

KEY INPUTS INTO A DESIGNING FOR CONSTRUCTION HEALTH, SAFETY, AND ERGONOMICS MODEL IN SOUTH AFRICA

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Construction health, safety, and ergonomics is inadequately addressed by architectural designers during the design process and disturbing accident statistics prevail, despite evidence that construction hazards and associated risks can be mitigated through appropriate design. A review of relevant literature and a mix of quantitative and qualitative prior preliminary studies as part of a PhD (Construction Management) study provide a backdrop for this paper. A pilot study questionnaire comprising a quantitative and qualitative mix was developed and distributed to 73 architectural designers in the Border region of the Eastern Cape Province in South Africa who are registered with the SACAP in order to: establish the dynamics of a model; engender an appropriate framework for a model, and to identify a range of key inputs suited to the model framework. The salient findings based on response percentages and mean score, and a measure of central tendency: established that architectural designers would be encouraged to design for construction health, safety, and ergonomics if they had a technologically grounded, flexible model which promotes a buy-in situation without stifling architectural freedom to assist the design process; recognised the SACAP work stages as being extensively followed during the design process; found the NBR to be the most widely used construction documentation during the design process, and identified a range of key inputs suited to a proposed model framework. Further research is necessary and it is recommended that the structure of the NBR and the SACAP work stages be suitably integrated in order to form the framework for a proposed model as such a format would be readily understood by architectural designers, and that the proposed range of key inputs be integrated with the proposed model framework to create the proposed model.

Keywords: architectural designers, key input, model framework.

INTRODUCTION

Internationally, the construction industry has earned a poor reputation for health and safety (H&S) (Mroszczyk 2005; cidb 2009; Gangolells et al. 2010). The South African construction industry is no different and demonstrates disturbing accident statistics (Compensation Commissioner 1999). International regulation such as the UK's

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Construction (Design and Management) Regulations (CDM 2007), underpinned by The Approved Code of Practice (ACOP) (HSE 2007) place legal duties on architectural designers, among others, to engage in safe design. Similarly, the Construction Regulations of 2003 (with some recent amendment) in South Africa compel architectural designers to practice safe design (Republic of South Africa 2003), however a lack of appropriate education and competencies (Smallwood 2006; Toole and Gambatese 2006) and the level of attentiveness demonstrated by architectural designers (Behm and Culvenor 2011) severely hinders the process. The development of a user friendly model suited to the South African situation is expected to promote encouragement for architectural designers to practice healthy and safe design, and could be integrated into architectural education and training programmes (Smallwood 2006; Schulte et al. 2008). Mitigation of construction hazards and risks through healthy and safe design could eliminate up to 50% of construction accidents (Health and Safety Executive (HSE) 2003; Behm 2006; Toole and Gambatese 2006).

The review of the literature considers a range of possible key inputs suited to a proposed framework for an architectural design model aimed at improving construction health, safety, and ergonomics. These include: local and international literature; causes of construction accidents; hazard identification and risk assessments; international models, and design recommendations.

This paper follows three earlier preliminary studies as part of a PhD (Construction Management) study, and continues to forge the direction of the main study. This predominantly quantitative study set out to: establish the dynamics of a likely model; consider the extent to which architectural designers embrace the SACAP work stages; consider the application of the NBR as the most widely used construction documentation during the design process in order to consider it toward a model framework, and to identify a range of key inputs suited to a recommended model framework.

REVIEW OF THE LITERATURE

Local and international literature

This consideration overlaps other key inputs and is considered more general in nature. It is deliberately kept brief, but is included as a key input not only for consideration of extant literature, but to ensure consideration of future literature deemed suitable for constant evolution of the said model. While exercising healthy and safe design, it is imperative that the creativity of architectural designers is not inhibited (Gangoells et al. 2010). Examples exist where creativity and innovation have flourished while exercising safe design, and have simultaneously demonstrated a positive effect on cost, quality and schedule (Behm and Culvenor 2011). Architectural designers should be encouraged and demonstrate enthusiasm toward safe design which could be underpinned by regulation, rather than being driven by regulation (Behm and Culvenor 2011). Having an appropriate model in place could achieve just that and could enhance competencies by being included in architectural education and on-going training (Smallwood 2006; Schulte et al. 2008).

