

OSH Example Quotes	
1.Knowing	“I need to know if I’m working at height or confined space so that lets me know the sort of PPEs and right tools for the job”
2.Doing	“To carry out what I do safely I require permit to work on a daily basis; correct PPE sums it up – it could be harness, gloves, eye protection, respiration mask”
3.Decision-making	“We always need briefing, paperwork, and sign up to method statements describing the works and everything that will be done; I sometimes suggest if work can be done in a different way”
4.Influencing	“Most of the planning work is done with briefing and pre-starts and I have lots of opportunities because we sit and speak with the construction managers and senior construction managers as they give you ownership on the sector you’re working”

The workers involved in the validation exercise were grouped as either ‘highly’ or ‘averagely’ engaged based on the following selection criteria in conjunction with their employers: a highly engaged worker is someone who has won health and safety awards; (or) actively contributes to health and safety discussions, committees or initiatives; (or) a health and safety champion; (or) show enthusiasm for health and safety matters when you speak to them. An averagely engaged worker is as any other worker that fulfils their work role or duties. The validation interview were analysed in relation to these two categories so that the rankings could be assessed for their ability to separate ‘average’ from ‘highly’ empowered workers. The four levels of the empowerment cognition from the preliminary interviews were assigned incremental weightings of 25% each (100% maximum) for validation. The output from the validation interview of 22 workers identified 11 workers clustering around 50% (knowing and doing) and these were ranked as ‘averagely empowered’. The other half (11 workers) clustered around 75% (six workers capable of knowing; doing; decision-making) and 100% (five workers capable of knowing; doing; decision-making; influencing) levels and were ranked as highly empowered; Figure 6. The validation exercise categorised the highly and averagely empowered workforce based on their range of performance on the interview questions from the empowerment cognitions, i.e. knowing, doing, decision-making and influencing. **Error! Reference source not found.** shows some of the quotes and how the empowerment construct was tailored for OSH for the different levels.

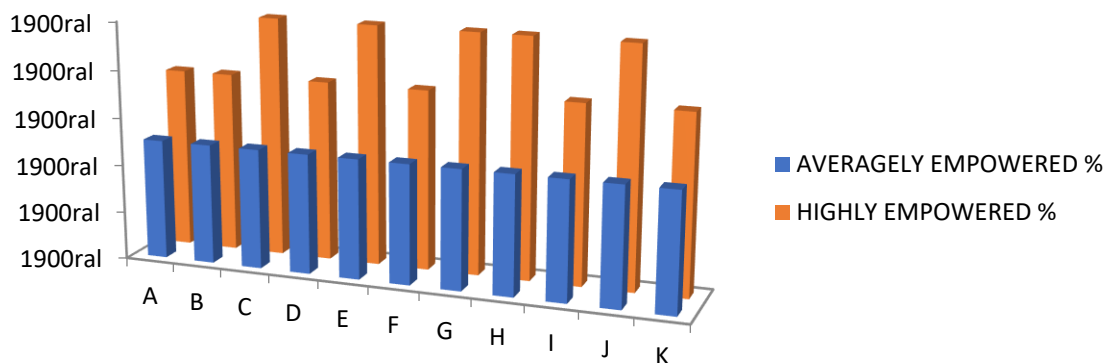


Figure 6: Validation of the Empowerment for averagely and highly engaged workers

Knowing - The validation exercise identified that the 22 workers involved knew the values of their work goals, beliefs and standards within their workplaces. This could potentially result in greater homogeneity amongst workers’ in terms of personalities, attitudes, and values which further enhances greater consistency about their perception of their roles and workplace.

Doing - The validation of the ‘doing’ appraised the capability or competence of the workers to successfully perform a given task (work-specific self-efficacy). Eleven workers cumulatively displayed qualities that aligned with knowing and doing criteria (levels 1 & 2). These were workers that knew the requirements of their tasks; have clarity regarding goals and work procedures, and their areas of responsibility but lacked the power to make some strategic

decisions. They were grouped as average in the empowerment scale. However, one worker in the average empowerment scale showed characteristics of a highly engaged worker. The validation also revealed that one of the workers considered by their employer as highly engaged and empowered did not display such characteristics, but rather that of an averagely engaged and averagely empowered worker. Therefore, deficiencies in role clarity, training and technical support, and unrealistic goals have the potential to lower the empowerment and engagement levels of the workers.

Decision-making - A worker's immediate supervisor has an important role in creating a non-controlling environment that empowers self-development and decision-making. Supportive managers and supervisors encourage workers' sense of decision-making and personal initiative, which in turn increases the workers' interest in work and enhanced creative achievement. Six workers cumulatively displayed qualities aligned with knowing, doing and decision-making regarding their work roles, thus making them high in the empowerment scale. The attainment of levels 1 to 3 is based on their perception of empowerment within their workplace. However, one of these workers considered high on empowerment scale displayed qualities of an averagely engaged worker. The need for an empowering work environment; one that provides informational feedback, offers choices with clear consequences, recognizes the problems the worker faces and provides a reason to act is important when workers need to make decisions around the tasks they undertake. The criticism that often comes with workers making decisions on OSH issues is the idea that management is seen as pushing responsibility onto workers, and with it comes liability if things do happen to go wrong. The ability to make decisions consists of having some control over work pace, and the ability to contribute to the development of risk assessments and method statements in partnership with management.

Influencing - The workers' own understanding that they can directly influence some strategic, administrative, and operating outcomes within their workplaces has the ability to drive their attitudes and behaviours. Five workers cumulatively displayed qualities that aligned with levels 1 to 4, thus making them very high on the empowerment scale. These were based on their perception of their levels of knowing, doing, decision-making and influence regarding their work roles in their workplaces. The five workers that demonstrated levels 1 to 4 characteristics on the empowerment scale were also classed as highly engaged. These workers had clear vision and well-defined goals, roles, and procedures and some level of autonomy within the workplace. These five workers that showed very high levels of empowerment and engagement were all working supervisors. However, the absence of network-forming opportunities, presence of high rule structure, low advancement opportunities, lack of meaningful goals and limited contact with senior management can significantly impact on the ability of the operatives to influence decisions.

CONCLUSIONS & RECOMMENDATIONS

The four cognitions of worker empowerment were developed with a focus on validating the empowerment levels of workers and their engagement as individuals within their workplaces. The result shows that these four cognitions can be combined cumulatively and used in determining the levels of empowerment and engagement of workers and also reveal their active orientation to a work role. These perceptions complement the more objective, job-oriented characteristics and worker differences as it is focused at the level of the operatives and supervisors in relation to their work environment.

Based on the output from the validation, this paper concludes that there is a pattern between the levels of workforce empowerment and engagement which can be related to their wellbeing. The results identify a pattern that workers showing average engagement characteristically also identified as average in the empowerment scale (knowing and doing levels). These were also identified to be majorly operatives within the workplace. Workers that were identified as highly engaged likewise demonstrated characteristics associated with high empowerment which was expected. These were identified as supervisors that have been deeply involved with supervisory roles within their workplaces. It can be inferred that high levels of workforce engagement tend to be associated with high levels of empowerment and wellbeing while average levels of engagement can be associated to average empowerment and worker wellbeing.

It can be inferred that the 'doing' (e.g. doing task safely) and 'influencing' (e.g. OSH policy; CDM) levels are most likely related to managerial effectiveness; while 'knowing' (e.g. safe systems of work) what to do within the role and the measure of 'decision-making' (e.g. stopping work if unsafe) are related to work effectiveness and job satisfaction. If workers are unaware of the extent of their authority and what is expected of them, they will hesitate to act and make decisions and thus feel incapable to influence decisions. Furthermore, the limits of decision-making should be clear so that workers are more confident about their OSH decisions, rather than being fearful about possible consequences for decisions made under vague conditions. Thus, assessing worker empowerment and engagement has revealed that it can serve as a useful indicative tool because it not only allows businesses to determine what levels of empowerment are perceived by their workers, but through its validation, could provide managers with useful information on some of the qualities that could be reformed to achieve even greater levels of perceived empowerment and wellbeing on the part of the workers.

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IMPACT OF STUDENT INDUSTRIAL TRAINING ON HEALTH AND SAFETY KNOWLEDGE OF STUDENTS IN CONSTRUCTION PROGRAMMES

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The construction industry continues to battle with the rising numbers of ill health, injuries and accidents on the construction sites. One key strategy recommended by researchers is health and safety education at all level of the industry. These include training of professionals who will manage the construction process. The aim of the study is to investigate health and safety (H&S) training among undergraduate students in construction programmes in Nigerian universities. The study also assesses health and safety training during the compulsory Student Industrial Work Experience Scheme (SIWES). One hundred and twenty questionnaires were administered to students studying B.Sc Building/Construction management. A checklist was also used to assess the health and safety content of the curriculums of Ten Bachelor of Science programmes in Building/Construction management. Finding from the study shows that there are few courses focusing on health and safety in the syllabus of the programmes but health and safety was part of Construction Management and Construction Technology courses. The study concludes that student industrial training work experience scheme (SIWES) has positive impact on health and safety competency of student. The study provides valuable insight on the extent which construction safety is addressed both in university curricula and industrial training.

Keywords: Education, Industrial Training, Health and Safety, Universities

INTRODUCTION

With the increasing number of injuries and accidents on the construction site in Nigeria and around the world, the importance for safety and health knowledge to be possessed by construction professions who manage (plan, direct and monitor) the execution of the projects cannot be over emphasised. The future for a safety working environment of the industry is associated with the safety education and training provided to the undergraduates of various construction professions (Yu, 2005). A key to creating and maintaining a safe workplace is providing effective safety education or training to workers including to those who are responsible for making decisions on a project such as safety managers, construction managers, and supervisors (Din et al., 2017). It is important that any personnel working in management, supervisory, and engineering roles have an understanding of construction site safety.

One of the opportunity students gets practical knowledge of work situation in construction is through industrial attachment. Studies (Yu, 2005) have recommended industrial attachment, site visits and practical experience as a method of improving health and safety knowledge of university students. According to Yu (2005) the curriculum of the building science programmes should be able to meet the expectation of the industry; tertiary institution should encourage the

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accumulation of practical skills in safety in the period of summer vacations, internship programmes or “year out” employment.

Industrial training is an opportunity that exists for students to learn about safety during their education prior to employment. Industrial training refers to the placement of students at the industry to gain experience in the professional employment world (Noor et al., 2014). Industrial training program is a prerequisite course for all undergraduate students in the Engineering & Built Environment faculty. The training program allows student gain more working experience in their field (Najid et al., 2012).

The health and safety content of curriculum is one factor among others that affect the quality of safety education that students receive, the knowledge and training received on the job during industrial training also impact the competency of the student before graduation. Despite the emphasis on safety education of workers, safety performance in the construction industry is far from satisfactory (Din, Rahman, and Gibson, 2017). Therefore, there is a need to analyze the content of the safety courses to evaluate their relevance to the major safety challenges faced by the construction industry.

While researchers have studied health and safety training in the construction industry generally, there is paucity of literature on the quality and extent of safety training in construction based courses. Gambatese (2003) conducted a study to learn how construction site safety is included in university academic programs. The study involved a survey of construction and engineering academic programs in the United States about how, and to what extent, construction safety is covered within the curricula of the programs. This study tries to answer the following research questions:

1. What construction safety contents are being taught in B.Sc Building courses?
2. What is the effect of SIWES on health and safety knowledge of undergraduate students?
This study results will help the construction industry understand the level of safety preparedness of undergraduates in Building/Construction programmes.

LITERATURE REVIEW

Health and Safety Education

Education is a big part of improving health safety performance in the construction industry. Safety education and training have been shown to benefit safety performance on construction jobsites. Improvements in safety performance can be gained when project personnel are knowledgeable of the potential construction site hazards and the appropriate means to mitigate the hazards. The education and training of project personnel in the area of safety are significant aspects of safe construction jobsites (Gambatese, 2003). Safety management systems require educated professionals and management that are knowledgeable in safety requirements and procedures. According to Yu (2005) safety and health education is both vital and a pre-requisite for management commitment in the built environment of various disciplines. As students and future professionals who will manage the construction process it is important they understand they have to ensure worker safety by eliminating potential safety hazards from the construction work site.

According to European Agency for safety and health (2010) professionals entering the workforce need education in order to develop the necessary Occupational Safety and Health (OHS) skill, knowledge and attitudes. This need is more evident for architects, Builders, construction managers and civil engineers who will have legal duties regarding the design, planning and execution of construction projects. Construction firms hire thousands of

university graduates who hold an academic qualification in Building, construction management, civil engineering, or other related fields, their knowledge of safety, and interaction with construction site personnel can have a considerable influence on construction site safety (Gambatese, 2003). These fresh graduates who are joining the industry are expected to have the essential awareness related to construction safety. Most institutions offer safety courses to undergraduate students, especially in construction programs. However, depths and breadths of the safety topics vary in different institutions (Gambatese, 2003).

Many of these employees enter the industry after receiving a formal education from a university. Therefore, incorporating construction safety in university curricula provides the opportunity for these employees to have an immediate impact on safety. Comprehensive safety and health education in tertiary level could improve the safety performance of site work, reduce the cost for clients and enhance the efficiencies of the projects. Safety and health education in building science programmes should promote the development of safety habits, skills, attitudes, awareness and knowledge conducive to safe behaviour in practice in their professions (Yu, 2005).

Student Industrial Work Experience Scheme (SIWES)

The challenges of globalization require engineering and technology graduates to be fully equipped with the necessary knowledge and skills before they enter the workforce. Higher learning institutions are now providing students with the opportunity to translate the knowledge gained into practice through industrial training, also known as practical training or internship (Rodzalan and Saat, 2012). Internship gives students the opportunity to integrate the theoretical learning in university with the practical work in the engineering environment.

The benefits of industrial training for students are undeniable since numerous studies (Norazah et al., 2012; Ayob et al., 2013; Nordin et al., 2013; Noor et al., 2014) conducted in various field produced positive outcomes.

In Nigeria students are required to undergo industrial training for a period of 24 weeks before their graduation. Training programme is undertaken in the 3rd year of a four year degree programme respectively and in the 4th year of a five year programme. The Industrial Training (IT) course is not peculiar to Nigeria alone in Malaysia it is conducted over five months in the Faculty of Engineering and the Built Environment in Malaysia (Mat et al., 2010). The benefits accruing to students who participated conscientiously in industrial training are the skills and competencies they acquire. These relevant production skills remain a part of the recipient of industrial training as lifelong assets which cannot be taken away from them.

During which, the student is attached to an industry based supervisor who will mentor and also assess the student. The student is expected to fill his training logbook and weekly progress chart and duly signed by the industry based supervisor. At the end of the programme the student is expected to write a technical report.

After the industrial training the daily log book activity report, the technical report, oral presentation, and the performance skills are assessed by the university (Noor et al., 2014). The faculty supervisors are required to evaluate the reports, log book and the work performance, while the organization supervisor are responsible to evaluate the students' technical skills as well as the soft skills.

METHODOLOGY

This study was carried out among 120 students who were involved in the SIWES programme for six (6) months in 2017. Questionnaires were presented to students after they have completed

their training. Convenience sampling was used and students were asked to willingly participate. The questionnaire were arranged to form a Likert-type scale with a five point spread ranging from ‘Strongly disagree’ given as 1 to ‘Strongly agree’ given as 5.

The study examined what construction safety content is being taught in universities. The study analyse construction safety syllabi of Ten B.Sc/B Tech in Building programme in Nigeria. Data were analysed using mean and percentage.

FINDINGS, ANALYSIS AND DISCUSSION

Table 1: B.Sc and B.Tech curriculum survey

S/n	Year	Courses offered
1	100 level/first year	Science courses and introduction to building
2	200 level/ Second year	Technology, structures ICT
3	300 level/ Third year	Building services, maintenance, structural analysis
4	400 level/ Fourth year	Law and contract administration, management, technology and tendering and SIWES (6 months)
5	500 level/ Fifth year	Professional practice and ethics, management, research

The study looks at the content of the curriculum of B.Sc and B.Tech Building. From Table 1. In their first year students take basic science and general science courses (Chemistry, Physics and mathematics), in some universities courses like Introduction to building are offered. Second year courses include Construction technology, computer programming, architectural design, computer application. Third year courses include Building (Electrical and mechanical) services, building maintenance, tendering/estimation, valuation and Reinforced concrete and steel design.

Fourth year courses includes building law and contract, project management, building information management, construction technology and economics. During the second semester student go for six months Student Industrial Work Experience Scheme (SIWES). The fifth (final) year of study consist of construction technology, project management, ethics and professional practice and research methodology and final year project.

Table 2: Health and safety content in tertiary education syllabus

	Universities										%	
	A	B	C	D	E	F	G	H	I	J		
Single course	X	X										20
Module in various course	X	X	X	X	X	X	X	X	X	X	X	90
Component of other course					X			X		X		50

Table 2 shows the H&S contents in curriculum of Bachelor of Science degree courses in 10 universities in Nigeria. It was found that twenty percent of schools surveyed have a course ‘Construction health and safety management’ dedicated to health and safety. In 90% of curriculum surveyed, health and safety are in modules in courses. The courses include construction management, construction technology, workshop and practice, professional ethics, construction plant and equipments.

It was observed that in institutions where construction health and safety were given a single course, topics on health and safety was found in other courses. Topics on safety include fire safety, workers welfare, occupational health and safety, plant and equipments safety. The result indicates that safety is being taught in a variety of courses within the Bachelor of Science and Bachelor of Technology curriculum. Al- Mufti (1999) suggested that the approach to teaching construction safety should comprise Safety as an integral part of all other teaching as opposed

to a separate course devoted to the topic.

Modules on health and safety include;

- i. Fire protection of buildings;
- ii. Safety in building and on building site.
- iii. Safety on temporary supports; formwork scaffolding
- iv. Safety on Construction site,
- v. Occupational Health & Safety at Workplace Act;
- vi. Fire safety & Protection Regulations;
- vii. Workman Compensation Act
- viii. Factory act and Safety Regulations applicable in workshops
- ix. Health and Safety as captured in the Builders' documents
- x. Safety regulations applicable in workshops

Respondents were asked to rank the benefits of health and safety. Results in Table 3 show that respondents ranked preventing death, illness and injuries in construction (4.33) as the most highly ranked benefit. Other highly ranked benefits include complying with safety regulation (4.05), increasing workers productivity and morale (3.96). This result shows that the respondents (students) recognise the importance of health and safety in construction. Preventing injuries and death is a moral, legal and financial argument for promoting health and safety (H&S) on construction site according to Huges and Ferret (2008).

