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Knowledge, attitude and practices for design for safety: A study on civil & structural engineers

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ABSTRACT

Design for safety (DfS) (also known as prevention through design, safe design and Construction (Design and Management)) promotes early consideration of safety and health hazards during the design phase of a construction project. With early intervention, hazards can be more effectively eliminated or controlled leading to safer worksites and construction processes. DfS is practiced in many countries, including Australia, the UK, and Singapore. In Singapore, the Manpower Ministry enacted the DfS Regulations in July 2015, which will be enforced from August 2016 onwards. Due to the critical role of civil and structural (C&S) engineers during design and construction, the DfS knowledge, attitude and practices (KAP) of C&S engineers have significant impact on the successful implementation of DfS. Thus, this study aims to explore the DfS KAP of C&S engineers so as to guide further research in measuring and improving DfS KAP of designers. During the study, it was found that there is a lack of KAP studies in construction management. Therefore, this study also aims to provide useful lessons for future applications of the KAP framework in construction management research. A questionnaire was developed to assess the DfS KAP of C&S engineers. The responses provided by 43 C&S engineers were analyzed. In addition, interviews with experienced construction professionals were carried out to further understand perceptions of DfS and related issues. The results suggest that C&S engineers are supportive of DfS, but the level of DfS knowledge and practices need to be improved. More DfS guidelines and training should be made available to the engineers. To ensure that DfS can be implemented successfully, there is a need to study the contractual arrangements between clients and designers and the effectiveness of different implementation approaches for the DfS process. The questionnaire and findings in this study provided the foundation for a baseline survey with larger sample size, which is currently being planned. In contrast to earlier studies, the study showed that the responding C&S engineers were supportive of the DfS. The study showed that the key to improving the DfS KAP of C&S engineers is by improving clients' motivation for DfS.

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1. Introduction

It is important to ensure that all key stakeholders in the construction industry, i.e. clients/developers, architects, engineers and contractors, do their part to minimize risks to construction workers, maintenance workers and users of the building or structure being constructed. The concept of design for safety (DfS) was introduced to minimize the risk of accidents and ill health through the consideration of hazards during upstream design phases of a construction project (Gambatese et al., 2008). DfS is also known as prevention through design (López-Arquillos et al., 2015), safe design (Safe Work Australia, 2012) and Construction (Design and Management) (Health and Safety Executive, 2015a). Even though the concept of DfS is applicable to the whole lifecycle of a structure, this study is focused on the safety and health of construction workers (Gambatese et al., 2005), who are usually the victims of construction accidents.

There had been significant research on DfS and most studies supported the importance of improving site safety and health through elimination and mitigation of hazards during design (e.g. Behm, 2005; Gambatese et al., 2005; Gangolells et al., 2010; Larsen and Whyte, 2013). However, several barriers to the implementation of DfS were identified in the literature. For instance, Gambatese et al. (2005) highlighted that there was a lack of consideration for safety during design in the US and the underlying issues include designer mindset toward safety, a lack of safety knowledge among

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designers and concerns about liabilities. Larsen and Whyte (2013) found that even after 18 years of the UK Construction (Design and Management) (CDM) Regulations, there were still challenges in getting buy-in from designers and "safety is very much seen as an afterthought or bolt-on to the design". This is consistent with the study by Brace et al. (2009), which found that designers typically do not see safety and health as part of their job. López-Arquillos et al. (2015) found that there is a lack of emphasis on DfS in the university courses for architects and engineers in Spain. The lack of tertiary education on DfS can easily lead to inadequate knowledge, attitude and practices (KAP) to implement DfS effectively.

In Singapore, the Manpower Ministry enacted the DfS Regulations in July 2015 (Ministry of Manpower, 2015) to drive safety improvement in the construction industry. The new Regulations came after the DfS was introduced as a voluntary scheme in 2008 (Workplace Safety and Health Council, 2011), and it will only come into force in August 2016. Singapore is not a pioneer in making DfS mandatory, for e.g. the European Union made DfS mandatory in the 1990s. To ensure effective implementation of the DfS Regulations, it is important to monitor and improve the DfS KAP of all stakeholders, including civil and structural (C&S) engineers. Thus, this study aims to explore the DfS KAP of C&S engineers so as to guide further research in measuring and improving DfS KAP of designers. During the study, it was found that there is a lack of KAP studies in construction management research. Therefore, this study also aims to provide useful lessons for future applications of the KAP framework in construction management research.