Hazard identification and risk assessments

Hazard identification involves identifying situations whereby people may be exposed to harm. Risk assessment involves the likelihood of harm occurring, and risk control involves the mechanisms applied to mitigate such hazards and risks (WorkSafe Victoria 2005). Relative to South Africa, Goldswain and Smallwood (2009) identified that "... architectural designers do not adequately conduct hazard identification and

risk assessments during the design process.” In order to achieve this from a design and construction point of view, Gangolells et al. (2010) identified a range of construction processes which can relate to construction hazards, and consider these in terms of risk probability and consequence severity. They also consider these in terms of the volume of work or exposure to any given process. The processes included are surprisingly similar to the framework of the NBR and includes, for example, earthworks, foundations, and structures (Republic of South Africa 2010).

International models

The Australian CHAIR is a fitting acronym for the Construction Hazard Assessment Implication Review which encourages designers to “... sit down, pause and reflect on possible problems.” (Workcover NSW 2001: 4) It offers three vital opportunities for all stakeholders to review design progression, respects the ‘principles of safe design’ and the ‘hierarchy of control’ offered by the Australian Safety and Compensation Council (2006). The United Kingdoms’ Gateway model (HSE 2004) provides opportunity for all stakeholders to assess the work undertaken by designers’, among others at given ‘gateways’ in the design and construction process. It includes a range of ‘support tools’ to facilitate such processes, and it expects stakeholders and designers to sign upon satisfaction of each gateway assessment before further work continues.

Design recommendations

Behm (2006) advocates and adds to the contributions of Gambatese and Weinstein who provided a range of design recommendations in order to promote safe design. These include, among others, recommendations relative to aspects of construction sites, inclusion of permanent safety features being incorporated into the design of structures, inclusion of safety information and warnings in construction documentation, appropriate scheduling of activities, establishing of procedures for specific activities, and includes the need for adequate competencies of all persons involved.

METHODOLOGY

This study follows three earlier preliminary studies, one of which was qualitative in nature, as part of a PhD (Construction Management) study which ultimately aims at developing a model suitable for use by architectural designers in South Africa in order to design for construction health, safety, and ergonomics. van Teijlingen and Hundley (2001) propose preliminary studies as crucial toward the success of the main study. All four have been dedicated to a gradualist approach of building a line of structured questioning for the 'action research' paradigm (Dick, 1993) using 'focus group' methodology for the main study (Azhar 2007; Cohen et al. 2007; O'Brien 1998). A survey of the literature and the previous preliminary studies contributed to the development of a questionnaire survey, chosen for cost effectiveness and to give respondents the opportunity to respond within their own time and in privacy (Leedy and Ormrod 2010). The primarily quantitative survey based on percentages, mean score and a measure of central tendency was conducted among a regional group of architectural designers in the Border region of the Eastern Cape Province in South Africa, registered with the SACAP. Questionnaires were distributed in hard copy to 73 randomly selected architectural designers and 15 responses were received, equating to a response rate of 20.5%. The low response rate can be expected from the South African construction industry (Crafford 2007). Relative to this paper, the questionnaire comprised 18 statements, inter alia, with respondents being required to

indicate on a rating scale or Likert type scale of 1 (totally disagree) to 5 (totally agree) the extent to which they concur (Leedy and Ormrod 2010). An 'unsure' option was included in order to accommodate uncertainty, as opposed to 'forcing' a 'scale' response. Open ended questions followed in order to solicit qualitative comments which could constitute additional emerging themes for the greater study. van Teijlingen and Hundley (2001), with reference to De Vaus' 1993 work, suggest the incorporation of both quantitative and qualitative questioning in pilot studies and what is referred to as 'mixed method design' by Leedy and Ormrod (2010). This quantitative study thus set out to: establish the need and nature of a likely model; consider the extent to which architectural designers embrace the SACAP work stages; consider the application of the NBR as the most widely used construction documentation during the design process in order to consider it toward a model framework, and to identify a range of key inputs suited to a recommended model framework.

FINDINGS

In the table which follows, the degree of concurrence is represented in terms of percentage responses to a scale of 1 (TD = totally disagree) to 5 (TA = totally agree), and a related mean score (MS) between 1.00 and 5.00, based upon the percentage responses. MSs $> 4.20 < 5.00$ indicate that the degree of concurrence can be deemed to be between agree (A) to totally agree / totally agree, while MSs of $> 3.40 < 4.20$ indicate that the degree of concurrence can be deemed to be between neutral (N) to agree / agree. MSs $> 2.60 < 3.40$ indicate that the degree of concurrence can be deemed to be between disagree (D) to neutral / neutral, while MSs of $> 1.80 < 2.60$ indicate that the degree of concurrence can be deemed to be between totally disagree to disagree / disagree. Allowance has been made for unsure (U) answers.