Table 3: Benefits of implementing health and safety

Benefits	5	4	3	2	1	∑f	∑fx	Mean
Preventing injuries and death	70	32	9	6	3	120	520	4.33
Complying with safety regulation	76	22	9	14	8	120	486	4.05
Increase productivity and moral	50	32	24	12	2	120	476	3.96
Avoiding insurance premiums and compensation claims	53	25	19	16	7	120	461	3.84
Reduced staff turnover	37	20	27	30	6	120	412	3.43
Reduce absenteeism	32	27	19	36	6	120	403	3.35
Sound reputation	22	14	30	40	14	120	346	2,88

1-Strongly Disagree, 2- Disagree, 3- Somewhat Agree, 4- Agree 5- Strongly Agree

Six health and safety regulations or requirements were identified from literature review. Students were asked to choose laws they are aware of. Health, safety & welfare provisions in conditions of contract (79%) was the H&S laws respondents were most aware of. 56% were aware of Health, safety & welfare provisions in Factory's Act 1990 while 44% indicated that they were aware of Health, safety & welfare provisions in Workmen's Compensation Act 2012. There was low awareness of Health, safety & welfare provisions in Health, safety & welfare provisions in Public Health Act 1990 (10%), Labour Safety and Welfare Law 2012 (11%) and Health, safety & welfare provisions in National Environmental Standards & Regulations Enforcement Agency (NESREA) Act, 2007 (12%). 32% of respondents indicated that they are not aware of any of the health and safety laws.

Table 4: Awareness of Health and safety law

Health and safety provision	Frequency (Nr)	Percentage (%)
Health, safety & welfare provisions in Workmen's Compensation Act 2012	53	44
Health, safety & welfare provisions in conditions of contract	79	66
Health, safety & welfare provisions in Factory's Act 1990	67	56
Health, safety & welfare provisions in Labour Safety and Welfare Law 2012	13	11
Health, safety & welfare provisions in National Environmental Standards & Regulations Enforcement Agency (NESREA) Act, 2007	14	12
Health, safety & welfare provisions in Public Health Act 1990	12	10
None of the above	32	27

On health and safety training in tertiary institutions all respondents agree that they have had health and safety topics treated in courses offered by their departments. This finding is in line with results in Table 2 that showed that health and safety content are taught in BSc and BTech curriculum. Result show that only 62% of respondents have had training on health and safety during their SIWES programme. This figure is low. Every trainee should be trained on H&S before working on the construction site.

65% of respondents believe that SIWES has improved their H&S knowledge, 35% of respondents think it hasn't. This is poor because health and safety knowledge should be improved on the job. This also shows that not all the companies gave their new employees training before going on the building site.

Table 5: Health and safety training

	Option	Frequency	Percentage (%)
Health and safety in curriculum	Available	120	100
	Not-available	0	0
	Total	120	100
Has SIWES been beneficial	Yes	108	90
	No	12	10
	Total	120	100
Health and safety training during SIWES	Available	74	62
	Not-Available	56	38
	Total	120	100
Improvement in H&S after SIWES	Yes	78	65
	No	42	35
	Total	120	100

The study also assessed the content of the safety training to evaluate their relevance to the major safety challenges faced by the construction industry. From Table 6 personal protection (equipments) 74%, site safety rules (65%), welfare provisions on site (54%), Company's safety policy (53%) were the most frequent H and S practice provided to the student training. Identification of site hazards (47%), manual material handling (47%), Fire protection programme (37%), site safety audit (30%), job hazard analysis (19%) and Ergonomics (5%) are the least frequent training offered to trainees during SIWES.

There is need for improvement in Health and safety training provided to new trainees and employees. The company's safety policy should ensure that H&S training to be provided to all newly recruited employee. Practices like emergency procedures, safety tool box talks, jobsite hazard analysis and ergonomics can be taught by the person responsible for health and

safety in the construction company.

Table 6: Health and safety Training during SIWES

Practices	Frequency (Nr)	Percentage (%)
Personal protection	89	74
Site safety rules	78	65
welfare provisions on site	67	56
Emergency procedures	65	54
Company's Safety policy	63	53
Identification of site hazards	56	47
Manual material handling	46	38
Safety tool box talks	46	38
Fire protection programme	44	37
Safety programs (project safety meetings, permits to work)	38	32
Site safety audit	36	30
Jobsite inspection	34	28
Carrying out post-accident investigation	24	12
Constructability	23	19
Job hazard analysis	22	18
Ergonomics	6	5

CONCLUSIONS AND RECOMMENDATION

The incorporation of construction safety into university-level curricula is one means by which individuals who commonly occupy engineering, supervisory, and management positions in the construction industry can learn about safety. SIWES gives the student opportunity for learning about safety as a compliment to on-the-job experience and training. It is important that Bachelor of Science and Bachelor of Technology in Building programs offers a course wholly devoted to safety because the traditional role of a Builder is on the building site.

Majority of the building science programmes in have safety and health content in their curriculum. Safety is mostly taught as part of the relevant courses, for instance, construction technology or construction management. Few of them are in a single course (Construction health and safety management) and in components of relevant courses. The study concludes that student industrial training work experience scheme (SIWES) has positive impact on health and safety competency of student. There is need for improvement with the scheme. Construction companies should ensure trainees are trained before engaging them on the construction site.

The study recommends the inclusion of site hazards identification, manual material handling, site safety audit, job hazard analysis and ergonomics in both syllabus of building programmes and training provided during the industrial training. The study recommends the development of a health and safety course programme for construction related courses like the occupational safety and health (OSH) training (OSHA 10) in construction. Health and safety should be the first training employers' site give trainees before engaging them on the construction site. The study results provides valuable insight on the extent to which construction safety is addressed both in university curricula and knowledge gained during Industrial training and how to improve their competence in H&S

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HEALTH AND SAFETY ISSUES ON CONFINED BUILDING SITES IN NIGERIA

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The aim of the study is to investigate the health and safety challenges on confined building construction sites. The study further looks into safety practices on confined sites in Nigeria. One hundred questionnaires were administered to construction site managers while ten confined building construction sites were visited. The checklist was used to assess health and safety provisions on these sites. The study found that health and safety practices on confined sites are inadequate. The study concludes that materials handling, difficulty in providing temporary facilities, congestion, ergonomic hazards and difficulty in managing waste and lack of adequate storage space are the issues affecting health and safety management on confined sites. The study recommends implementing health and safety plan, build-ability analysis, construction programming and site design/ layout as strategies to improve safety on confined sites. There is dearth of studies on confined building sites in general especially in developing countries like Nigeria where confined site construction is becoming a norm, this studies intends to close that gap.

Key words: Confined sites, Building, H&S management, Nigeria

INTRODUCTION

The construction industry has earned a reputation of being highly hazardous and dangerous because of the high rate of injuries, ill health and deaths that occur on the construction site around the world (Ajayi and Thwala, 2015; Sass and Smallwood, 2015). Statistics indicate that the construction industry is among the most hazardous industries in the world. Construction workers in developed counties are 3-4 times more likely to die at work and the risk is estimated to be 3 to 6 times greater in developing countries (Loiselle and Werna, 2014). This stresses the need to maintain a safe and healthy working environment in the industry.

According to Shittu *et al.* (2015) health and safety practices have remained ineffective in addressing the challenges of health and safety in construction because it has been largely generalised without taking cognisance of the peculiar determinants of effective health and safety system. One of such areas is the confined site construction. Spillane and Oyedele (2013) noted that confined construction sites, by their very nature, have characteristics that are likely to increase the health and safety risk. Oyedele, Meding and Konanahall, (2010) defined a confined construction site as a site where the building footprint occupies in excess of 90% of the development site, within the limits of the site boundary. Bidy (2009) posits that confined site construction is rapidly becoming the norm in the construction industry especially in urban centres. Construction activities in urban areas are characterised with negative impacts on the buildings and areas surrounding the construction site which includes traffic congestion, and safety hazards (Khaled, Mohammad and Shaher, 2015).

One of the reasons why confined site construction has increased according to Spillane and Oyedele (2013) is because clients now insist on optimal utilisation of an acquired development

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site, particularly due to the high cost of land and the enhanced potential for an increased return on investment. The increase in number of confined site has also been driven by designers' optimising spaces, ever-rising cost and shortage of land in prime locations. Kumar and Cheng (2015) declare that in most urban construction projects, site space is limited and must be used judiciously in order to avoid problems with accessibility, safety and congestion. A confine space differs from a confine site. A confined space is a large enough space that is configured so that an employee can bodily enter, it has limited means of entry and exist, and is not designed for continuous human occupancy (Occupational Safety and Health Administration, 2017). A confined space can be found on any site irrespective of the size. While confined site has to do with limited space on site.

Spillane *et al.* (2011) conducted a quantitative research on confined sites using a qualitative method, the study suggested a quantitative study using the issues identified to confirm their importance and wider occurrence in other construction sites. There is also dearth of studies on confined site construction which requires redress, due to its prominent nature in the construction industry today. Similar studies (Spillane and Oyedele, 2013; Spillane, Oyedele and Meding, 2012; Spillane and Oyedele, Meding and Konanahall, 2010; Spillane *et al.*, 2011) have been carried out in the United Kingdom, Unites States and Ireland, no studies have been carried out in a developing country. This research aims to fill this gap in knowledge by highlighting the need to identify the numerous issues regarding the implementation of health and safety on confined construction sites in a developing country like Nigeria. The aim of the study is to investigate the health and safety challenges on confined building sites in Nigeria.

LITERATURE REVIEW

Confined Site Construction

Tommelein and Zouein (1993) argue that space is as an important resource as personnel and other resources, which requires extensive and detailed management. This shows the importance of space on the construction site. Pradhananga and Teizer (2014) posit that space is a major constraint in urban construction sites, especially, when, multiple crews work simultaneously, share the same working space and heavy equipment are involved. Space has effect on safety on a construction site. The lesser the space available on site the more hazardous the environment becomes (Mossman, 2008). A confined construction site has been defined by Spillane and Oyedele (2013) as a site where permanent works fit the site footprint, extending to levels above and/or below ground level, leaving spatial restrictions for other operations (e.g. plant and material movements, materials storage, personnel management and temporary accommodation, etc.) and require effective resource co-ordination beyond normal on-site management input. A confined site differs from a confined space on site.

A confined space is any space that is large enough for an employee to enter and perform the assigned work but is not designed for continuous occupancy (Occupational Safety and Health Administration, 2017). Michigan institute of Safety and Health Administration (2015) defined confined space as a space that, because of its physical construction, could be subject to the accumulation of loose materials or explosive, toxic, or flammable contaminants or could have an oxygen deficient atmosphere. Examples of confined spaces are storage tanks, process vessels, bins, boilers, ventilation ducts, sewers, underground utility vaults, tunnels (after construction is completed), pipelines, open top spaces more than four feet in depth, such as pits, tubs, vaults, and vessels.

Confined sites are characterised with limited space on site which could lead to spatial conflict. A spatial conflict occurs when the spatial requirement of construction task which are executed the same time overlap. Sades (1989) spatial constrains disturbs the execution of operation

which has a negative effect on site productivity. Spatial conflict does not only have effect on health and safety but also productivity. According to Marx and Kornig (2013) spatial constrain on construction sites also have effect on the construction time.

Construction Spatial Requirement

Each construction activity requires a space on the site. The space on a confined construction site is limited. According to Bansal (2013) workers, equipment, materials, temporary facilities (TFs), and the structure under construction share the available space on a jobsite during its execution. Akinci et al. (2002) identified six type of spaces required by construction activities. These are

1. Building component space: physical space occupied by building component to be installed;
2. Labour crew space: space used by labour crew installing components;
3. Equipment space: space used by equipment supporting labour crew or component during installation;
4. Hazard space: space generated when activity creates hazardous situation;
5. Protected space: space required to protect component from possible damage for certain period of time; and
6. Temporary structure space: physical space occupied by temporary structures, such as scaffolding and shoring. Temporary structures are modelled like permanent building components.

A little modification was made by Marx, Erlemann, and Kornig (2010) where he divided construction site spatial requirement into three resource, topology and process space (see Table 1). Resource spaces are spaces required for both human and material resource on the construction site. They include labour, equipment and material. The topology space contains the area of the building under construction, the walk way or road for movement, storage space and space for temporary structures on site. While the process space is the space required to carry out the necessary site operations.

Table 1: Construction spatial requirement

	Topology space	Process space
Work resource space	Building structure	Working space
Crew space	Building space	Hazard space
Equipment space	Construction site	Protected space
Material space	Storage space	Post processing space
	Temporary structure space	
	Road space	
	Emergency space	
	External constrain space	

METHODOLOGY

This study is a quantitative research. The primary data for the study were obtained through administering questionnaires and filling of checklist. Ten construction sites, around Nigeria were selected for investigation via purposive sampling technique based on fulfilling the requirement of a confined building site. The sites visits were carried out to obtain first-hand information relating to health and safety practices with emphasis on actions taken to prevent accident and injuries on confined sites in Nigeria.

One hundred questionnaires were distributed to construction managers; sixty three were properly filled and found worthy to be included for data analysis. The response rate was sixty

three percent (63%). Purposive sampling was used to administer questionnaires to only respondents who have experience working on a confined building construction site.

The respondents were asked to rank each of the factors on a scale of 1-5 on.

On health and safety issues on confined sites on the “frequency” of occurrence, where 1 was “not at all” and 5 was “always”.

$$\text{Relative Severity Index (RSI)} = \frac{\sum fx}{\sum f} \times \frac{1}{k}$$

Where,

$\sum fx$ = is the total weight given to each attributes by the respondents.

$\sum f$ = is the total number or respondents in the sample.

K = is the highest weight on the likert scale.

FINDINGS, ANALYSIS AND DISCUSSION

Table 2: Most common injuries reported on confined sites

Type	Frequency	Percentage (%)
Slips and falls	39	62
Overexertion and repetitive motion injuries	34	54
Falling debris, materials or objects	33	52
Getting caught in-between objects or materials	29	46
Machinery accidents	23	36
Trench collapses	19	30
Falls from high heights or scaffolding	7	11
Electrocutions	3	5
Fires or explosions	0	0

The study looked into type of injuries commonly reported on confined sites. As seen in Table 2, slip and fall is the most reported accidents according to respondents. Overexertion and repetitive motion injuries (54%), falling debris, materials or objects (52%) and getting caught in-between objects or materials (46%), machinery accidents (36%), trench collapses (30%) are also commonly reported on site. The least reported cases of accidents are falls from high heights or scaffolding (11%), electrocutions (5%) and fires & explosions (0%).

Table 3: Health and safety practises on confined sites

Practices	Site										%
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
H& S policy and planning											
Job hazard analysis	-	-	-	√	-	√	-	√	√	-	40
Providing insurance cover for sites and Employer-paid insurance plan	√	-	-	-	√	-	-	-	√	-	30
H&S record and follow-ups	√	√	-	√	√	√	-	-	√	-	60
Health and safety policy and plan	√	√	-	-	√	-	-	-	√	-	40
H&S equipment											
Provision of first aid facilities	√	√	-	√	√	√	-	√	√	√	80
Provision of personal protective equipment	√	√	-	√	√	√	-	√	√	-	70
Having a designated safety personnel	√	-	-	√	-	√	-	√	-	-	40
Fire prevention facilities	√	√	-	√	-	√	√	-	√	-	60
Provision of crane and lifting equipments	-	-	-	√	√	-	-	√	-	√	40
Welfare provisions on site									√		
Provision of toilet	√	√	-	-	√	√	-	-	√	-	40
Provision of drinking water	√	√	√	√	√	√	√	√		√	80

Practices	Site										
Provision of facilities for rest	√	√	-	-	√	√	-	-	-	-	40
Provision of changing room	√	√	-	-	√	-	-	-	√	-	40
Provision of washing facilities	-	√	-	-	-	-	-	-	-	-	10
Site conditions											
Is site fenced (hoarding)	√	√	√	√	√	√	√	√	-	√	90
Provision of lighting facilities	-	-	-	√	√	√	-	√	√	√	60
Is there protection to stop people from falling into excavation	√	√	-	√	-	√	-	-	-	-	40
Well placed sign and symbols	-	√	-	√	√	√	-	-	-	-	40
Storing materials outside the site	√	√	√	-	-	-	√	-	√	√	60
Presence of traffic man	-	-	-	√	√	√	√	√	√	√	70
Adequate clearance for slewing vehicles	√	-	-	√	√	√	-	-	√	-	50
Proper site layout	-	√	-	-	√	√	-	-	√	-	40

Under H& S policy and planning, job hazard analysis was found to be poor with 40% compliance. There is poor insurance cover for employees at a compliance rate of 30% and health and safety record keeping was at 60% compliance (see Table 3.). Health and safety plan was found at only 40% of the site visited.

On provision of health and safety equipment, first aid facilities were found in 80% of site visited. Compliance with the use of personal protective equipment was found to be 70%. Presence of designated safety personnel was found to be low at 40%. Fire prevention facilities were also found in 60% of site visited. The provision for lifting equipments was found in 40% of sites visited.

On welfare provisions on site; provision of toilet facilities, provision of rest facilities and changing room were at 40%. Provision of washing facilities was found to be very poor at 10%. drinking were provided in 80% of site visited.

On site conditions, it was found that most 90% of the sites were fenced. Provision of lighting facilities was complied with in some (60%) site. protection from fall (excavation) were available in 50% of site visited. The study found low (30%) compliance with placement of safety sign and symbols on site. Storing material outside the site was observed in 60% of site visited. Traffic men were present in most (70%) site. Adequate clearance for slewing vehicles and proper site layout was found in 50% of the sites surveyed.

Job hazard analysis is not usually carried out on most sites. Job hazard analysis help the worker analyse the task to be undertaken and helps the worker identify the risk involved in the task to be carried out. The study found the low implementation of a health and safety plan on most construction project. According to AbdulHafeez, Ibrahim and Shakantu (2018) the poor implementation of health and safety plan was one of the major factors responsible for poor safety record in the industry. The study found the substantial compliance with the use of PPE and presence of first aid facilities in case of injuries or emergency. Appointing safety personnel on construction site were found to be low. This could be one of the causes of high rate of injuries in construction. The study found that provisions of welfare facilities (changing rooms, toilets, washing room and facilities) on site was poor. According to HSE (2018) clients and contractors are responsible regarding welfare on construction projects.

There was high compliance on hoarding and fencing on most sites visited. It's a welcome development because hoarding is an important component for ensuring health and safety of not only the worker but also for visitor and the general public. Confined sites are usually within urban environments and built up areas. It ensures people are safe from activities of construction sites. There was low compliance of use of fall protection. Low level of application of fall

protection into excavation may be because the Nigerian safety code doesn't specify the conditions where it is necessary while OSHA code specifies that a fall protection is required from 1.8 m dept in foundation.

Building materials were found to be stored on the street because of lack of space on the construction sites. This could be a health and safety risk for the general public especially when it is done without permit. Implementation of proper site layout was average. The importance of proper site layout to health and safety cannot be over emphasised especially in a spatially restricted place like a confined construction site. Anumba and Bishop (1997) have linked site layout to health and safety performance on construction site.

Table 4: Issues affecting health and safety management in confined site construction

Issues affecting health and safety	5	4	3	2	1	∑f	∑fx	Mean	RII
Challenges of handling materials	34	19	6	4	0	63	272	4.30	0.86
Difficulty in providing temporary facilities on site	36	12	9	4	2	63	265	4.21	0.84
Workplace becoming over-crowded (congestion)	32	17	6	7	1	63	262	4.10	0.82
Ergonomic challenges	31	17	6	6	3	63	256	4.06	0.81
Close proximity of individuals to operation of large plant and machinery	36	13	10	2	2	63	248	3.94	0.79
Difficulty in managing waste on-site	27	16	11	3	6	63	244	3.87	0.77
Lack of adequate storage space	33	12	5	6	7	63	242	3.84	0.77
Poor housekeeping	24	16	10	7	6	63	234	3.71	0.76
Difficulty in ensuring personnel getting to and from their area of work safely	16	20	14	12	1	63	227	3.60	0.72
Intersections and collisions of personnel in heavily travelled routes during construction operations	18	22	10	5	8	63	226	3.59	0.72
Difficulty in ensuring site is tidy and all plant and materials are stored safely	22	16	5	12	8	63	221	3.51	0.70
Increased safety risk due to various tasks being executed in close proximity to each other	20	9	10	17	7	63	199	3.16	0.63
Difficult to account for and manage personnel due to the restricted working conditions	16	12	7	19	9	63	196	3.11	0.62
Difficulty in the management of on-site traffic	10	12	16	10	17	63	173	2.75	0.55
Difficulty in controlling hazardous materials and equipments on site	9	14	16	12	22	63	165	2.61	0.52

Challenges in handling materials (RII=0.86), difficulty in providing temporary facilities on site (RII=0.84), congestion (RII=0.82), ergonomic challenges (RII=0.81) close proximity of individuals to operation of large plant and machinery (RII=0.79), poor housekeeping (RII=0.77), and lack of adequate storage space (RII=0.76) are the most highly ranked health and safety issues on confined building sites.

In a confined site where there are spatial restrictions, materials handling is a major challenge. Handling of materials involves transportation and storage. Numerous injuries could occur from improper handling and storage of materials, while moving material manually or mechanically workers need to understand the potential hazard associated, the task at hand and how to control it to minimise danger. Lack of space on a confined site restricts the number of plant and equipments required for a typical construction projects. The presence of machines and

equipment will also reduce the amount of space for circulation and other activities. According to Spillane *et al.*, (2012) spatial restrictions hinder the effective implementation and utilisation of plant on-site and movement of material using plant and machinery. Where spatial limitations occur, the process of unloading and distribution of material around site can prove difficult and time consuming along with increasing the health and safety concerns both to the machine operative and to the personnel on-site.

Welfare provisions are fundamental in safeguarding the health and wellbeing of workers. The provision of toilet, changing room and lockers, washing facilities, drinking water and facilities for rest is a basic expectation (HSE, 2015). In a site where space is limited providing welfare facilities is challenging. It requires space and the manager has to choose which facility is important enough to be on the site. It confirms the findings from Table 2 where provisions of welfare facilities on site were poor.

Poor housekeeping contributes to accidents by hiding hazards that can contribute to accidents and injuries. According to Muriri and Mulinge (2014) a badly planned and untidy site is the underlying cause of many accidents on construction sites in Kenya. The Canadian Centre for Occupational Health and Safety also add that poor housekeeping causes accidents like tripping, slipping and hit by falling objects. Ergonomic hazards were also found to be an issue on confined sites. Ergonomic hazards are leading causes of workplace injuries of construction site (Ibrahim, Mustapha and AbdulAzeez). This injuries may be present because of some of the risk factors which are present on confined site such as manual handling of heavy and irregular-sized loads; adopting awkward work postures, working in confined spaces and cramped space and poor site layout (Smallwood and Ajayi, 2007; Smallwood and Haupt, 2009).

CONCLUSIONS

Confined building sites have been and would continue to be the norm in the construction industry because of the increasing need to optimise land, increase in population, urbanisation and cost of land especially in cities. Confine sites have shown to have more health and safety challenges than the normal construction. The study was able to determine that health and safety measures (planning and prevention) employed on confined site construction sites are inadequate and fail to meet the required standards, which could result in illnesses, injuries and death. Health and safety issues on the confined building sites identified in the study are; challenges in handling materials, difficulty in providing temporary facilities on site congestion, ergonomic challenges, close proximity of individuals to operation of large plant and machineries, poor housekeeping and lack of adequate storage space. The study recommends implementing health and safety plan, build-ability analysis, implementing a construction programming and implementing a good site design/ layout. The study ties to bridge the gap in knowledge on confined building construction site in developing countries where the risk of injuries, illness and death are higher.

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COST IMPLICATIONS AS MOTIVATORS FOR HEALTH AND SAFETY IMPROVEMENT IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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Accidents impose huge financial burdens on organisations and the economy as a whole. The current study investigated financial implications associated with poor health and safety (H&S) performance, which constitute motivators for implementing H&S in the South African construction industry. Questionnaires were used to collect data for the study. Construction practitioners including project managers, construction managers and site managers were sampled using convenience sampling. Data was analysed using SPSS to output mean and standard deviation values. Additionally, the factors were ranked to determine the most important cost implication(s) for H&S implementation and improvement. Findings revealed that the cost of compensation and medical treatment as well as the cost of clearing the sites after accidents ranked highest; whereas the cost of insurance claims ranked the least. The study was conducted in one province of South Africa and may not be generalisable to other geographical regions with different views. The study highlighted the cost implications of poor H&S implementation, and as such reveals motivators for H&S implementation and improvement in the Gauteng Province of South Africa. H&S performance will be improved taking cognisance of costs which can be avoided if organisations commit to H&S implementation.

Keywords: Construction industry, Health and safety, Financial implications, South Africa, Gauteng

INTRODUCTION

Globally, the construction industry has one of the highest rates of accidents and injuries among all industries (Gürçanlı and Müngen, 2013; Maano and Lindiwe, 2017). The construction industry in the United Kingdom (UK) accounts for about 8% of GDP and employs about 10% of the workforce but has a worker fatal injury rate of 1.37 per 100,000 workers (over 3 times the average rate across all industries, which is 0.43 per 100,000 workers) (Cooney, 2016; Health and Safety Executive (HSE), 2017). In the United States (US), the construction industry accounts for 5% of all workers, but 20% of all fatalities and 9% of all serious injuries and disabilities (Gürçanlı and Müngen, 2013). Construction industries in developed countries also face challenges that are related to an increase in occupational accidents, injuries and diseases (Maano and Lindiwe, 2017).

Poor H&S performance precipitates financial impacts (which may be direct or indirect)

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associated with poor safety performance in an organization (Asanka and Ranasinghe, 2015). Direct impacts include costs associated with unique compensation provided to workers due to injuries associated with the accidents, medical care and insurance premiums to defray treatment costs; while indirect costs relate to the lost, delayed or degraded production as a result of shortage of skilled workers, cleaning up after the accidents, replacement of the materials, deliveries of new materials and wages of the workers, etc. (Construction Industry Development Board (CIDB), 2009; International Labour Organisation (ILO), 2012; Asanka and Ranasinghe, 2015; Samarghandi et al., 2016). Other costs include pain and suffering and reduced quality of life, which are detrimental to workers, employers, societies and the economy as a whole (European Agency for Safety and Health at Work, (EASHW), 2012; ILO, 2012; Ghasemi et al., 2015). Poor H&S leads to sickness, impaired work efficiency, absenteeism, presenteeism, reduced corporate image and customer loyalty, and lost work days, costing huge amounts in medical bills and compensation. For instance, presenteeism costs companies approximately \$1,392 to \$2592 per injured employee yearly (EASHW, 2012). Globally, the ILO estimates that around 4% of the world's gross domestic product (GDP), or about US\$2.8 trillion, is lost annually in direct and indirect costs owing to occupational accidents and work-related diseases (ILO, 2014). These costs are avoidable and preventable through perception and mindfulness of foreseen implications and consequences of H&S culture in an organisation. Thus, continuous research on H&S motivators is necessary to achieve desired improvement.

There are many motivators to improve H&S performance and studies have been conducted with regard to such including improvement in productivity, cost reduction, corporate image or negative publicity, compliance with regulation, fear of sanctions, and so on (Kazaz et al., 2008; Terrés et al., 2013; Barg et al., 2014; van Heerden et al., 2018). However, although studies have been conducted on H&S motivators, they do not focus on financial implications which are indeed grave and detrimental to all stakeholders involved. In Terrés et al. (2013), conducted exploratory and confirmatory factor analysis of safety motivators in Catalonian construction sector based on a previous HSE study and intimated that financial and other penalties enforceable by the HSE, if poor H&S practices were pinpointed, were considered too insufficient to compel construction companies to act on safety improvement. Ghasemi et al. (2015) focused on financial and non-financial incentives to encourage H&S practices. Cooney (2016) identified legal, economic and financial incentives for implementing H&S in the workplace. However, this study focused on the procurement and cost-effectiveness or savings in relation to H&S issues and clients' role. More recently, van Heerden et al. (2018) incorporated other H&S implementation motivators including the need to manage hazards, regarding H&S as important and a way to do business, compliance with legislation. The objective of the current study is therefore to identify financial implications which could motivate H&S implementation in construction organisations. A literature overview is presented in the next section, followed by the methods employed in conducting the study, the findings and discussion as well as conclusions drawn.

COST IMPLICATIONS AS MOTIVATORS FOR HEALTH AND SAFETY IMPLEMENTATION

Lopez-Alonso et al. (2013) define the cost associated with H&S implementation as the value that deplete with the undertaking of measures to reduce the risk of accidents and to provide a friendly working environment which is free from hazards that may cause injuries, fatalities or

illness on the construction sites. Hence, construction organisations may be motivated to part with this value in order to provide that safe work environment for their employees.

Motivation is an intangible and hypothetical construct that is used to explain human behaviour and it can be defined as “providing a drive to act to satisfy desires (Barg et al., 2014). Thus, individuals or employers motivated to implement H&S on construction sites are driven to do so by certain factors which may be related to the costs they may incur, otherwise. According to Smallwood and Haupt (2005), some contractors set aside an amount less than 0.5% and others even less than 0.25% of the contract sum for investing in H&S on their contracts and this is insufficient as costs of accidents is higher than the cost of prevention. Further, higher amounts may be spent on medical expenses than if allowance was made to prevent accidents and injuries in the first place (Ibarrondo-Davila et al., 2015). In other words, the funds invested by construction organisations in H&S implementation and practices would cost companies less than the financial consequences which could result in the absence of good H&S performance culture.

Therefore, accident prevention could save companies or organisations huge costs if planned for through proper H&S programmes and policies in the workplace. The implications of not planning and subsequently implementing H&S range from shortage of skilled labourers as well as hindrance of flow of work on sites as a result of stoppage of work to attend to the injured worker(s), with associated with delays and overruns on the affected projects (Asanka and Ranasinghe, 2015).

Additionally, accidents result in days of absence to investigate the accident or incident reported and/or to allow the injured to recuperate (sometimes in a state of presenteeism, which could cause further degradation of health) (EASHW, 2012) or extra costs (not previously budgeted for) to replace the injured worker (Battaglia et al., 2014).

Further, an embedded cost for the repair and/or replacement of any damaged equipment or materials must be absorbed when an accident happens (Farooqui et al., 2008). The costs of cleaning up and replacing damaged equipment are therefore important concerns to employers as the end up losing money in the aftermath of accidents (van Heerden et al., 2018).

Other costs, which may be direct or indirect include costs include costs of medical expenses (including nursing and recuperation costs), hospitalisation and disability costs, wages of the victims, worker compensation costs, costs of training and replacing the injured with new employees, administrative costs, insurance costs, (Farooqui et al., 2008; CIDB, 2009; Battaglia et al., 2014; Ibarrondo-Davila et al., 2015; van Heerden et al., 2018).

Therefore, H&S implementation is important in order to avoid the costs associated with non-implementation. The current study focuses on investigating what these accident-related costs motivate construction companies in South Africa to improve H&S.

METHODS

The current study was part of a broader Bachelor of Technology research investigating H&S implementation and factors motivating employers and managers to adopt and implement H&S practices. However, the present paper focuses on cost implications of H&S implementation.

The study adopted a quantitative approach. A questionnaire was developed from literature review undertaken using databases accessible through the candidate’s institution, including

Academic Search Complete, Springer, Science Direct, Emerald Insight, as well as Google and Google Scholar. The questionnaire was divided into sections containing biographical information of respondents and H&S implementation motivators, including financial and non-financial motivators. However, the present paper focuses on the cost implications. The questions were about cost implications associated with H&S performance, which drive or motivate H&S practices in an organisation. The questionnaire was Likert-scaled, with responses ranging from 1 = strongly disagree to 5 = strongly agree.

The questionnaire was self-administered in construction organisations in the Gauteng Province of South Africa, to project managers, construction managers, site managers, quantity surveyors, foremen. These professionals were selected using convenience and snowball sampling techniques. Companies which the candidate was familiarized with during in-service training were initially approached. Thereafter, referrals were made by initial respondents to who helped to identify further professionals. The respondents included in the current study were available and willing to participate. Due to the method of data collection (hand-delivered), all distributed questionnaires were completed (a total of 50) and were used in the analyses.

Descriptive statistics was used to analysed the data. The mean score rank was used because it was the most widely used (Chan et al., 2016) and acceptable at the researcher's level of research.

FINDINGS AND DISCUSSION

Table 1 presents findings on the financial implications which motivate implementation of H&S in work environment. The associated costs of medical treatment of injured employees ranked the highest with Mean = 4.62. Medical treatment and compensation of injured employees can be expensive and may result in financial loss (Ibarrondo-Davila et al., 2015). It is indeed better to allocate and plan for H&S performance by sufficiently investing in implementation practices than to have to pay for medical expenses as a result of occurrence of accidents and injuries (Lopez-Alonso et al., 2012). The implication of this finding are that the construction companies sampled are concerned about medical treatment costs, as they are linked to the insurance they pay as well, for compensation. Workers' compensation costs in the construction industry are a significant cost element and they may exceed 50% of base labour costs (in some cases) (Byreddy, 2018). Implementation of H&S practices such as audits and training programs to help to reduce the rate of occurrence of accidents is therefore desirable.

The costs of cleaning the sites after the accidents ranked second, with Mean = 4.16. This finding is consistent with the views expressed in van Heerden et al. (2018) which stated that the cost of cleaning up the site after the occurrence of an accident is a motivator for implementation of H&S practices. Safety measures like tidying up (house-keeping) after operations or use of tools and equipment is cheaper than cleaning up after an accident (Chi-Ping, 2007).

The third-ranked factor was replacement of the damaged materials and injured workers after the occurrence of accidents with a Mean = 4.00. This seemed to be deemed important because the cost for the repair and/or replacement of any damaged equipment or materials must be absorbed and organisations bear the brunt of it, as well as training new employees to replace injured workers after an accident (Farooqui et al., 2008).

These findings further align with the views expressed in Waehrer et al., (2008), which showed that a cost model of fatal and non-fatal injuries included direct medical costs, indirect losses in

wages and household productivity as well as an estimate of the quality of life costs due to injury. This underscores the need for a continuous attention to costs associated with accidents in order to emphasise the importance of H&S implementation in the construction industry.

Table 1: Result on financial implication variables

S/No.	Variables	Mean	Standard deviation	Rank
1	The associated costs with medical treatment of injured employees	4.62	0.277	1
2	Cost of cleaning the sites after the accidents	4.16	0.193	3
3	Cost of replacing damaged materials and injured workers after an accident	4.00	0.188	4
4	Cost incurred due to personal compensation of employees injured from the accidents	3.88	0.187	5
5	Loss of production after an accident	3.88	0.187	6
6	Cost overruns on projects	3.82	0.199	7
7	The cost of penalties and fines due to non-compliance to safety regulations	3.58	0.201	8
8	The cost of the insurance claims that result from	2.96	0.099	9

CONCLUSION

The study set out to identify the financial implications of non-implementation of H&S practices, which in turn motivate or drive construction organisation to implement in order to achieve desired Hand performance improvement. The objective of the study has been met. The study identified that the associated cost of medical treatment, cost of cleaning up sites after an accident, and cost of replacing damaged materials and recruiting new workers were the top motivators for implementing H&S practices in the sampled organisation.

Thus, in essence, organisations should allocate sufficient amounts to cater for H&S performance in terms of prevention rather than waiting to react and then end up spending more after the occurrence of an accident. This will go a long way in improving H&S performance and reducing or eliminating the costs associated with non-implementation of H&S practices.

The limitations of the study, having been conducted in one province of South Africa, precludes a generalisation of the findings to construction organisations in other geographical areas. In addition, the list is not exhaustive. Further studies could include more factors and employ more rigorous methods to conduct a similar study.

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EMPLOYEES MOTIVATION: A DIAGNOSIS ABOUT PEOPLE MANAGEMENT IN THE CONSTRUCTION SECTOR

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The construction industry has great impact on the social aspect of Brazil, as it is responsible for the generation of almost 10% of the current working class jobs. Additionally, the construction companies have to be continuously competitive in the market. Engaged human capital stands out as a differential in works with increasingly lean teams and ever-shorter deadlines. However, human resource management in this sector still needs improvement. The present work aims to elaborate a diagnosis about people management in a construction site, focusing on the motivation of employees. The study identified the main needs and opinions of employees within the work environment, as well as related good management practices, through a survey conducted among workers of the production team at a construction site in the city of Salvador. Data were analyzed from the basic pillars of organizational people management (remuneration, leadership, work environment and safety), taking into account the organizational characteristics of the sector (employee profile, high turnover, civil engineer as leader and outsourcing services). The results show that employees' main desires range from purely monetary stimulus to topics that do not need direct investments such as recognition and job growth opportunities.

Keywords: People Management, Construction Sites, Employees Motivation.

INTRODUCTION

Construction is a complex industry, which has interconnection with other industries. Due to this, the construction industry is one of the most responsible for the generation of jobs in Brazil, directly or indirectly. According to IBGE (2016), the construction sector is responsible for 8,96% of the employed people in Brazil. Thus, this sector has an important social role in the national context, since it offers the means of living for a large part of society, especially the less favored groups that comprise the base of the social pyramid of this country.

On the other hand, the construction sector has suffered since 2014 with a strong economic crisis established in the country, drastically reducing the opportunities for capital generation and the supply of works. Challenged with this difficult situation, competitiveness has been increasing every day, facing the ever more demanding consumer market and the number of companies struggling for even more scarce business opportunities. This scenario, combined with the Brazilian economic situation and its small prospect of improvement, requires companies to

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reduce even more their costs, to decrease their work teams, to reduce deadlines and to maintain the quality of their products in order to survive in this competitive market.

In addition to these factors, there are great difficulties in the people management sector in construction. Workers in the construction sector tend to have low professional qualifications, usually work in environments with serious problems related to environmental conditions, safety, leadership and lack of training, and tend to be hired temporary due to characteristic of this type of industry (Morais and Souza Junior, 2011; Schmidt, 2011). Studies show that the major problems encountered in construction are related to the lack of appropriate management methods and the lack of skilled labor (Barreiros *et al*, 2014).

In view of this, there is a need for leaders and the Human Resources sector to create a management system that focuses on worker well-being so that employees remain motivated to perform their tasks. According to Casado (2002), motivation has been seen as a way to improve productivity, organizational health, and satisfaction of employee. Robbins (2003) defines work motivation as the enthusiasm of the worker to apply important effort toward organizational goals, while seeking to meet some individual needs.