Table 1 indicates the degree of concurrence with statements related to designing for construction health, safety, and ergonomics. It is notable that 77.8% of the mean scores (MSs) are above the midpoint score of 3.00, meaning that architectural designers concur with most of the related statements. For purposes of discussion, the findings are elaborated in terms of themes as opposed to MSs, which are simultaneously reflected. The first theme seeks to establish the need and nature of a likely model. The MS of 4.18 relative to 'architectural designers would be more encouraged to design for construction health, safety, and ergonomics if they had a guiding model to assist them' is notable and motivates the need for a model. The profound MS of 4.60 relative to 'a guiding model should be technologically grounded and should not stifle architectural freedom' is significant. The MS of 4.07 relative to 'a guiding model should include checklists and allow opportunity for design notes in order to assist the process' is closely followed by the MS of 4.00 relative to 'a guiding model should be flexible in nature and should promote a buy-in situation making architectural designers more willing to use the model'. To the statement 'a guiding model should include a process which architectural designers can follow in order to design for construction health, safety, and ergonomics', a lesser MS of 3.60 was recorded followed by a MS of 3.40 relative to 'architectural designers would like a guiding model which includes prompts or keywords in order to engender deeper thinking during the design process', however it should be noted that 13.3% of respondents provided an unsure answer. The low MS of 2.64 relative to 'a guiding model should be prescriptive and regulatory in nature whereby architectural designers are forced by regulation to use the model' is also significant. The second theme focusses on a framework for the proposed model and embraces the second and third objectives of this study. The most significant MS of 4.33 relative to 'a guiding model

should have a framework which is familiar to architectural designers and offers ease of use' has substance. This is followed by the MS of 4.20 relative to 'architectural designers follow the SACAP work stages during the design process' and the MS of 4.00 relative to 'architectural designers use the application of the NBR during the design process'.

Low MSs are recorded relative to the use of other construction documentation and are significantly lower. The MS of 2.53 relative to 'architectural designers use a Bill of Quantities (BoQ) during the design process', the MS of 2.47 relative to 'architectural designers use the Preambles for Construction Trades during the design process', and the MS of 2.33 relative to 'architectural designers use a Work Breakdown Structure (WBS) during the design process' reflect this. The third theme seeks to identify a range of key inputs suited to a proposed model framework. To the statement 'architectural designers would need to understand the causes of construction accidents in order to design for construction health, safety, and ergonomics' a MS of 4.07 was recorded. The MS of 3.79 relative to 'consideration of existing design recommendations would prove beneficial to developing a guiding model suitable for use in South Africa' followed. The MS of 3.73 followed relative to 'consideration of local and international literature would prove beneficial to developing a guiding model suitable for use in South Africa'. Finally, two equal MSs of 3.53 were recorded relative to 'architectural designers would need to identify hazards and undertake risk assessments in order to design for construction health, safety, and ergonomics' and 'consideration of international models would prove beneficial to developing a guiding model suitable for use in South Africa' respectively.