In this way, the objective of this research is to do a diagnosis of the people management system of a civil workconstruction site, focusing on the motivation of the employees, in order to identify their needs and opinions, as well as related good management practices. The aim is to understand, from a real context, how it is possible to improve the working conditions of the construction worker, including how to deal with them in the day to day, so that he/she feels increasingly motivated, and considered as an essential part of the organizational environment in question.

It is hoped that the results obtained will contribute to the dissemination and application of good practices of people management among the companies of the sector, in order to bring greater well-being to the employees of the construction sites and, consequently, greater engagement and disposal of them to contribute with the companies' goals and dreams.

MANAGEMENT AND MOTIVATION OF PEOPLE IN THE CONSTRUCTION INDUSTRY

Kanungo (1979), cited in Mafini and Dlodlo (2014) divides the theory of motivation in intrinsic motivation (e.g. recognition, responsibility, autonomy, ability utilisation, etc.) and extrinsic motivation (e.g. remuneration, working conditions, promotion, prestige, etc.), linking these factors to job satisfaction and dissatisfaction. Hennessey and Amabile (2005), on the other hand, also indicates that the intrinsic factors are in fact motivators whereas the extrinsic factors, related to hygiene, are essentials and do not necessarily produce motivation to the workers.

The motivation of construction workers, however, is associated with basic aspects such as: minimum conditions of cleaning, acceptable limits of safety, food and social life inside the construction site, and even situations that lead to greater autonomy for workers, challenges, the understanding of the human problems of each one, and the opportunities for professional growth, under conditions of positive supervision and leadership (Heineck, 1997).

Besides, Mafini and Dlodlo (2014) indicate statistically significant relationships between job satisfaction and four extrinsic motivation factors: remuneration, quality of work life,

supervision and teamwork.

Although, the reality of most construction companies in today's market is the lack of concern about people management and retention. For most of them, this management consists only in the selection and hiring of employees with the maximum possible experience, leaving behind fundamental tools, such as training and development of employees (Oliveira, 2007).

A study by Tavares (2012) showed that most of the conflicts related to People Management in the construction industry are related to the relationship between the engineer and employees. The communication between leaders and leaders is present as an origin of many problems: divergence of opinions in technical procedures, leader's neglect of workers' rights (like orders at lunchtime or abuse of working hours) and an authoritarian way to deal with employees.

The relationship conflicts between employees and managers are also highlighted as a reason for employee dissatisfaction due to low salaries, insufficient benefits, absence of career plans and poor working conditions. In addition, there is a divergence between managers and employees with respect to values, personal expectations and forms of motivation that hinder the harmony between the two parties. Another relevant conflict in the analysis was the cultural one: the great difficulty of part of employees to assimilate and internalize concepts and procedures due to their low qualification and educational level. Finally, the behavioral conflict was presented: noncompliance of orders by employees, aggressive reactions on the part of the worker in situations of divergence, inadequate and authoritarian attitude on the part of the leader (Tavares, 2012).

METHODOLOGY

The present study comprises an exploratory research, focusing on a case study, in which qualitative and quantitative results were served as a basis for obtaining a diagnosis of the people management system (PMS) of the evaluated work.

Initially, we identified in bibliography the main theories and good practices on people management for human motivation and labor productivity improvement for construction sites. As a result, a tool (questionnaire) was developed supporting the elaboration of a diagnosis of the PMS of a construction site, based on the employees' perception of existing or non-existent motivational practices in the organization.

The questionnaire comprised 3 parts. The first part (Part A) consisted of basic questions to characterize the interviewee (company, position, age, schooling, and number of children). The second part (Part B) consisted of 22 multiple choice questions (I agree, I partially agree, I disagree) to identify the interviewee's perception of the main pillars of the people management system (company vision, leadership, work vision, development, safety and work environment), and finally, the third part (Part C), where the interviewee should signal their opinion against a set of 10 good practices for motivation in the work, indicating which they consider more important / interesting. The good practices were: P1: Larger Fixed Salary; P2: Variable Salary (The more you produce more gain); P3: Fixed Benefits (e.g. Medical Assistance, Dental Plan, Transportation Voucher, ...); P4: Punctual Benefits (e.g. Thirteenth and Fourteenth Salary, Christmas Basket); P5: Benefits for employees with children (e.g. Day Care, School Supplies, ...); P6: Opportunity for Growth within the Company; P7: Recognition for good work; P8: Participation in decision-making; P9: Training for professional development; and P10:

Reduced working hours for a better quality of life.

The questionnaire was used to support structured interviews applied in part of the operational team of a construction site located in the city of Salvador. The work site in question was chosen for its representativeness in relation to the construction sites of small and medium-sized companies in the region.

It was applied in two visits to the worksite adding a total of 26 employees questioned. The criterion of employee choice was to try to accommodate as many different roles and profiles as possible to get a diversified sample. The employees of the house were prioritized to the detriment of outsourced workers since it is understood that these employees are directly influenced by the outsourced company's PMS. In total, the research interviewed 7 outsourced workers and 19 employees of the house occupying the following positions: stockman, carpenter, manager, foreman, painter, practical, security, servant and technician.

Initially, the results obtained in Part B of the questionnaire were analyzed, to identify the employee perception about the work PMS. It was considered that when marking the "I agree" alternative of Part B questions, the employee showed 100% satisfaction / motivation with the PMS of his/her work environment. By ticking "I agree", the employee showed 50% satisfaction / motivation. Finally, when marking the "I disagree" alternative, the employee showed 0% satisfaction / motivation. Thus, it was possible to obtain quantitative results for each of the employees' answers for further analysis and comparison.

In a second place, the Satisfaction / Motivation Degree was analyzed by interviewed profile (Part A of the questionnaire). The results were analyzed considering the relation of the interviewed with the company (hired or outsourced), their function in work site, their age and their family situation. Then, the results were analyzed per pillar (company vision, leadership, work vision, development, safety and work environment).

Finally, the results of Part C of the questionnaire were analyzed to identify the main wishes and needs of interviewed in order to achieve a greater engagement with their work environment.

RESULTS ANALYSIS

Table 1: Diagnosis results

INTERVIEWED	MULTIPLE QUESTIONS (PART B)																						MOTIVATION GRADE
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	
1	50%	100%	100%	50%	50%	100%	50%	100%	100%	100%	50%	50%	100%	50%	100%	50%	100%	100%	50%	50%	50%	100%	75%
2	0%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	50%	50%	50%	0%	100%	80%
3	100%	50%	0%	100%	100%	100%	100%	0%	100%	0%	100%	100%	0%	0%	0%	100%	100%	0%	0%	50%	100%	55%	
4	100%	50%	100%	100%	100%	0%	100%	100%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	0%	100%	82%
5	100%	100%	0%	50%	0%	100%	100%	100%	0%	100%	0%	100%	100%	100%	50%	50%	100%	100%	100%	100%	100%	100%	75%
6	100%	100%	50%	0%	100%	50%	0%	50%	100%	100%	100%	50%	100%	50%	100%	50%	0%	50%	50%	50%	50%	100%	64%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	50%	100%	0%	0%	50%	50%	50%	0%	16%
8	100%	50%	50%	50%	50%	100%	100%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%	100%	50%	0%	50%	77%
9	100%	0%	0%	50%	100%	100%	100%	0%	100%	100%	0%	0%	100%	100%	100%	100%	100%	0%	50%	50%	50%	100%	64%
10	50%	0%	0%	50%	100%	50%	100%	50%	100%	100%	100%	100%	0%	100%	100%	100%	50%	0%	100%	50%	100%	68%	
11	100%	100%	100%	100%	50%	100%	100%	100%	50%	0%	50%	0%	50%	50%	0%	100%	100%	0%	50%	100%	50%	0%	61%
12	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	98%
13	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	0%	100%	91%
14	100%	50%	100%	100%	100%	50%	100%	100%	50%	100%	100%	100%	0%	100%	100%	100%	100%	100%	50%	0%	0%	100%	77%
15	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	100%	93%
16	50%	100%	100%	50%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	50%	89%
17	100%	50%	100%	100%	0%	50%	100%	0%	100%	50%	100%	100%	100%	50%	50%	100%	50%	100%	50%	50%	50%	100%	70%
18	100%	100%	50%	100%	100%	100%	50%	100%	50%	100%	50%	100%	100%	100%	100%	50%	100%	50%	50%	50%	0%	100%	77%
19	100%	50%	100%	100%	100%	100%	100%	50%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	50%	0%	0%	100%	82%
20	50%	50%	50%	50%	0%	50%	50%	100%	100%	100%	100%	100%	0%	50%	100%	100%	100%	100%	50%	50%	100%	50%	68%
21	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	50%	100%	100%	100%	100%	50%	100%	0%	100%	89%
22	100%	50%	100%	100%	100%	50%	50%	100%	100%	100%	0%	100%	100%	50%	100%	50%	100%	50%	50%	50%	50%	100%	77%
23	100%	0%	100%	50%	100%	0%	0%	0%	0%	100%	50%	100%	100%	0%	50%	50%	0%	50%	0%	0%	0%	0%	39%
24	100%	0%	100%	0%	0%	100%	0%	100%	100%	100%	100%	0%	100%	100%	100%	100%	0%	100%	100%	0%	100%	100%	68%
25	100%	0%	0%	100%	0%	0%	100%	50%	100%	50%	50%	100%	0%	50%	100%	50%	100%	50%	100%	100%	0%	50%	57%
26	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	50%	50%	50%	50%	50%	84%
TOTALS	85%	60%	65%	73%	71%	73%	73%	75%	77%	85%	71%	83%	77%	62%	87%	81%	81%	77%	58%	60%	37%	79%	72%

Table 1 presents the Degree of Satisfaction / Motivation obtained for the total sample and per employee. Only 2 employees have satisfaction / motivation below 50%. Approximately 31% of respondents had a satisfaction / motivation level between 50% and 75%, while the majority of interviewees (about 58%) had a satisfaction / motivation level equal to or greater than 75%. The work analyzed resulted in an Overall Satisfaction / Motivation Level of 72%. There is a relatively favorable general motivation, despite the difficult working conditions of a work environment such as a construction site.

Some external factors may have influenced this result, such as the current economic situation of the construction sector, which currently suffers from a shortage of works and job opportunities, making the individual who finds himself a job feels privileged about a general context of lack of employment. Considering that Chiavenato (2003) indicates that the individual's motivation is related to the persistent tension that leads him to satisfy one or more needs, the motivation, in this case, arising from the need to continue employed.

Figure 1 shows the Satisfaction / Motivation Degree by their relation of the interviewed with the company (hired or outsourced), by their function in work site, by their age and by their family situation.

It is observed that the Satisfaction / Motivation Degree of the company employees is considerably superior to the outsourced ones. This result may indicate a difference between the human resources policy of the construction company and of the outsourced company. Even if the contracting company seeks to integrate as closely as possible the outsourced individual into the organizational environment, the outsourced employee can feel a "visitor" in his/her own work environment. And this feeling of not belonging to the general context in which one works is potentially discouraging for the collaborator.

The Satisfaction / Motivation Degree of older employees (over 45 years) and/or employees with children also tends to be higher. This result suggests that these kinds of employees have a greater sense of responsibility and commitment because of his/her necessity to support itself and family.

In relation to the function, the worst degrees of satisfaction / motivation were identified for the stockman, servant, manager, painter and security. The majority of these functions needs low qualification and responsible for auxiliary activities with little or no specialization and technical rigor. In addition, this type of manual labor can often be physically degrading and without a well-defined scope. Taking the servant as an example, this individual ends up performing tasks ranging from cleaning to construction.

Figure 2 shows the Degree of Satisfaction / Motivation per pillar. It can be seen that the most critical pillar of the PMS in the work studied was the Work Environment (only 58% of Average Satisfaction / Motivation Degree). This result corroborates Barros (2014) that states that, despite all the technological advances of the sector, the construction industry has yet to solve a chronic problem: poor working conditions. When entering the detail results of the questions related to this pillar, it is noticed that the employee is not satisfied with regard to their working conditions, from their physical dependencies to the basic services offered, feeding in special. Added to this, the employee does not consider the work environment-friendly and human, in which there are celebrations and special events. These results corroborate Santana (2012) that indicates that construction industry of Salvador suffers the lack of adequate places to eat and to prepare the food, resulting in the absence of taste in food and lack of different options of meals.

The pillar of Company Vision should also be observed (Average Satisfaction / Motivation Level of 70%). The responses related to this pillar indicate that although the employee is proud to work in the company, this is not enough for him to create an identity and loyalty to it, since most interviewed workers signaled that he would not be in the Company if he got another opportunity with better remuneration. These results may demonstrate a tendency for employees to still see the Company only as a source of temporary survival, not as a place where they can pursue new challenges and professional growth. In addition, employees also indicated that they do not feel valued and recognized in their work environment, which ratifies and reinforces their lack of ties with the Company.

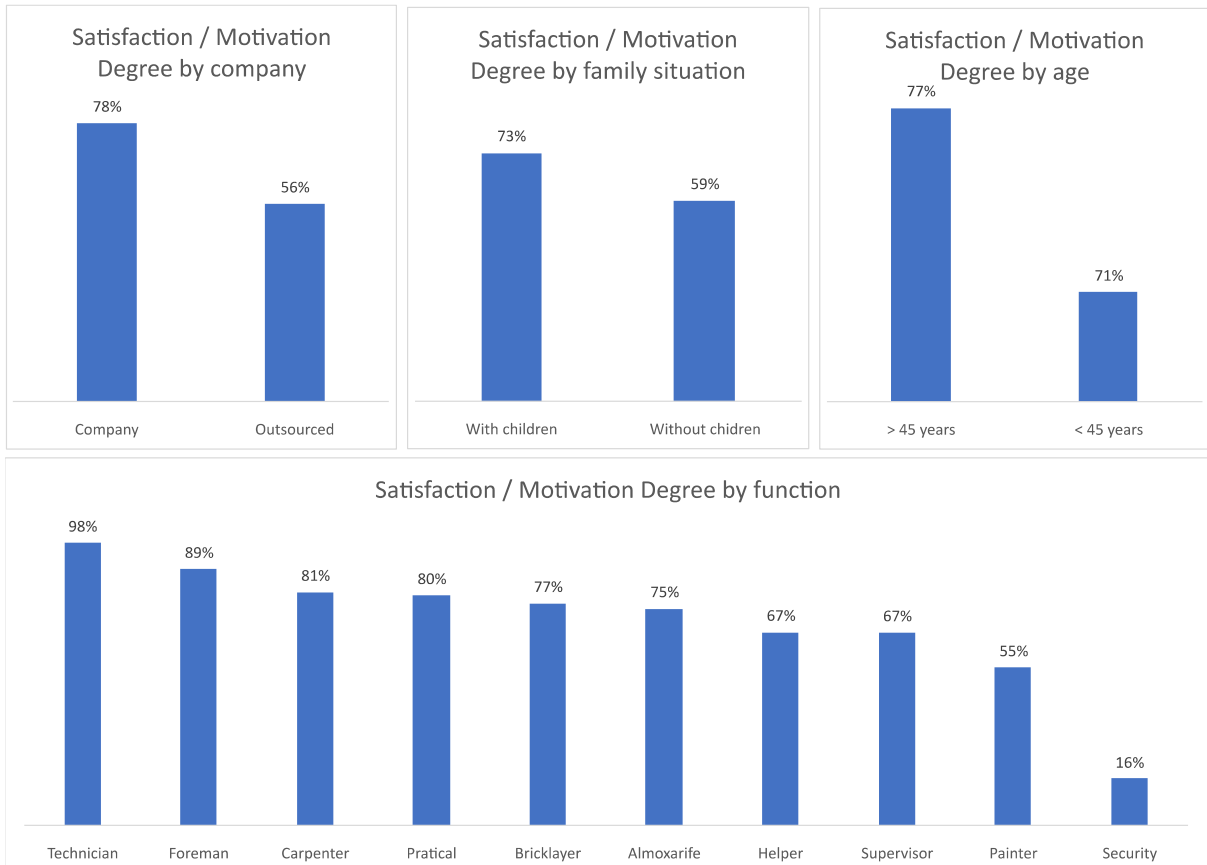


Figure 1: Satisfaction / Motivation Degree of workers by specific situations

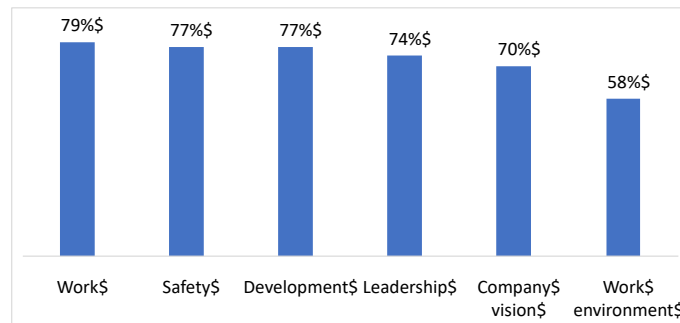


Figure 2: Satisfaction / Motivation Degree of workers per pillar

Finally, the interviewees were asked to signal their opinion regarding a set of 10 good practices for motivation at work, indicating which ones are considered more important / interesting. The following 5 proposals were the most voted:

- P1: Larger Fixed Salary
- P2: Variable Salary (The more you produce more gain)
- P3: Fixed Benefits (e.g. Medical Assistance, Dental Plan, Transportation Voucher, ...)
- P6: Opportunity for Growth within the Company
- P7: Recognition when I do a good job

The first three most voted proposals stand out because they are directly linked to the

remuneration of employees. This result corroborates Tavares (2012), which indicates as main reasons for the conflicts between employees and managers the employees' dissatisfaction with their salaries, insufficient benefits and absence of a career plan. By analyzing in detail each of the three first most voted proposals (P1, P2 and P3), it is possible to conclude that the employees seek a greater direct financial return (result obtained with P1 and P2) and a company support for health insurance (result obtained with P3). Therefore, providing the minimum medical care to employees can be a good tool for them to feel more secure and cared for in their work environment. It is also important to highlight the interest of employees in a variable remuneration system (result obtained with P2). This result demonstrates a tendency for employees to no longer be satisfied with the classic pay model of a fixed salary with sporadic "premium hours". It is necessary to implement a mixed remuneration model: a fixed part and a variable part according to their productivity. That way, employees will have a financial boost for their productivity and will be rewarded for it.

On the other hand, the alternatives P6 and P7 show that employees not only have financial yearnings that generate a direct return but also need for esteem and approval that do not generate financial investments. The votes in P6 indicate that the employees look for professional ascension. It is important to take advantage of this ambition of the employees creating a system of promotion of the best workers as a way to motivate them and to extract the best of their productivity. It is also noted that employees seek better recognition for their activities (P7). According to Hertel (2002), as employees feel listened to and recognized, they automatically create a genuine interest in work and a sense of importance in the business.

CONCLUSIONS

It is observed that construction workers would benefit from an integrated and participative management system that aims the well-being and health of employees, making them feel engaged and motivated to reach the goals of the company allied with their personal goals.

The results indicated that:

- The construction workers were more sensitive to extrinsic motivation than to intrinsic motivation.
- Employees' needs are majorly related compensation, benefits, and stability.
- A critical employee profile, which is certainly a potential for lack of motivation and low productivity, is outsourced employees, with no children, less technical posts, and under 45 years of age. This kind of employees deserves double focus and a greater focus on the part of its managers.
- The main aspects of PMS that need to be improved at a construction site are: work environment, recognition, worker health, pay model and growth opportunities.
- Employee's main wishes range from purely monetary stimulus to topics that do not generate a direct financial return to them.

Thus, it is necessary to set up a set of good practices focusing on the points of greatest criticality and the opportunity to improve well-being: remuneration, recognition, safety, work environment and development. It can be seen that basic management tools that do not produce significant additional cost to the company can considerably increase the degree of employee satisfaction / motivation.

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GENERATIONAL MOTIVATION PREFERENCES AMONGST CONSTRUCTION OPERATIVES IN WESTERN CANADA

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Motivation is a critical aspect of employee wellbeing. If an organisation can keep their employees motivated it will maintain a healthy cooperative environment. Employee motivation studies tends to categories respondents according to role and job position, but very little research has considered the issue of age and motivation. Currently, there is no known research studying this phenomenon in relation to the construction industry and only a handful of generational research studies in white-collar industries. This research study set out to determine if generational differences in motivation exists in construction operatives in Western Canada. The motivational study was based around Self-Determination Theory a relatively modern approach to motivation (viewing it in the context of autonomous and controlled motivation). Through a survey of ninety eight respondents, drawn from an open trade union that provides operatives to general contractors in Western Canada, motivational and managerial preferences were assessed for each generation along with other demographical grouping. The results revealed there were only minor motivational differences between generations. The operative's self-determined motivation was relatively homogeneous between generations. The primary difference between generations were their preferences to management practices. Generation Y [aged 16 to 35] were less satisfied with their relationship with their supervisor and felt their supervisor was less effective compared to other cohorts. This paper will discuss the implications of these findings in respect to the construction industry's drive to improve productivity.

Keywords: Generations, Motivation, Operatives, Communication, Canada

INTRODUCTION

Productivity in Alberta's construction industry has been declining over several years (Jergeas, 2009); a trend also seen internationally (Merrow, 2011). An Alberta based survey of industry professionals identified 'labour management, conditional and relations' as the top area concerning construction productivity improvement (Jergeas, 2009). While labour management has been identified as a top issue, little emphasis has been placed on evaluating worker motivation to identify areas that could improve performance.

Improved motivation is linked to improved worker performance. The primary objective of this

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research was to identify the motivational preferences of the construction operatives. This objective was achieved through identifying how preferences change with a worker's generation, along with how different generations react to current management practices. Research was focused on the three generations currently in the workforce: Baby Boomers (1944-1960), Generation X (1961-1980) and Generation Y (1981-2000) (Arsenault, 2004; Twenge and Campbell, 2008). With motivational preferences identified, strategies developed within current literature can be evaluated to identify which are best applied to improve performance of the craft workforce.

LITERATURE REVIEW

Latham and Pinder (2005) defined motivation as the process that determines how energy is used to satisfy needs. In a work setting, better motivated employees tend to be more productive. In the majority of literature, motivation has typically been divided into two broad categories; intrinsic and extrinsic motivators (Cerasoli, Nicklin and Ford, 2014; Chang, 2003; Chuang, Dean and Dellmann-Jenkins, 2009). Intrinsic motivators come from an individual's inherent interest or enjoyment from performing a task while extrinsic motivators come from the use of external rewards or to avoid punishment (Gagne, 2014).

Most jobs require employees to perform tasks they are not intrinsically motivated to do. To improve performance there is an optimum level of motivation than can be achieved through extrinsic means (Chang, 2003). Cerasoli et al. (2014) showed that both intrinsic and extrinsic factors can simultaneously contribute to performance, but have different levels of contribution dependant on the task. Extrinsic incentives have shown improved performance for straightforward and repetitive tasks, while intrinsic factors improved performance for more complex tasks.

A more modern approach to motivational theory is the work focused around Self-Determination Theory (SDT) (Gagné and Deci, 2005; Gillet et al., 2013; Gagne, 2014). SDT is different from other motivational theories because of its focus on autonomous and controlled motivation (Gagné and Deci, 2005; Gagne, 2014) compared to the focus on extrinsic and intrinsic motivation utilised in other works (Cerasoli, Nicklin and Ford, 2014; Chang, 2003; Chuang, Dean and Dellmann-Jenkins, 2009).

Autonomous motivation refers to behaviour related to a full sense of volition, willingness, and choice, while controlled motivation refers to a sense of pressure and obligation (Gagne, 2014). SDT has a third category referred to as amotivation, or the lack of motivation. Autonomous motivation can be induced through intrinsic and extrinsic motivators while controlled motivation comes only from extrinsic motivators. Differentiating the amount of autonomous motivation induced through extrinsic motivators, SDT separates it into four categories: External, Introjected, Identified and Integrated regulation.

It is hypothesised that generations share specific attributes and values influenced by the media, popular culture, along with critical economic and social events shared by each cohort (Twenge et al., 2010; Arsenault, 2004; Smola and Sutton, 2002). Arsenault (2004), Twenge and Campbell (2008) and other researchers studying generational differences have categorised four cohorts, the years for each cohort can vary, but for this research the cohort years are as follows; Veterans (1922-1943), Baby Boomers (1944-1960), Generation X (1961-1980), and Generation Y (1981-2000).

The research on generational differences in motivation shows a trend of each successive generation having a greater preference for extrinsic motivators than the last (Dokadia, Rai and Chawla, 2015; Ng, Schweitzer and Lyons, 2010; Smola and Sutton, 2002; Twenge and Campbell, 2008). Comparisons within the construction industry have shown professionals prefer intrinsic rewards, unskilled labour preferring extrinsic rewards and tradespeople a mix of both intrinsic and extrinsic rewards (Asad and Dainty, 2005).

The management styles currently utilised by construction firms could also be very influential on younger trades peoples' motivation. There is a potential challenge, related to older trades peoples' management styles being utilised on the younger workforce; similar to the friction caused when the workers' values don't align with the company's (Twenge et al., 2010). This can be a result of Generation Y's preference for individual work (Dokadia, Rai and Chawla, 2015; Ng, Schweitzer and Lyons, 2010) and the differences in preferred leadership traits (Arsenault, 2004) creating a misalignment between Generation Y and the management styles currently being used to manage tradespeople.

Gaining an understating on how generational differences affect motivation in constructions is one small step in understanding how to provide a better work environment for construction operatives and improve workers' performance.

METHODOLOGY

This research has taken an explanatory approach (Fellows and Lui, 2015) to identify if there are generational differences in motivation within the Western Canada's construction industry. Data collection utilised a positivistic approach, with the distribution of an online questionnaire. An interpretive approach was utilised, interviewing construction professionals to provide further clarity to the results observed from the questionnaire. Due to the surveys limited response, an interpretive approach was also used to extrapolate the questionnaire's results as they can not be statistically applied to the general population.

STD was utilised as the framework for this study for it's additional categories defining extrinsic motivation. The study aimed at evaluating two hypotheses'.

Hypothesis 1 – Generation Y has higher controlled motivation compared to Generation X and Baby Boomers.

Hypothesis 2 – Baby Boomers and Generation X will have higher satisfaction from current management practices than Generation Y.

A survey was selected as the primary method of data collection to obtain information from a broad audience. The survey was separated into three sections. The first section was designed to establish the respondent's orientation to each respective motivation type within SDT. This section of the survey was based on Tremblay et al. (2009) "Work Extrinsic and Intrinsic Motivation Scale (WEIMS)". Questions utilised were verbatim from Tremblay et al. (2009) study including the randomised order of the questions.

Responses were recorded on a seven-point Likert scale; seven represented the statement corresponded exactly with why a respondent was currently involved in their work, and a response of one meant the statement did not correspond at all. Questions were randomised so that statements related to the same motivational type were not clustered together.

RESEARCH RESULTS

The survey was completed by tradespeople represented by CLAC labour union. The survey was submitted to 5000 members through the union's communications department in which a total of 98 individuals participated with 84 surveys were completed fully to be used for the analysis. The response rate was 2.0% and completed surveys response rate was 1.7%. Out of the 84 participants, 81 were male, two were female and one preferred not to select a response. 96% of respondents identified their nationality as Canadian. The age of the respondents ranged from under 21 to over 55. Due to the limited response rate, trends observed from within the participants of the survey may not be representative of the general population.

WEIMS Survey Results

Generation Y showed a higher mean W-SDI than Generation X and lower mean than the Baby Boomers. The higher W-SDI represents an increase in autonomous motivation. Within the test group, the descriptive statistics do not support this hypothesis, as Generation Y showed a higher average autonomous motivation than Generation X. The t-Test also shows that the differences observed are not statistically significant between any generation.

The only significant difference observed came from comparing external regulation of Generation Y to both Generation X and Baby Boomers. Generation Y's mean external regulation was 4.64, with Generation X and Baby Boomers at 5.18 and 5.42 respectively. Both Generation X and Baby Boomers show higher extrinsic regulation than Generation Y.

A second comparison was performed by grouping respondent by age in ten-year increments; 30 and under, 31-40, 41-50, 51 and older. Similar trends were shared with the generational comparison. There was no significant difference in W-SDI or any uniform increase or decrease of the means for any motivational sub-category.

When comparing motivation by generation the data does not support the hypothesis that younger generations are more extrinsically orientated. The results show there is not a statistical difference in W-SDI between generation or age groups.

Management Satisfaction Results

The overall results show most workers are relatively satisfied working in the trades. The management satisfaction section on the survey was aimed at answering the second hypothesis; Baby Boomers and Generation X will have higher satisfaction from current management practices than Generation Y.

Results from the survey support this hypothesis. Generation Y was less satisfied in their relationship with their supervisor (Q2). There is over a full point difference compared to Generation X and Baby Boomers, 3.89 to 5.23 and 3.89 to 4.94 respectively. Generation Y also feel that their supervisors are less effective when compared to Generation X (Q3) and they feel their work environment is less effective compared to Baby Boomers (Q4). When comparing age groups, 30 and under groups rated Q2, Q3 and Q4 over a full point lower than all other age groups. Showing a divide in the level of workplace satisfaction for the youngest operatives within the workforce.

Open Response Results

The final section was the open response that allowed the respondents to use their own words to write about what motivated them to start a career in the trades and what motivates them to stay in the trades. Out of the 84 completed surveys, 70 answered the optional extended response questions. These responses were generalised into three categories; Autonomous, Controlled and Mixed.

The chi-square test was applied to each group. For the generations analysis H_0 = Motivation Type is independent of generation and H_1 = Generation impacts motivation type. For each question chi-square test resulted in 0.92 and 0.45 respectively. Both values are greater than the significance level of 0.1, H_0 is accepted, generation does not affect motivation type for the open response questions.

Interviews

Five interviews were performed with construction professionals. Opinions were split on whether a person's motivation is related to their generation. Most felt differences were more related to experience and life stages over a specific generation.

There was a consensus between interviewees on the changing management styles over the years. While some individuals still use the older, more directive-based management styles with their crews, closer to McGregor's (2000) Theory X. A transition within the industry has occurred, to a more collaborative based approach to manage the craft workforce, moving closer to McGregor's Theory Y.

In general, interviewees felt the softer management approach has been equally effective across generations. But younger generations have been observed to react poorly when more direct approaches are utilised. This aligning with Uwakweh (2006) and Twenge and Campbell's (2008) research. Engagement was suggested as a possible reason why there is a difference in the management satisfaction for Generation Y workers.

When discussing the challenges in motivating and managing the younger workforce the same themes were repeated by the interviewees; keeping them engaged, keeping them involved, keeping them interested.

DISCUSSION

The focus of this study was to understand if generational differences impact motivation of the craft workforce. The proposal for hypothesis one, was not supported. This study showed, when comparing generations, Generation X had higher external regulation, linked to higher controlled motivation, than Generation Y. There are few possibilities why this study's findings do not align with past research.

1. The lens the research was focused through. Focusing on SDT and controlled and autonomous motivation, results can not be directly correlated to studies using other theoretical frameworks.
2. The craft workforce's higher extrinsic preferences compared to managerial jobs (Asad and Dainty, 2005). There is a potential saturation effect, where the external or controlled motivation levels are already at their highest point, negating the generational effects observed in different industries.

3. Respondents were primarily employed at 'out-of-town' projects; this could add to the saturation of extrinsic motivation. 'Out-of-town' workers had higher external regulation than 'in-town' workers (5.14 to 4.30 respectively).

While the saturation of extrinsic motivation is a plausible explanation for the differences seen, the focus of this discussion will be on how SDT framework gives a unique value to this study.

Research focused on extrinsic and intrinsic motivation may have led to what is observed as generational differences in motivation. SDT identifies a different aspect of motivation through the spectrum of controlled to autonomous motivation, which may not be affected by a person's generation. Further research is required to confirm this.

What is being perceived as lack of motivation within younger generations, isn't supported by this research in terms of SDT. Extrapolating from the management satisfaction survey results, it is proposed that there is a lack of engagement with the youngest generation. Supervisors identifying performance issues as motivational issues may not be addressing the root cause of performance problems. Similar to Real et al. (2010) findings, the stereotypes perpetuated in common culture about Generation Y give supervisors a simple reason to why younger workers are not performing to their expectations.

The second hypothesis, was supported through the management satisfaction section of the survey. Showing Generation Y is less satisfied with their relationships with their supervisors. They feel their supervisors are less effective compared to Generation X and Baby Boomers and feel their work environment is less effective when compared to Baby Boomers. A contributing factor to this lack of engagement is likely related to the misalignment of workers' values compared to their supervisor (Twenge et al., 2010) and the use of rewards that don't help motivate the workforce (Uwakweh, 2006).

Uwakweh's (2006) study supports the use of expectancy theory recommending that apprentices' performance would benefit from incentives such as challenging tasks with clear and achievable expectations, involvement in the planning of the work, along with praise and encouragement. The recommendations in the study align with Generation Y's desire for involvement, challenge with ambiguity and desire for frequent praise. Employers need to evaluate what behaviours they want to encourage and ensure their reward systems reflect this.

Related to changing values, a potential issue with engagement is how worksites communicate information. As highlighted in the interviews, management styles have changed over the years, becoming more inclusive, and better tailored for the younger generation. The challenge comes from supervision utilising the same communication approach for all their workers. There is a potential issue related to how younger workers receive and interpret the messages depending on the medium used.

Outside of construction, how individuals communicate and receive information has dramatically changed over a single generation, with computers, cell phones and social media. Construction is still primarily using verbal directions with the occasional drawing or specification. This method has worked for Generation X, Baby Boomers and a segment of Generation Y but may not be the most effective method to communicate with the youngest within the workforce.

Younger workers from Generation Y have spent their entire lives in a digital age; emails, texts

and instant access to a world of information. Younger workers may not be as adept or comfortable with receiving verbal instructions with limited information. Generation Y's desire for shared information and use of digital media (Myers and Sadaghiani, 2010) impacts the effectiveness of verbal communication used, impacting the workers' level of engagement.

In addition to the challenges of tailoring how a company communicates with its workers, the construction industry has limited tools it can employ to improve engagement. Tools employed by other industries, such as flexible working hours, individual work, or working from home (Dokadia, Rai and Chawla, 2015) can't be utilised due to the nature of the work. Managers need to look at other options to improve engagement.

How supervisors, and higher level management, communicate with the craft workforce is a simple option to improve engagement (Jung, Westerman and Walden, 2017), but comes with the challenge of changing the style of interaction that has been utilised for decades. As communication is a broad topic there are three main areas that should be focused on to best improve the relationship between Generation Y and their supervisors and in turn, their engagement.

1. Supplementing verbal communication with the use of communication and information technologies (CITs). Improve Generation Y's engagement through their affinity for digital media (Myers and Sadaghiani, 2010).
2. Increasing the level of information communicated. Providing a broader level of information to complement the day to day directions could help feed Generation Y's desire for shared information (Jung, Westerman and Walden, 2017; Myers and Sadaghiani, 2010).
3. Providing appropriate and timely feedback. Ensuring foremen understand Generation Y's need for more frequent praise and sensitivity around negative feedback (Twenge and Campbell, 2008; Uwakweh, 2006) can be beneficial in improving the relationship between a foreman and his crew. Providing a supportive environment is also associated with increased self-determined motivation through autonomy-supportive leadership (Gillet et al., 2013).

Improving autonomous motivation through employee engagement and autonomy-supportive leadership (Güntert, 2015; Olafsen et al., 2015) will help improve the performance of Generation Y, and hopefully narrow the perceived performance differences between generations.

CONCLUSIONS

This research set out to investigate motivational preferences of the craft workforce in Western Canada. There was no statistical difference in motivation between Generation Y and Baby Boomers. Through the lens of SDT, no single generation has monopoly on controlled or autonomous motivation. This is important as performance issues being perceived as a lack of motivation in younger workers are the result of some other factor. A plausible explanation proposed in this research for these performance issues is different levels of engagement between generations on the worksite.

Most companies have limited resources, so efforts should focus on improving engagement of the overall workforce and not one specific demographic. Engagement has been a popular topic within the new millennium (Meyer, 2017), with a wealth of knowledge produced by academics

and practitioners. The challenge is taking the lessons from research primary applied to office settings and applying them to the construction industry. Meyer (2013) identified three drivers to engagement; employee empowerment, work design and leadership. Utilising these drivers, engagement can be improved through increasing the amount of communication, improving work design through technology and improving leadership; in turn, workers autonomous motivation should increase resulting in improved performance.

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CAREER PROGRESSION OF WOMEN IN THE CONSTRUCTION PROFESSION IN PALESTINE

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Gendering is an important issue in construction practice and economic system. This paper explores the career progression of women in the construction profession in the Gaza Strip-Palestine. This study was based on a questionnaire survey distributed to 50 women engineers in the Gaza Strip. The results revealed that the majority of the respondents' women engineers believed that the parent responsibilities have a significant impact on their career progression. The highest priorities of the factors affecting current job satisfaction of women engineers were remuneration package, balance of work and private life. Professional satisfaction-pride in work was considered the most important career goal by women engineers. The respondents suggested that good performance on previous projects, compatibility with office culture, and compatibility with senior management were the key factors upon which career progression is commonly based. Gender and family commitment were considered as the main barriers to career progression by women respondents. Continuing education and training program, which focus on recent development within the construction industry and managerial skills, are recommended. This study is valuable for women career development in order to fully participate and contribute to the development of the construction profession. Qualitative research method in gendering issues is recommended.

Keywords: Women, Career, Progression, Construction, Education.

INTRODUCTION

The construction industry in Palestine is considered a large sector of the economy (Enshassi et al., 2009). It plays a crucial role in extending job opportunities for Palestinian labor force. The Palestinian Central Bureau of Statistics (PCBS) indicated that 21 % of the employed persons in were working in construction. The construction industry contributed in year 2013 by 14.1% of the Palestinians GDP (Enshassi et al., 2013). The sector has played a crucial role in extending job opportunities for Palestinian labor force. It employs about 30% of laborers indirectly in industries related to the construction sector and other services and productive sectors (Enshassi et al., 2015).