Table 1: Degree of concurrence with statements related to development of a model

Statement	Response (%)							MS
	U	TD	D	N	A	TA	MS	
Architectural designers would be more encouraged to design for construction health, safety, and ergonomics if they had a guiding model to assist them	6.7	0.0	0.0	0.0	73.3	20.0	4.18	
A guiding model should be technologically grounded and should not stifle architectural freedom	0.0	0.0	0.0	0.0	40.0	60.0	4.60	
Architectural designers would like a guiding model which includes 'prompts or keywords' in order to engender deeper thinking during the design process	13.3	0.0	0.0	26.7	40.0	20.0	3.40	
A guiding model should be flexible in nature and should promote a buy-in situation making architectural designers more willing to use the model	6.7	0.0	6.7	13.3	20.0	53.3	4.00	
A guiding model should be prescriptive and regulatory in nature whereby architectural designers are forced by regulation to use the model	0.0	13.3	33.3	20.0	26.7	0.0	2.64	
A guiding model should have a framework which is familiar to architectural designers and offers ease of use	0.0	0.0	0.0	0.0	66.7	33.3	4.33	
Architectural designers use the application of the National Building Regulations (NBR) during the design process	0.0	6.7	6.7	13.3	26.7	46.7	4.00	
Architectural designers use a Bill of Quantities (BoQ) during the design process	0.0	13.3	26.7	53.3	6.7	0.0	2.53	
Architectural designers use a Work Breakdown Structure (WBS) during the design process	6.7	13.3	33.3	40.0	0.0	6.7	2.33	
Architectural designers use the Preambles for Construction Trades during the design process	0.0	20.0	26.7	40.0	13.3	0.0	2.47	
Architectural designers follow the SACAP 'work stages' during the design process	0.0	0.0	0.0	13.3	53.3	33.3	4.20	
Architectural designers would need to understand the causes of construction accidents in order to design for construction health, safety, and ergonomics	0.0	0.0	0.0	26.7	40.0	33.3	4.07	
Architectural designers would need to identify hazards and undertake risk assessments in order to design for construction health, safety, and ergonomics	6.7	0.0	6.7	20.0	53.3	13.3	3.53	
Consideration of 'local and international literature' would prove beneficial to developing a guiding model suitable for use in the context of South Africa	6.7	0.0	0.0	20.0	53.3	20.0	3.73	
Consideration of suitable 'international models' would prove beneficial to developing a guiding model suitable for use in the context of South Africa	6.7	0.0	0.0	26.7	60.0	6.7	3.53	
Consideration of existing 'design recommendations' would prove beneficial to developing a guiding model suitable for use in the context of South Africa	0.0	0.0	0.0	40.0	33.3	20.0	3.79	
A guiding model should include a process which architectural designers can follow in order to design for construction health, safety, and ergonomics	0.0	6.7	0.0	33.3	46.7	13.3	3.60	
A guiding model should include 'checklists' and allow opportunity for 'design notes' in order to assist the process	0.0	0.0	6.7	6.7	60.0	26.7	4.07	

Relevant open ended questions and responses are included as follows:

'Do you have any comments or suggestions regarding a possible framework for a guiding model?'

- Exposure of professionals to necessity of a model would highlight shortcomings in knowledge, and
- Good idea to relate to SANS 10400 (NBR).

‘Do you have any comments or suggestions regarding possible inputs into the framework of a guiding model?’

- Checklist, and
- Exposure and understanding of construction technologies.

‘Do you have any comments or suggestions relative to construction health, safety, and ergonomics?’

- Designers and architectural practitioners should be actively exposed to the physical construction process of projects to ensure a practical understanding of the erection and construction process and constraints;
- Use CDM regulations from the UK as a benchmark, and
- Very important as deaths / accidents far too high.

CONCLUSIONS

Given the objectives and methodology of the study, it is likely that the responses received were from the more committed architectural designers.

The findings relative to the first theme querying the dynamics of a model indicate that architectural designers would be encouraged to design for construction health, safety, and ergonomics if they had a technologically grounded, flexible model which promotes a buy-in situation without stifling architectural freedom to assist the process. A flexible process is required which includes the need for checklists and allows opportunity for capturing of design notes. Slightly less enthusiasm was expressed relative to the need for prompts and keywords, but some doubt existed in this area. It was made clear that the model must not be prescriptive and regulatory in nature if a buy-in is to be expected.

The findings relative to the second theme clearly indicate that architectural designers suggest a model framework which is familiar to them and offers ease of use. As extensive use is made of both the SACAP work stages and the NBR during the design process, these strongly lend themselves as a model framework which will be familiar and easy for architectural designers to use. It is clear that BoQs, Preambles for Construction Trades and WBSs will not form a suitable model framework. The third theme sought to identify a range of key inputs suited to a proposed model framework. While an understanding of the causes of construction accidents predominated, consideration of existing design recommendations, consideration of local and international literature, the need to identify hazards and undertake risk assessments, and consideration of international models all proved valuable as key inputs. The open ended qualitative questions suggest the importance of the study as accidents and death rates are ‘far too high’, and that exposure and enhanced understanding by designers is required. International benchmarking in the form of the UK's CDM Regulations is also suggested and it is a ‘good idea’ to relate the model framework to the NBR.

Architectural designers require an enhanced contextual understanding of construction health, safety, and ergonomics and further research is required toward development of an appropriate model. It is recommended that the NBR and the SACAP work stages

be suitably integrated in order to form the framework for a proposed model as such a format would be readily understood by architectural designers, and that the proposed range of key inputs be integrated with the proposed framework toward development of the envisaged model.

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