Until today the construction industry with its extreme gender stratification is still conservative in its recruitment of women. The majority of women working in the construction industry undertake administrative, technical and professional work while the intake at the operative level is very low and the data are scarce to non-existence, but in most countries these represent

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less than 1% of the workforce (Clarke et al., 2005). Inevitably it can be concluded that construction is not only male-dominated but is devoid of female participation. The percentage of women employed in the construction industry globally is less than 10% (Geerstemar, 2005).

The engineering profession has not been as successful in attracting women as other previously male-dominated fields such as law or medicine (Alexander et al., 2010). While the climate for women in engineering has been slowly changing over the years, lack of encouragement, peer pressure and other factors still act as barriers preventing more women from pursuing a career in this non-traditional field. Some men and women assume that women are incapable of performing in a construction company until they prove themselves to be capable (Geertsema, 2007). The conception is there, for example, that women are unable to supervise men and are unable to combine work and family responsibilities.

The Palestinian Central Bureau of Statistics "PCBS" labor force survey in 2006 showed that women workers were concentrated mainly in the service sector in health care, education, general administration (where 50.3% of the employed women are concentrated). About a third of Palestinian women 32.5% work in the agriculture sector, 8.3% in commerce, 0.6% in transportation, 0.3% in construction, and 8.1% in manufacturing (PCBS, 2006). It is of concern that a significant proportion of all jobs in Palestine are effectively assumed to be earmarked as male territory, because they are within the bounds of construction. This restricts women's chances of equal opportunities within society and the economy as a whole (Enshassi et al., 2008). In Palestine, a scarcity of information exists regarding the role of women engineers in the construction industry. Therefore, this study aims to explore the career progression of women in the construction profession in the Gaza Strip-Palestine

LITERATURE REVIEW

The construction industry is characteristically a male dominated sector in terms of employment at all levels (Haupt and Smallwood, 2004). Recruitment at senior and management levels by construction has been homogeneous, with a marked propensity for companies to attract, recruit and select men. This has led to a demonstrable under-representation of women and minorities (Dainty et al., 2001). While the entry of women into site surveying and construction management is relatively recent, there have always been greater numbers of women at the construction field, but men still comprised the majority. It would seem that women's place was clearly circumscribed as being in the softer part of the construction industry (Greed, 2000).

For women on construction sites, field work has sunk in status and meaning, from being an essential initial ritual to becoming just a dead-end job. Pay and conditions are poor; generally, women's pay is known to be lower than that of equivalent men in construction (Enshassi et al., 2008). The industry remains in denial relative to the status of women within its ranks (Bagilhole, 2002). As a result of the industrialization of economies, it is necessary to integrate women into economic systems through necessary legal and administrative changes. Women have always been part of the development process and economic growth (Enarson, 2004), although not given due recognition for their contribution which is not often as visible as that of their male counterparts. Further, the perception exists that women are unskilled and therefore worthy of only low wages (Roxana, 1990).

Women have not been allowed to effectively played a significant role in economic development, particularly in male dominated industries such as the construction industry

(Enshassi et al., 2008). This lack of integration of females into all sectors of the economy has resulted in the enforcement of their active participation through the use of government policies (Madikizela et al., 2005). Greed (2000) found that there were log jams of women at middle management level seeking to be promoted, and feeling overtaken by younger men; in construction the women had difficulty even getting a job. Whitman (2005) stated that the barriers to achieve women engineers' future goals were: gender, family commitments, lack of time, age, lack of professional support, poor relationship with industry, negative personality, and respectively. In Germany, it was reported that 48% of the students over all disciplines were women, but only 20% of the engineering students were women (Ihsen, 2005; 2006). Menches and Abraham (2007) stated that, 50% of the professional occupations employed between 10 and 25% women and 50% employed fewer than 10% women. Menches and Abraham (2007) added that, the average percentage of women in professional position was 12.8%.

RESEARCH METHOD

This study adopts a questionnaire survey approach to investigate several career issues of women engineers in construction profession in Palestine. A convenience sampling procedure (women engineers who were willing to collaborate in the survey) was employed in this study. A total of 50 questionnaires were distributed, and 31 questionnaires were returned (62% response rate). The researchers distributed the questionnaire to the respondents by hand in order to get more response. A pilot study was conducted with a convenience sample of five women engineers who were willing to devote time for the interview. Comments and feedbacks from the pilot study were examined and some modifications were made especially with respect to questionnaire readability. The questionnaire was divided into five sections; the first section was about the demographic information of respondents, the second section of questionnaire is about current job satisfaction, the third section is career goals, the fourth section is perception of career progression, and the last one is barriers to career progression. Descriptive analysis was used in this study.

RESULTS AND ANALYSIS

Respondents Characteristics

Table 1 show that the majority of the respondents (48.40%) were primarily young women engineers. The respondents might be considered to be in the early to mid-career stages, and they had particular concerns and opinions related to that career stage.

Table 1: Respondent' ages

Age	Group number	Percentage
21-30 years	15	48.40 %
31-40 years	11	35.50 %
41-50 years	4	12.90 %
Over 50	1	3.20 %
Total	31	100 %

The following information describes the major characteristics of the respondents.

Material status:

- Never married 51.0%
- Married 44.0%
- Divorced/separated 5.0%

Is your spouse an engineer?

- Spouse an engineer 31.0%
- Non spouse an engineer 69.0%

Is your spouse working in an allied discipline within the building industry?

- Spouse working in an allied discipline within the building industry 39.0%
- Non spouse working in an allied discipline within the building industry 61.0%

Do you have children?

- 85% of responses have children
- 15.0% not have children

In terms of parental responsibilities, (looking after young children, caring for school aged children etc), in an average working week, what percentage of the responsibilities do you fulfil, and what percentage is fulfilled by others?

- I fulfil 58% of the responsibilities
- Others fulfil 42% of the responsibilities

What level of impact do you believe your parental responsibilities have had on your career?

- No impact is 6.50%
- A significant impact is 42.0%
- A small impact is 6.50%
- A very significant impact is 29.0%
- A moderate impact is 16.0%

What tertiary degrees have you received?

- Graduate Diploma is 9.70%
- Master's degree is 6.5%
- Bachelor degree is 83.8%

Have you ever worked with flexible employment arrangements such as:

- Working part time is 6.50%
- Job sharing is 61.3%
- Working from home is 32.2%

What is your current work title?

- Site engineer is 19.40%
- Manager is 6.5%
- Office engineer is 48.40%
- Business consultant is 25.7%

How many hours of engineering work per week do you currently do?

- The average hours of engineering work per week is 38.8 hr.

Current Job Satisfaction

In this section women engineers were invited to rate the factors that affect their current job satisfaction. This section contains eight factors that believed to affect women engineers current job satisfaction. As illustrated in Table 2, the results revealed that most of current job satisfaction factors are considered very important to women engineer as the mean values for all factors were above 3.0. The findings showed that the main factors that affect women current job satisfactions were remuneration package and balance of work and private life.

Remuneration factors was considered very important to women engineers due to the harsh current economic situation in Palestine. Women engineers believed that balance of work and private life is important factor which helps them to continue their family life without difficulties. Such results are consistent with previous studies (Enshassi et al 2008, Ihsen 2005).

Table 2: Factors affecting current job satisfaction

Current job satisfaction factors	Mean	Rank
Remuneration package	4.16	1
Balance of work and private life	4.00	2
Skill development opportunities	3.48	3
Support to develop professionally	3.48	3
Opportunity for high profile work	3.29	4
Control over own work	3.90	5
Organizational culture	3.19	5
Flexibility and control over working hours	3.16	6
Support to develop personally	3.03	7
Present rate of career progression	2.77	8

Career Goals

In this section the women were asked to rate their career goals for the next five years. Table 3 illustrates the career goals for the next five years. The respondents indicated that the most important career goal was professional satisfaction-pride in work with a mean score of 4.45. This was followed by grow own practice for women with a mean score of 4.33. Both of these goals demonstrated a willingness of the respondents to make their way in the profession. The third important goal was looking after their families and their career. It should be noted that women engineers in Palestine considered family issue a crucial aspect in their daily life. These results confirmed previous research results (Enshassi et al., 2008; Geertsema, 2007).

Table 3: Career goals for the next five years

Career Goals	Mean	Rank
Professional satisfaction- pride in work	4.45	1
Grow my own practice	4.33	2
Looking after my family and my career well – finding a balance	4.02	3
Making a difference- culturally, environmentally, community	3.88	4
Finish/attain benchmark leading projects	3.70	5
Be more profitable – bottom line	3.22	6

Perception Regarding Career Progression

As shown in Table 4, most of career progression factors were very important. The respondents'

women engineers suggested that good performance on previous projects, compatibility with office culture, and compatibility with senior management are the key factors upon which career progression is commonly based. This suggested that career progression was dependent on previous experience and good management skills. Business income generated was considered by the respondents an important factor related to their career progression. Academic qualification and academic achievement have received low ranks in this classification because working in construction need special managerial skills and good practical experience. Availability to work over time was rated by the respondents as the last factor in dependency of career progression. The women engineers in Palestine do not prefer to work overtime due to their family commitment and responsibilities. In addition, the Palestinian culture does not encourage women engineers to work extra hours on construction projects. These results are in line with previous studies (Enshassi et al., 2008; English et al., 2006).

Table 4: Factors related to career progression

Career progression factors	Mean	Rank
Good performance on previous projects	4.65	1
Compatibility with office culture	4.51	2
Compatibility with senior management	4.44	3
Business income generated	4.33	4
Gender	4.20	5
Appearance	4.11	6
Ability to manage and lead staff	3.98	7
Number of hours worked	3.91	8
Academic achievement	3.80	9
Age	3.80	9
Academic qualifications	3.65	10
Technical competence	3.47	11
Length of work experience	3.30	12
Ability to bring in clients and work	3.00	13
Availability to work overtime	2.90	14

Barriers to Career Progression

As illustrated in Table 5, all barriers to career progression were considered important. Gender was ranked by the respondents in the first position with mean value of 4.60. The culture and attitudes of the society in the Gaza Strip attributed to the barriers for gender work in construction field. Family commitment barrier was ranked in the second position by the women respondents with a mean score of 4.44. This barrier included the demands associated with running households, raising children, maternity leave, and general parental responsibilities as well as acting as care-givers to grandchildren and elderly parents. These results agreed with previous studies (Enshassi et al., 2008; Enarson, 2004; Geertsema, 2007).

Lack of time was ranked in the third position with mean value of 4.2. This barrier includes not having enough time to pursue goals outside of work hours, to continue one's education, to expand one's skill base and to market work. Age was ranked in the fourth position with mean value of 3.98. Lack of professional support was ranked fifth with mean value of 3.76. The respondents felt that their employer did not support them throughout their careers. Poor

relationship with industry was ranked by the women respondents in the sixth position. Women engineers experienced problems in making direct contact with the industry, and there was too much competition due to large number of men engineers in the market. The last rank of these barriers was negative personality characteristics (mean value = 3.31). Negative personality characteristics were “self-diagnosed” by the respondents, which include: a lack of confidence, questioning one’s capacity to make a contribution and considering oneself to have poor organizational abilities.

Table 5: Barriers to career progression

Barriers to career progression	Mean	Rank
Gender	4.60	1
Family commitments	4.44	2
Lack of time	4.20	3
Age	3.98	4
Lack of professional support	3.76	5
Poor relationship with industry	3.65	6
Negative personality characteristics	3.31	7

CONCLUSIONS

The purpose of this paper was to elicit the perception of women engineers in the Gaza Strip about current job satisfaction, career goals, perception of career progression and barriers to career progression in the construction profession. The results showed that the majority of the women engineers believed that the parent responsibilities have a significant impact on their career progression. This result reflects the culture of the society in the Gaza Strip which has a strong commitment to family.

The results showed that the highest priorities of the factors affecting current job satisfaction of women engineers were remuneration package and balance of work and private life. It is noted that women were interested in remuneration package in order to help their relatives and to build their own lives. The most important career goal was professional satisfaction-pride in work. Women engineers suggested that good performance on previous projects, compatibility with office culture, and compatibility with senior management are the key factors upon which career progression is commonly based. Gender and family commitment were considered as the main barriers to career progression.

It is advisable to provide leadership by implementing equal opportunity and flexible workplace for women engineers in the construction industry. This issue should be supported by the government and local non-governmental organizations. Women should be allowed to fully participate and contribute to the development of the construction profession. Continuing education and training program, which focus on recent development within the construction industry and managerial skills, are recommended. Qualitative research method in gendering issues is recommended in order to overcome the limitation of this study.

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SOCIAL SUSTAINABILITY OF ROAD TRANSPORTATION INFRASTRUCTURE: AN INTEGRATIVE REVIEW OF MANAGERIAL PLANS AND PLANNING CONSIDERATIONS FOR SAFETY ASSURANCE

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Sustainability of road infrastructure with regard to safety and security is crucial since they are vital aspects of human life and wellbeing. The study identifies necessary plans and planning considerations at the initial stage of projects in order to ensure sustainability with regard to safety on infrastructure projects. A detailed literature review was conducted using studies covering a 10-year period, obtained from online databases. Findings indicated that integrating safety in land use planning, financial frameworks and legislation which are supportive of safety initiatives, strengthening managerial and technical capacity for road safety management, sharing information among stakeholders, governance and institutional considerations, as well as designing for road safety performance are important considerations to ensure sustainability. Being a review, the findings may not really reveal what is considered important in reality. Further studies could therefore validate or refute the findings of the current study. The study highlights factors necessary to ensure sustainability with regard to safety, which is considered to a minute extent. Effective planning entails taking the operational stage of developments into account. Therefore, the study provides evidence which could allow for more attention on safety planning in order to assure sustainability of infrastructure projects.

Keywords: infrastructure, planning, safety, sustainability, transportation

INTRODUCTION

The contribution of infrastructure in socio-economic development is immense. Transportation infrastructure are seen as the backbone of any economy since they support basic urban activity and play a vital role in fostering efficiency and productivity (Yang et al., 2015). Sustainability thus becomes important in the delivery of these infrastructure projects (Matar et al., 2015). According to Zavrl and Zeren (2010), overall sustainability of transportation infrastructure project encompasses economic, social and environmental aspects. A transportation system can be said to be sustainable when it is able to provide economic development and meet the transportation needs of the society in a manner consistent with natural rules and human rights

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(Bueno, Vassallo and Cheung, 2015).

However, social sustainability aspects are very seldom given considerable attention. Sustainability assessments mostly focus on biophysical and economic considerations of the built environment (Sierra et al., 2017), natural resource consumption and harmful emissions (Zavrl and Zeren (2010). These are inadequate since social sustainability considerations including fairness, equity, human safety, security and health, promoting development and cultural heritage preservation are essential goals in the provision of urban infrastructure (De Lozano et al., 2014).

Social sustainability is associated with adequate distribution of wellbeing in the present and future or a change in society with respect to evolving development goals (Sierra et al., 2017). It also includes health and safety, accessibility to facilities and public transport, social equity and noise pollution, satisfaction of citizens as well as variety and quality of transport (Mansourianfar and Haghshenas, 2018). Social sustainability is especially important in the case of road transportation infrastructure, which delivers a wide range of economic and social benefits and thus provides a fundamental foundation to the performance of any economy (World Road Association (WRA), 2014). However, traditional indicators focus on vehicle mobility and travel time, which are unable to access sustainable systems (Mansourianfar and Haghshenas, 2018). This is inadequate since fatalities and injuries on roads are ubiquitous and cost economies huge amounts.

Road crashes have been identified as a socio-economic challenge. Globally, nearly 1.25 to 1.3 million people die in road crashes every year, an average of 3287 deaths per day, accounting for 2.2% of all deaths, and an additional 20-50 million are injured or disabled (Republic of South Africa, 2016; Association of Safe International Road Travel (ASIRT), 2018). These crashes cost \$518 billion (1-2% of annual gross domestic product (GDP) globally, In the United States (US) alone, there were about 6.3 million fatal, injury and property damage crashes in 2015 (Statista, 2018). Nearly 37,000 million people die in road crashes every year in the US and this costs \$230.6 billion or an average of \$820 per person.

In the EU countries, road accidents comprise over 90% of all transport accident fatalities and accident costs and are the leading cause of death and hospital admission for people younger than 50 years (European Commission, 2016). The Global Status Report on Road Safety 2013 estimated the rate of road traffic deaths at 24.1 per 100,000 people in Africa, the highest in the world (Figure 1) (Small and Runji, 2014). In South Africa, road safety issues are a cause for concern. The country has the second highest road accident fatality rates with 31.9 fatalities per 100 000 population in Africa, after Nigeria (with 33.7 per 100 000 population) (City of Tshwane, 2015; Tancott, 2015). In 2016, 14,071 people died on South African roads, a significant jump from 12,944 deaths recorded in 2015 (a 9% increase) (Writer, 2017).

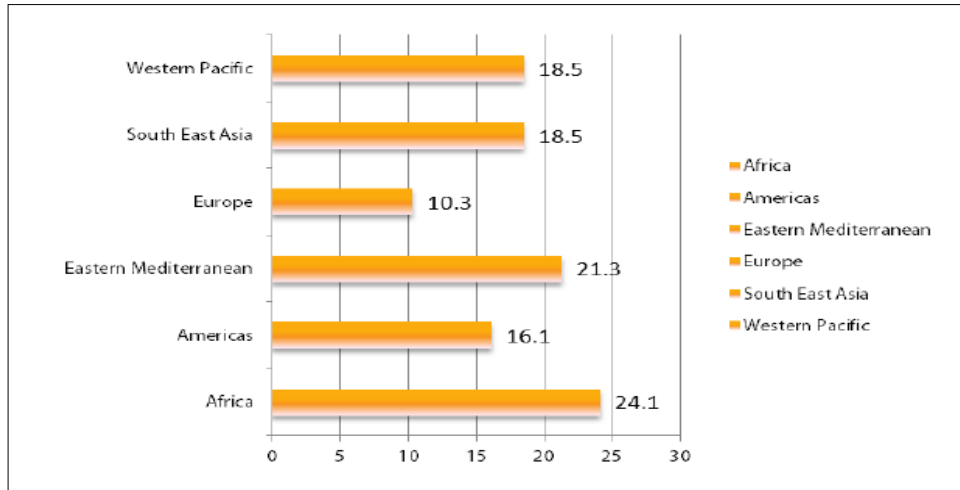


Figure 1: Estimated Road Fatalities per 100,000 Population 2010 (Source: Small and Runji, 2014)

These statistics are alarming and should be a major worry for road infrastructure stakeholders. Unless action is taken, road traffic injuries, which are currently the 9th leading cause of death, are predicted to become the 5th leading cause of death by 2030 (ASIRT, 2018).

According to Writer (2017), road accidents and deaths are contributed by human factors, vehicle factors as well as road and environmental factors. Therefore, delivery of sustainable road infrastructure should consider whether the system is safe to use for the citizens taking cognizance of vehicle factors, human factors, road structure and environmental factors. Moreover, road infrastructure delivery is complex and fraught with uncertainties which need to be considered during the planning phase in order to select the most sustainable scenario for improving traffic safety conditions in urban areas. However, fatal and long-term injury in road accidents is a largely predictable and avoidable problem, which is amenable to rational analysis at the planning stage and remedy (European Commission, 2016).

Various actions and initiatives exist which attend to safety in road infrastructure delivery. For instance, the Vision Zero policy, which evolved since the 1970s in Sweden, but primarily envisages a chain of responsibility that both begins and ends with system designers (Belin, 2012). Another is the Road Safety Audit (RSA) Standards, which are extensively used in many countries such as US, United Kingdom (UK), New Zealand, United Arab Emirates (UAE), Australia and South Africa. The RSA has been useful in assessing future or existing highway projects (pre and post-construction) by a multidisciplinary team, in order to qualitatively estimate and report on potential safety problems and deidentify measures to extirpate concerns or improve in safety for all road users (UAE Department of Transport (DOT), 2012; USDOT, 2014). Further, the United Nations Road Safety Collaboration (UNRSC) with the World Health Organisation (WHO) in 2004 to improve global road safety across the UN system is in place. The collaboration is an informal consultative mechanism to implement recommendations of the World Report on Road Traffic Injury Prevention (WHO, 2018a). Despite these initiatives, accidents and fatalities still occur and without increased efforts and new initiatives, strategies or commitments to prevention, the number of road traffic deaths and injuries is projected to increase by about 65% over the next 20 years (Belin, 2012; WHO, 2018b).

Although studies have been conducted on social sustainability of road infrastructure projects, most studies incorporate other elements of sustainability; very few have focused on safety

planning as a means of assuring social sustainability of road infrastructure projects. Mansourianfar and Haghshenas (2018) studied sustainability assessment incorporating economic, social and environmental concerns in the delivery of micro-scale transport infrastructures, with a focus on the construction and operation phases. Torres-Machi et al. (2017) focused on assessing sustainability of maintenance alternatives that consider, in an integrated manner, technical, economic and environmental aspects over road pavements' life cycle. Although this study focused on operation and maintenance of road physical structure, it emphasized the paramount need to budget and plan for sufficient funds to maintain road networks' structural capacity, to avoid deterioration which leads to accidents, while at the same time fulfilling their primary objective of mobility.

Further, Zavri and Zeren (2010) studied the applicability of a matrix developed by the Cooperation in Science and Technology program (COST) to assess sustainability of urban infrastructures, including environmental, social and economic aspects. Although, Zavri and Zeren's study did not focus on roads infrastructure, it revealed that social infrastructure covers various services defining relations between stakeholders. This suggests that plans and planning considerations made at the conception and initiation of road infrastructure projects entail stakeholder dynamics, which may affect the social sustainability of such projects, especially where private investors are involved. The current study assesses plans and planning considerations made under such conditions to achieve long-term sustainability of road infrastructure projects in terms of safety. This study argues that the probability of social sustainability of road infrastructure projects lies in the capability of managing presenting risks and to do this, adequate, strategic and effectual planning has to be made to achieve desired results. The strengths and weaknesses of a project relate to the resources and capabilities with regard to finances, human capital, and receptiveness to innovation (Isik et al., 2009). With increasing public awareness on health, safety, security and wellbeing, the link between sustainability and planning becomes more pertinent. Planned managerial actions in the planning stage should be put in place to mitigate occurrence of safety risks. The objective of the current study is therefore to identify important planning considerations to ensure safety performance at the operational stage of road transportation infrastructure systems.

METHODS

A distillation of relevant literature was undertaken from databases including Google, UJoogle, Academic Search Complete, Emerald Insight, Science Direct, Ref Seek, Taylor and Francis and Google Scholar. Materials used were journal articles, conference papers, web documents and online newspapers. The materials were included based on their currency, that is, literature spanning over 10 years (2009 to 2018). Keywords included infrastructure, safety, security, sustainability and planning, used in conjunction with various types of infrastructure and stakeholders in order to identify different views regarding safety planning and sustainability.

FINDINGS

Literature evinces that certain factors considered at the planning stage of road transportation infrastructure projects contribute to ensuring that safety performance is achieved or improved at the operational stage of such projects. These factors are discussed hereunder.

Land use planning

Integrating road safety in land use planning by working on all components of the system which

will reduce or even eliminate deaths and serious injuries as a result of collisions, for instance the Safe Systems approach as used in Canada and Australia, which shifts away from human behaviour only, to look at the entire system (Steinmetz et al., 2015; Berthod, 2016; Republic of South Africa, 2016). The Safe System approach has the objective of eliminating deaths and serious injuries, with the guiding principle that everyone should be responsible for creating and ensuring a safe road system (Steinmetz et al., 2015). Land use policies influence road safety because decisions can be taken before new road infrastructure development. This integrated approach can also be affected by the number of actors involved, distribution of competing interests. Further, planning programs and by-laws (construction, zoning, subdivision standards, conditions for issuing planning and building permits, and so on), and other land use decisions which define geometric design, travel needs, modes, and traffic conditions and impact on users' safety (Berthod, 2016). For instance, clear boundaries along roads and between environments help to adjust driving behaviour and speed.

Financial resource planning

Sufficient funding (whether internal or external sources) allocated to strategically oriented safety initiatives in order to meet the road safety goals and objectives is a critical consideration in planning (Small and Runji, 2014; Yang et al, 2015). Planning for procurement and financing structures should therefore be treated as critical aspects of infrastructure planning as opposed to stand alone function/process because it allows for measures to be put in place for the management of the project while in operation (Responding to South Africa's infrastructure challenges, 2016).

The financial frameworks and regulations obtainable in a particular country influence the availability of finance for road maintenance plans (Zhang and Chen, 2013). The sources of finance as well as the cost of obtaining such finance for road projects need to be considered in road project developments. Moreover, the financial burden or responsibility of maintenance lies on the cash flow from the road investment while in operation, especially in the case of public- private partnership projects, which rely on the cash flow during the operational stage. The constant cash flows generated in the operation phase are used to pay off debts and generate revenue (Khmel and Zhao, 2016). However, planning considerations should include plans to amass sufficient funding to cover road maintenance and safety management costs as well.

Strengthening Managerial and Technical Capacity for Road Safety Management

Road safety management entails road safety audits, enforcement of traffic laws, the use of technology to monitor and detect speed offenders as well as planning for other safety features and facilities to ensure traveller safety (Republic of South Africa, 2016). Achieving effective management of road safety can be through identifying capacity to handle or manage road safety situations (Small and Runji, 2014). The establishment and continual strengthening of the management team responsible for road safety management function is an essential building block to the progress that that is desired in roads safety situation.

Information Sharing among Stakeholders

Sharing information about road safety creates public awareness (sharing system-related information). Messages related to directions, regulatory requirements, warnings of hazards and other useful information can be conveyed to the public through signs, signals (eg, intersections, pedestrian crossings, etc, for different types of vehicles. Since vehicle speed is directly related

to the control of the driver, it is important to provide the road user with clear signals and the type of environment they are in, reinforced with information at appropriate times (World Road Association (WRA), n.d.).

The views of the public should be also solicited both during the planning of road safety strategies (Republic of South Africa, 2016). This encourages participation in safety-related design initiatives aimed at providing mitigation measures to ensure that accidents do not occur or that those that do occur are less severe. In this sense, human factors or considerations are critical in the design and provision of treatments to ensure conspicuity and visibility of signs, credibility, consistency and understanding of messages. Clear indications of expected driving actions, especially speed choice and clear warning hazards can do much to reduce the number of collisions and to mitigate the severity of those that occur (WRA, n.d.).

Governance and Institutional Considerations

Road safety crisis cannot be effectively tackled without first addressing the political will to act, and the institutional capacity to respond and this requires road safety to be recognized within a community or government as a sustainable development goal that requires effective response (Small and Runji, 2014). The level of political control defines the environment which influences operational activities and thus response to incidents or accidents (Botlhale, 2016). It is essential to ensure that there is an enabling environment for successful operations.

Literature further revealed that the commitment of government, strong control and sponsorship, as well as clear objectives and leadership during operation influence the performance of projects (Glaister et al., 2010; Mišić and Radujković, 2015; Osei-Kyei and Chan, 2016). The role of government through its various departments and agencies, in ensuring that the roads are safe and secure is critical (Republic of South Africa, 2016). The level of government's influence, transparency and authority on road projects may be a source of concern as contracts are sometimes awarded to incompetent concessionaires, or mismanaged. These give rise to poor quality roads and thus unsafe conditions (Byaruhanga and Basheka, 2017).

Additionally, institutional and governance structures influence the effectiveness of existing laws and standards or directives regulating roads, vehicles and road users as well as safety improvements proposed (Small and Runji, 2014). They also influence the financial regulator and regulations.

In general, good governance principles place road safety performance topmost on the agenda and fosters engagement with management on the full range of human, financial and system resources needed to improve safety performance.

Designing for road safety performance

At the feasibility stage, road safety considerations include assessment of aspects such as route locations, layouts, treatments, interchange locations and type access control, impacts on the existing road network, traffic control and management plans and other features (Li, 2010). These are carried through to the design stage, which entails detailed audit and reviews of the geometric designs, safety hardware, landscaping, intersection and interchange details, provisions for special users (pedestrians and bicyclists), alignment, sight distances, lane and shoulder widths, super elevation, and provisions for drainage, and other roadside objects. Incorporating safety-conscious outcomes into the design at the initial stages of project planning ensures that safe systems principles (how best to avoid incidents and impacts) are specified at

the initial stage and by so doing, the possibility of road users being killed or seriously injured is reduced greatly or eliminated completely.

SUMMARY OF FINDINGS

The above review identified that there are certain critical considerations which could essentially contribute to effective and successful road safety management at the operational stage of road transportation projects. However, it appears that although the identified factors (discussed above) could singly influence road safety during operations, they are intertwined and related in such a way that it can be deemed that roads safety (sustainability) is directly or indirectly related to the institutional structures in place (as represented in Figure 3). Figure 3 presents a system framework developed from the synthesis of literature above. It suggests that institutional and governance structures could lead to effective road safety management practice through land use policies and other controls regulating the availability of finance and design configurations and road safety management dynamics.

As supported by Small and Runji (2014), “when given full effect, the institutional management functions form the essential aspects of a road safety management system for any country and provide direction on how cost-effective interventions are identified, prioritized, scoped, funded, targeted and delivered. They also assist in building support for sustained road safety improvement and creating the human, financial and institutional capacity needed to sustain support, and transform it into improved safety results within the community”. Substantial reductions in road deaths and serious injuries can be achieved through a focus on achieving specific results, applying system-wide, evidence-based measures, underpinned by effective organisational management (European Commission, 2016). Achieving road safety results requires long-term ownership, leadership and political will by government, and commit to a strong result-focused plan and implementation strategy through institutional management arrangements, which will in turn resolve any capacity weaknesses that threaten to inhibit implementation of effective action (European Commission, *ibid.*). This suggests a shift in paradigm advocating the strengthening and attention to system-based governance and institutional structures as an overarching approach to road safety.

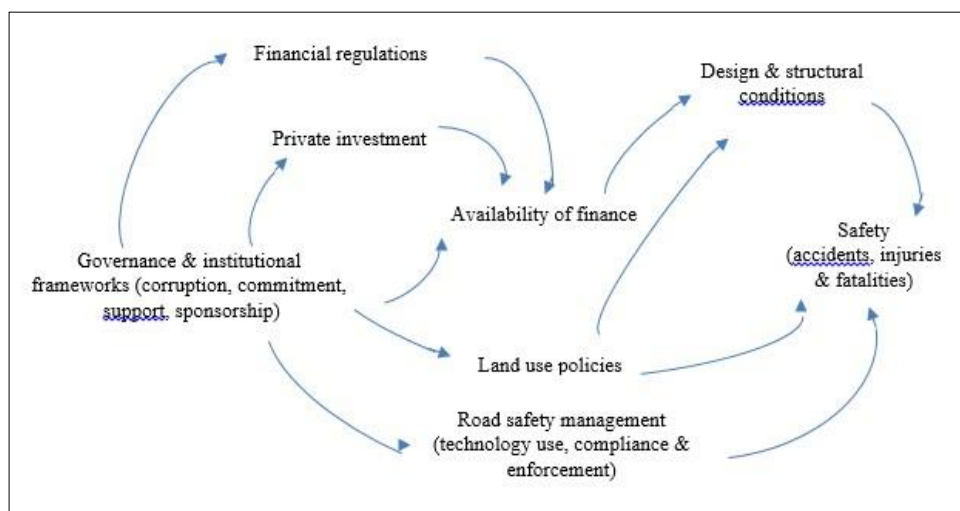


Figure 3: System framework showing interrelationship between governance and institutional frameworks and road safety (Author's work)

CONCLUSION

The paper sought to explore planning considerations which could contribute to road safety performance during the operational stage of projects. The study found that land use planning, financial resource planning, strengthening managerial and technical capacity for road safety management, information sharing among stakeholders, governance and institutional considerations as well as designing for road safety performance. These factors were also believed to be interrelated and road safety performance could be ultimately linked to governance and institutional frameworks. These relationships were presented in a systems model. Future studies could employ system dynamics software to analyse and establish the nature of the relationships (positive or negative influences) in the developed model.

The findings of the current study provide important information that could contribute to effective planning, which could contribute to desired road safety performance, which is a vital aspect of social sustainability.

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UNDERSTANDING THE CURRENT GAZE OF WORKPLACE WELLBEING IN OFFSITE MANUFACTURING

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The controlled offsite manufacturing environment provides an opportunity for understanding the relationship between workplace wellbeing and the nature of conditions that shape potential for workers to improve gains through working conditions and productivity respectively. The new factory-based workplace environment brings with it new challenges in wellbeing to health and to safety. Coupled with this, there is no empirical evidence to support the numerous claims that wellbeing for people working in offsite manufacturing factories is much improved because of the controls that are implicit. The concept of workplace wellbeing, those associated with human and social capital, is developed and situated in the existing offsite manufacturing literature using a desktop study technique. Emergent findings from the literature review suggest that a contextually based conceptual framework requires workplace wellbeing to be addressed through a sociocultural analytic lens from a humanist perspective to tease out the phenomenon from the viewpoint of the worker. There is a tendency to focus on offsite manufacturing through the lens of the economic rationalist which espouses efficiency over time, materiality and innovation over people. While humanist values such as human and social capital have been identified as some of the key mediators for wellbeing-based productivity, a review revealed a lack of published research into the context specific factors affecting workplace wellbeing in offsite manufacturing in Australia.

Keywords: workplace wellbeing, offsite manufacturing, human capital, social capital.

INTRODUCTION

The concept of learning from failures is fundamental to the practice of construction. Developments in production processes give way to incremental change in the Australian construction field through innovation and efficiencies, by moving elements of process from onsite construction to offsite manufacturing (OsM) (Goulding et al., 2013). A unified field of practice between onsite construction and offsite manufacturing, where both systems affect the other, amplifies the capacity to perform environmental, social and economic change in the sector. The aim is to have extended reach for prefabrication (Steinhardt et al., 2014) whilst enabling production based improvement strategies for construction. From the blurred diffusion between the two delivery systems, does OsM forge its own identity towards potential or does the industry remain intertwined with and considered an extension of traditional construction? For Blismas et al. (2006) the fundamental regard for healthier and safer work conditions are one of the more significant benefits of prefabrication. However, does the absence of site based risks in OsM, provide a workplace wellbeing environment for employees or are other factors involved?

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The term wellbeing represents a sociocultural construction of a personal development phenomenon - that is, wellbeing is a self-actualised journey to potential and virtue, whether it's happiness or having a 'good life' and expressed as emotion (Erdogan et al., 2012). Wellbeing is context free and actively pursued. Nussbaum (1999) extended the definition of wellbeing to include entering empathically into the lives of others where the agency of the individual is to find meaning as a '*primary motivational force*' (Frankl, 1985) as well as reacting to the dynamics of contextual forces (Sang et al., 2007). This effect places the OsM employee as an active participant in the dynamic system of the workplace wellbeing process. This paper explores what consideration has been made towards workplace wellbeing in OsM literature.

CONTEXT

Offsite Manufacturing (OsM)

OsM is seen as an intrinsic collaborator of the construction industry providing a manufacturing base for processes and preassembly of parts, a quality-controlled product (Goulding et al., 2014) and environment. At the intersection of OsM and onsite construction is a language shared across both platforms. The language used by designers, engineers, and by skilled and unskilled workers in both sectors, acts synergistically with other social elements to function as a system of cultural values and norms.

Research over the last 20 years with a spike in the last 5 years in Australia regarding the health and wellbeing of male construction workers, points to unacceptable levels of work related deaths both deliberate (Milner et al., 2017) and accidental (Milner et al., 2015). Risk factors include but are not limited to: the prevalence of unsafe working conditions (Godfrey et al., 2007) and a range of entrenched negative occupational behaviours that place these risk factors into an escalated state of play. Player et al. (2015) described occupational behaviours as 'unhelpful conceptions of masculinity consisting of stoic beliefs' where adversarial culture, was found to be endemic in what is predominantly a male workforce (Turner et al., 2017; ABS, 2016). Whereas Dainty et al. (2007) posit that the diversity of people employed on different contractual basis, thrust together under short term project conditions does not favour effective working relationships to develop.

Project based terms of employment may create personal stressors for employees and contractors. Overwork (Green, 1999), low decision latitude (Turner et al., 2017), bullying and stoicism (Milner et al., 2017) and a combination of external issues such as macroeconomic push pull factors where a boom in one area causes shortages of builders and supply in another (Mbiti et al., 2011), impede on job security, safety and workplace wellbeing. Environmental factors contributing to the unwell-being of workers and by default affects productivity, are influences which are bound to organisational clarity and communication of objectives to the workers. Operational unpredictability has a flow on effect. When job insecurity that temporary project-based work provides for the long term basic needs of employees (Hardie, 2010), or a lack of organisational clarity (Warr, 1994) results in instability.

The aim of this paper was to generate the position, that to investigate the effect of working in the OsM environment on the workers wellbeing, a deeper understanding of systemic conditions is required. Presented below is a critical discussion on the working definition of workplace wellbeing.

Workplace Wellbeing

Two schools of thought exist when it comes to defining context-based wellbeing or, in the case of this research, workplace wellbeing. The first is that a litany of definitions focus on context-

based workplace wellbeing as job satisfaction (DeWitte et al., 2016). The workplace environment plays a mediating role in shaping the actualisation of a worker's wellbeing. Where organisational outcome is productivity engineered through a sense of purpose, belonging, agency and providing a backdrop for sociocultural narrative of meaning and understanding (Carmichael et al., 2016). It is within a person's nature to invest work with meaning. This provides a platform for the rationalisation of what represents a good work environment to the individual whilst remaining relative to the individual's attitude and choice (Frankl, 1985), and bound to the social context (Ma et al., 2016).

The second school of thought regards job satisfaction or a person's attitude towards their work environment as an experiential *evaluation*. This being the case, value judgements are made concerning their job, cognisant of their affective experience of the job as a consideration made relative to time (Weiss, 2002). According to Visser et al. (2004), attitudes that are formed, held and maintained at work are embedded within a homogenous social network. Attitudes formed within homogenous social networks such as with co-workers, are dependent on the makeup of the group such as positivity and support, or negative with adverse behaviour (Uchino et al., 2004). However, the same set of conditions in the OsM environment may be experienced as enabling or oppressive to a person whilst enjoyable and satisfying for another. It is within context that judgements are made, and environmental attitudes are formed and maintained (Weiss et al., 1996).

Although both conceptual views of job satisfaction have acquired the psychological construct of "attitude", the point at which divergence occurs, is that affect, and evaluation are separate constructs (Weiss, 2002). With the understanding that workplace wellbeing is self-actualised and activated in response to the relationship between a person their job, other members of the workplace and the organisational environment over time, identifying the concepts that provide an understanding of the workplace wellbeing phenomenon in OsM is necessary (Jabareen, 2009). From literature in multidisciplinary bodies of knowledge situated in the fields of psychology, social sciences and construction management, the following concepts of human and social capital within the context of the workplace environment emerged as having either positive or negative affect over workplace wellbeing and productivity.

FROM CONTEXT TO CONCEPTUAL

Firstly, human capital or the skills, knowledge and personal attributes that employees bring to an environment, contribute to evaluating the participants' perspective of the lived experience (Sandberg, 2007; Weiss, 2002). How does an employee's skills support workplace wellbeing? If finding meaning is achieved through finding purpose, then employment would satisfy those needs. How can it be achieved and what stands in the way? The answer may be found in using job satisfaction as a mediating factor and as a constituent of self-actualisation and the eternal search for meaning which is formed over time as an attitude rather than as an affect ((Frankl, 1985; Weiss et al., 1996).

The common thread between higher implementation rates of OsM in developed countries, such as Sweden, Finland, Japan (Steinhardt et al., 2013) and Germany (Lovell, 2003) is the use of specifically multi-skilled workforce. This is where people working on the production line possess a range of skills applicable for more than one type of process, which is also found in lean production (Womack et al., 1990). This lies in contrast to Australia, the UK and US where the frequency of OsM application is by comparison slow and erratic (Arif et al., 2012). People on the production line (other than supervisors) are hired with no specific trade-based qualifications pertaining to construction or manufacturing.

There are instances where unskilled labour is deemed as a cost saving consideration for OsM

implementation (Arif et al., 2010), whereby people trained experientially in a manufacturing setting, learn skills without the accumulated effect of bad habits being perpetuated (Blismas et al., 2007). For professionals such as designers and supervisors in the field of construction who require professional development, experiential training in a virtual prototype (VP) setting has been suggested to provide targeted learning in the OsM industry before implementation (Goulding et al., 2014). Professional skill sets are tacit and exploited through mobilisation whereas an unskilled person, requires the ability to create agency through participation in the community of practice (Duguid, 2005). Agency comes in opposition to deploying skilled labour. However, what has not been defined are the type of skills, knowledge or systems required for learning to occur to yield a more productive outcome.

For productivity to occur in an organisational setting, a systemic strategy for knowledge retention and consistency within the workforce is required. It follows that what a member of the workforce contributes to their community of practice as social capital which is in the form of value forged through relationships of trust, becomes invested into the system of practice (Coleman, 1988). Building community capacity is an effective force for positive change.

Researchers in the field of construction are divided on the notion of whether the manufacturing process particularly lean construction are one sided in favour of the community of practice or the organisation. Green (1999) plunges his pen into the argument with fervour, inciting followers to think in favour of the individual whereas the rationalist sees the system as a re-engineered process producing environmental and project management-based efficiencies. Navigating Green (1999) requires embracing collaborative culture and social capital or 'social networks', as a subjective predictor of social wellbeing within the system dynamic (Bourdieu 1986).

Understanding of social capital comes with acknowledging that experience is shaped by what Lev Vygotsky (1931) termed as the sociocultural theory of cognitive processes, where the development of knowledge is fluid. It is developed alongside and precedes experience (historical), social and situational contexts where outcomes learnt are through interaction and behaviour (Lantolf, 2006). Fluidity, of knowledge and culture has elements of transferability between contexts.

Construction workers whether they are offsite or onsite, share a habitus in which agency and structure is realised through cultural appropriation. That is, skilled and unskilled workers in OsM, may share a working history and culture on construction sites (Blismas et al., 2007) with language and behaviour used to mediate the conventions of the sociocultural artefacts. Whether it's in the form of language (Lantolf, 2006), behaviours, strictures or skills of construction, these may be brought to the offsite environment. It is within the context of the environment and systemic support for the innovation worker, that the difference resides.

Social involvement in a community or organisation, is embraced through a collaborative culture where according to Hofstede (1993) culture is a collective phenomenon and social capital or 'social networks' (Bourdieu, 1986) are a subjective predictor of social wellbeing within the system dynamic. These tangible benefits of shared understanding, become rendered as implicit in the costing of OsM and omitted in research (Blismas et al., 2005).

DISCUSSION

Does the rationalist perspective of OsM adequately address workplace wellbeing?

The lens of investigation from academia and industry has been at a macro level where context-based approaches for the construction industry explores aspects of OsM through a rationalist lens. These identify overarching economic systems benefits and barriers of cost, time and

quality (Goulding et al., 2013), whilst conducting implicit evaluations on the workplace for the welfare of employees. The beneficiaries of these workplace benefits are skewed towards the flow on effect from OsM to the onsite construction workforce rather than the realised benefits for the offsite worker (Arif et al., 2010). Blismas et al. (2006), posited that welfare benefits have predominantly been marginalised as ad hoc values by industry whilst Sunding et al. (2015) posit that in order to inform performance and productivity gains in construction management, the dialogue regarding the OsM workforce requires an internal audit.

Identification of the predominant benefits for workers in OsM are situated within health and safety. These benefits are attributed to environmental factors where adverse working conditions and physical relocation from the external work site to one that is housed inside a factory, buffers environmental hazards and safety issues (McKay et al., 2005) whilst Arif et al. (2010) concentrated on the effect for onsite workers benefits. These factors, imply that the directional shift from onsite construction to OsM will positively affect the workplace wellbeing of workers in terms of safety, productivity and performance (Abbott et al., 2015). However, McKay et al. (2005) found that the offsite production-based industry whose purpose was to merely put a roof over the construction process, lacked in the productivity gains that technology could bring.

In larger markets such as the UK, Sweden, Germany, and Malaysia, where OsM is established, research and government policies have integrated demand for increased output for social housing, with strategies of OsM adoption. Understanding the complexity of a phenomena such as OsM through a systems lens which Groák et al. (1986) termed the 'economic/technical framework' has predominantly been approached from a macroeconomic level. OsM which currently is at a nascent phase of development in Australia, has lacked practice-based operational maturity to evaluate how OsM workplace conditions, translates into workplace wellbeing or job satisfaction. Between the context being conceptualised at the macro level, Schweber et al. (2010) makes the case that the minutiae of detail at the micro level is left in shadow. It is at the micro context-based level, according to Phua (2013), where the individual level of analysis occurs, that OsM research lacks the sociocultural balance. It is not yet clear what systemic factors affect OsM within the organisational setting of Australian construction and how working in OsM shapes the employee's experience of wellbeing.

To date, only a limited number of studies have addressed how the agency of the OsM workers, informs and affects the wider cultural discourse of workplace wellbeing. Academic discourse has taken two approaches to define OsM. One that focusses on the rationalist engineering production orientation reflecting logical sense making of the engineer's world under the various guises of prefabrication, pre-assembly and modularisation. The second explores OsM as a sociocultural phenomenon. The way in which ideas and concepts are communicated in the OsM literature falls within the first of the two contextual frameworks: Functionality and rationality versus social meaning and cultural immersion. The former, misplaces the directional pull of productivity.

The primary operationalisation occurs with economic rationalism at the macro level rather than one that incorporates nurturing of the elevated expectations of OsM through a human based lens; one suggested by Goulding et al. (2013) that incorporates the needs of construction workers as an 'interrelated discipline', at the micro level. The macro level defines the principle of investigation at conceptual or development phase, whereas the micro level lends itself to the operational phase of development.

The connection between a sociocultural phenomenon and societal values can be illustrated with Dutch cultural values. These are characterised by socialistic and egalitarian notions of inclusion, adaptation and individualism (Hofstede, 2001) and expressed through bilateral

creativity as individuals and as a society (Rinne et al., 2013). Individualism promotes creativity through flexible and sustainable practices which carry consideration for their production. Where workers are the actors and drivers of change based performance productivity, this shift of focus towards individuals, provides a platform for fundamental improvements for the workplace wellbeing in OsM.

Optimism towards OsM in the salient literature lists amongst reasons why the construction industry sees a directional shift towards prefabrication, is for efficiency gains in construction where delays have been marked by continuous deficiencies in quality, time and therefore cost (Sunding et al., 2015). Prolonged construction times, difficult site conditions (Dubois et al., 2002), and material waste from defects are easier to stomach than the statistics associated with the unwell-being of its workforce.

The authors argue that it is difficult to determine whether remarks voiced by Pan and Goodier (2012) on improved conditions applies to workers in OsM or acts as a flow on effect for onsite construction workers using prefabricated elements? The literature also suggests that even though human endeavours are the focus, the language of the literature omits this reflection and does not tease out what these benefits are in the workplace.

CONCLUSION

This paper highlights two gaps in knowledge: firstly, there is little research based on the social, cultural and physical characteristics inherent in the OsM environment to examine what variables from the perspective of people working in OsM, have a bearing on their workplace wellbeing and performance. Secondly, there is a lack of knowledge on the cultural and structure of agency of the innovation workforce in the OsM workplace environment and the contextual mediating factors contributing to their workplace wellbeing in Australia as the elements haven't been teased out.

One of the significant outcomes of this study is that it highlights a pathway for future research in Australia, where until empirical research investigates the experiential realities in practice through the lens of the OsM working population, evidence supporting the argument that wellbeing in this environment has beneficial outcomes dissimilar to that of onsite construction, remains implicit and cannot lead to improvements in workplace wellbeing or productivity. Will the OsM workplace environment be any different from onsite or is there a relocation of these inconvenient truths for workers?

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FALL PREVENTION DIAGNOSIS

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This paper presents the proposal and practical experiment of the Fall Prevention Diagnosis method. This method aims to contribute to the reduction of occupational accidents caused by falls in the Construction Industry, through the assessment of workplace safety conditions at construction sites. To this end, the questionnaire is structured in 9 Groups, 43 Subgroups, 412 Questions. The groups correspond to the most relevant topics that can cause the fall of people or materials, such as scaffolding, personal protective equipment, electrical installations, fall protection; order and cleanliness; cranes; stairs/ladders, ramps, and walkways; construction site elevators; handling and transportation of people and materials. The questionnaire is applied using a mobile device and a computerized system that prepare the visit report. The methodology foresees the completion of 02 (two) visits for the questionnaire to be carried out. Once answers are compared, one will be able to identify the progress of safety conditions in the workplace. The method of this study was applied to 1,360 construction sites in Brazil. This significant result enables the assessment of the contribution of the FPD (Fall Prevention Diagnosis) to: generate and disseminate occupational safety information to the actors involved in the Construction Industry; provide technical information to enable a company to take action to reduce accident risk factors; improve the safety conditions at construction sites; support the development process of new technologies for the Construction Industry.

Keywords: Construction industry, Diagnosis of the construction sites, Protection against fall

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AWARENESS AND TRAINING PROGRAM

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This paper presents a proposal and practical experiment of the Awareness and Training Program method. The method consists of 3 training modules that prioritize the most relevant topics for the prevention of fatal and disabling accidents in the construction industry, such as protection against falls, protection in excavations and electrical installations. Each module consists of a slide presentation, with an estimated time of 60 min, and two videos addressing essential aspects of the training. The pedagogical principle used in the method is that of meaningful learning, whose approach considers that the knowledge acquired is related to the previous knowledge that the student possesses. Knowledge building through the internal and active mobilization of the individual, so that the worker can attribute the meaning of learning to their lives, that is, useful learning and continuously revisited, restructured and modified. The method was used in 1,238 construction sites in Brazil. This significant result ratifies that the ATP (Awareness Training Program) method contributes to: broaden workers' access to occupational safety information in the construction industry, make workers aware of occupational accidents, and reduce occupational accidents at construction sites.

Keywords: Construction industry, Training and awareness, Protection against falls, Protection in excavation, Protection in electrical installations

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LESSONS AND LEARNING IN MANAGEMENT OF LARGE WORKS: A COMPARATIVE STUDY BETWEEN BRAZIL AND THE UNITED KINGDOM

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Civil construction is one of the economic activities with high rates of serious and fatal work accidents in the world. The objective of this study was to analyze and compare two realities of safety management in large works to understand management strategies more efficient and effective in health and safety. For this, we compared two case studies using previously established categories of analysis. The first case explored the construction of the Olympic Park in the United Kingdom in 2012, without serious and fatal accidents and delivered on time. The second case was the construction of an airport in Brazil, with 17 serious work accidents and 2 fatal ones and delayed delivery. The analysis was based on interviews, observations and document analysis. In the United Kingdom, the strategic management of the work included safety concerns from the outset and decisively influenced the overall planning of the work, technological and constructive choices highlighting practices that reduced exposure to risks and contributed to the results obtained. In Brazil, there were delays in schedules and prevailed management decisions and practices that excluded safety in the strategic agenda of the system and worsened the situation with successive changes of managers and in charge of the execution of the work. We understand that accidents occur as a result of lack of management, planning, coordination, and communication between different levels of the organization, and safety must be a priority among the highest levels of management.

Keywords: Occupational Health, Safety management, Construction sector, Accident Prevention.

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SAFETY PLANNING OF TEMPORARY STRUCTURES FOR FALL PREVENTION USING BIM

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This research, in progress, started with the opportunity of integrating safety planning to construction management process. It is known that temporary structures are representative for the construction process, influencing safety and duration of works. The planning process of these structures is considered complex and requires a lot of attention due to the following reasons: assembly and disassembly of these structures are high-risk activity and, despite the impact on safety and productivity of entire construction project, temporary structures are often omitted from drawings or Building Information Modeling (BIM). Several researchers are studying accident Prevention through Design process (PtD) to avoid or minimize the work hazards associated with construction. Concentrating on temporary fall prevention structures, the aim of this research is to build the necessary knowledge that allows the formal representation of temporary structures characteristics, to allow virtual model construction, including safety measures in the construction schedule. Specific objectives include: identifying collective protection technologies adopted to reduce falls from heights with a focus on building periphery; detailing of found solutions regarding process of systems assembly and disassembly; performing analysis regarding planning for assembly of each one of the systems; presenting a solution that best meets the following: design/assembly, connection with building structure, and worker safety; developing integration between virtual modeling and schedule information. The union of the two concepts - BIM and PtD - becomes a differential to optimize and to view safety planning. From a case study of collective protection equipment, it is expected to present guidelines for project design and planning of safety measures.

Keywords: Safety, Planning, Collective Protection Equipment, Building Information Modeling (BIM), Prevention through Design (PtD).

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SELECTION CONSIDERATIONS FOR PERSONAL PROTECTIVE EQUIPMENT (PPE) USED IN THE CONSTRUCTION INDUSTRY

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In many developing countries, PPE use is a very important aspect of safety discussions because it is often the only avenue for the protection of employee safety. The use of unsuitable PPE on construction sites introduces other hazards in the form of ‘poor fit’, ‘equipment getting in the way of work’ and discomforts associated with their use. Providing workers with PPE that meet all safety requirements but is uncomfortable to use, results in non-compliance with PPE protocols and a compromise on their health and safety protection. This study investigates the processes involved in the selection and procurement of PPE for construction workers as part of a broader study into the use of Personal Protective Equipment (PPE) in the construction industry in Ghana. Primary data was collected by the using a questionnaire survey conducted on D1K1 and D2K2 construction firms operating in Ghana. Data was subjected to both descriptive and Regression Analysis. Results obtained indicate that the decision to procure PPE is usually based on the firms’ health and safety policies, however, most construction companies procure PPE from what is available on the open market. Again, the source of procurement is largely dependent on price. Additionally, workers’ comments and experiences from using PPE usually do not play a role in the procurement process. It is recommended that pragmatic steps should be taken by stakeholders in the PPE supply chain to ensure the procurement of user-friendly PPE for construction workers.

Keywords: Construction workers, Discomfort, PPE Selection.

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LEADERSHIP TRAINING PROGRAM

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Based on the assumption that successful projects must be well managed and lead, not only in production issues but also in occupational health and safety, this paper presents a proposal and practical experiment of the Leadership Training Program, which aims to contribute to the development and improvement of leadership skills, adding a culture of occupational safety to the construction industry leaders and managers. The program comprises of training in three hierarchical levels of leadership in construction sites: foremen and managers, contract managers and engineers, businessmen and directors. It focuses on leadership tools aimed at improving productivity in the Construction Industry, based on the understanding that occupational health and safety are directly related to workers' performance. To this end, the pedagogical principle used is the meaningful learning. The program methodology is applied through 4 modules distributed in face-to-face meetings and online education, and they contemplate: human behaviour, service chains, resource management, leadership and financial impacts arising from occupational accidents and diseases. The method was applied at a hierarchical level with 49 professionals from companies of different sizes, being 25 foremen and team leaders, 18 engineers and 6 businessmen. Through these trainings, we were able to assess that the Leadership Training Program can contribute to the development of a participatory leadership culture, which is essential to foster an organizational environment of trust and commitment regarding occupational safety. It can also promote an organizational culture change focused on occupational safety to positively impact productivity, meeting deadlines and reducing occupational accidents.

Keywords: Leadership training program, Occupational safety and health; Construction industry.

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ORGANIZATIONAL, SYSTEMIC AND HISTORICAL ANALYSIS OF A SLAB COLLAPSE OCCURRED DURING AN AIRPORT CONSTRUCTION

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The structure collapse is one of the worst events of construction industry. During the construction of an airport, a structure collapsed at beam's concreting process injuring 16 workers. This paper aimed at understanding the organizational, systemic and historical determinants of this collapse to prevent similar ones in future. For this, it was applied the Model of Analysis and Prevention of Work Accident, the Model of Organizational Analysis Event and the Change Laboratory. This is a qualitative research with ethnographic data collection (observation, individual and collective interviews, document analysis and group sessions). The accident analysis allowed to understand the underlying and systemic causes of this event. It was originated in network with multiple failures in interaction (management of projects and changes; management of materials and logistics; management of outsourcing companies; management of emergencies; safety management). These factors emerged historically in the organization as a result of management decisions at different levels, including: government decisions which developed contradictions between the different elements of the activity system and that defined impractical schedule; hampered by formation of joint venture without expertise in project management; and without enough time to build a safety culture, aggravated by the turnover of directors. The activity system was in crisis and the resilience and commitment of workers prevented the occurrence of other accidents or anomalies. It is necessary to review the management model of large works in Brazil with an integrated safety management to the strategic management of the all construction.

Keywords: Occupational Health, Safety, Organizational analysis, Airport, Accident Prevention.

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