2. Knowledge, attitude and practices (KAP) study

The current concerns about the DfS KAP of designers need to be carefully examined so that the intent of DfS can be implemented effectively. KAP studies are common in the medical and public health disciplines (e.g. World Health Organization, 2007; Yassin et al., 2002) and they are usually used to facilitate evidence-based interventions to improve the situation or behavior of a target group. The key component of a KAP study is a questionnaire survey (World Health Organization, 2007), which can be complemented with focus groups, in-depth interviews and observations. Despite its popularity in the medical and public health domain, the KAP framework was rarely used in construction management research. The KAP framework facilitates exploration of what C&S engineers know about DfS (knowledge), their attitude toward DfS (attitude) and how they are applying DfS in the real world (practice). These information are valuable for designing targeted interventions to increase the consideration of safety and health issues during design.

This study consists of two main components: an online questionnaire survey and a series of 8 semi-structured interviews with experienced C&S engineers. The survey questionnaire contained 4 main sections, namely, knowledge, attitude, practice and general information. Table 1 presents an overview of the KAP questionnaire. The questionnaire was developed based on a review of past research on DfS. In addition, five pilot surveys were conducted prior to administering the survey to assure face validity, improve the clarity of the instructions and assess the time needed for the survey. The link to the online questionnaire was publicized through the Institution of Engineers Singapore (IES) and the personal contacts of the researchers. As recommended by World Health Organization (2007) a variety of question types, e.g. multiple choice, ranking and Likert scale, were used in the survey to explore the KAP of the C&S engineers.

Eight semi-structured interviews were also conducted to supplement the questionnaire survey and provide a more holistic understanding of the current situation. A set of interview questions was developed prior to the interviews, but the discussion may deviate from the prepared questions depending on the responses from the interviewees (Silverman, 2010). The interviews were generally focused on C&S engineers' KAP in terms of DfS, barriers and motivators for effective DfS, possible interventions to improve DfS and impact of DfS on design.

Table 1
Overview of KAP questionnaire.

Question	KAP area
1. When did you first learn about the concept of Design for Safety? (Multiple choice)	Knowledge
2. How did you first learn about Design for Safety? (Multiple choice)	Knowledge
3. Have you attended any Design for Safety training course? (Yes/No)	Knowledge
4. Rate your understanding on the concept of Design for Safety. (Likert scale of 1–6)	Knowledge
5. Rank your level of familiarity with implementing Design for Safety during concept, detailed and pre-construction design stages. (Rank 1–3)	Knowledge
6. Indicate your level of familiarity with the corresponding controls for each hazard. (Likert scale of 1–6 for each item on a list of 16 hazards or accident types)	Knowledge
7. Do you think implementation of Design for Safety is important (Likert scale 1–6)?	Attitude
8. Which stakeholder has the greatest influence on the safety of your design? (Multiple choice)	Attitude
9. Which stakeholder is your greatest motivation for undertaking safety in designing? (Multiple choice)	Attitude
10. My professional duty should involve designing for safety. (Agree/Disagree)	Attitude
11. The factors contributing to the success of Design for Safety are: (Rank a list of 5 factors)	Attitude
12. Do you agree that Design for Safety will improve the injuries and fatalities rate in the construction industry? (Agree/Disagree)	Attitude
13. Have you ever been asked to address construction worker health and safety in the design phase? (Multiple choice)	Practice
14. The role of a Design for Safety Coordinator is essential in facilitating design for safety. (Likert scale)	Practice
15. What are the problems you faced when designing for safety? (Select more than one from a list with 8 options including "Others")	Practice
16. Which of the following concerns do you have for design for safety? (Rank 1–4 with a separate open ended question for other concerns)	Practice
17. Are there sufficient DfS guidelines, manuals, online resources or other material to facilitate planning? (Likert scale 1–6)	Knowledge/ Practice
18. What are the types of design guide that you use to facilitate your design work in general? (Open ended question)	Knowledge/ Practice
19. In your opinion, what other type of design guide will assist you in carrying out your DfS duties as a designer? (Identify top 3 with rank 1–3)	Knowledge/ Practice
20. Please leave other feedback here.	

3. Survey data and discussion

3.1. Respondents

A total of 67 survey responses were collected, but 19 of the responses were incomplete, i.e. 48 responses were complete (72% completion rate). Response rate could not be calculated because the link was disseminated via the internet and emails. Thus, the number of persons that received the link was not known. In addition, five of the respondents were not C&S engineers and had to be removed. Thus, finally a total of 43 responses were considered in this analysis. Out of the 43 responses, 17 (40%) had more than 10 years of experience in the industry. 95% of the respondents had at least 1 year of experience. Twenty-two (51%) of the respondents were at least 31 years old at the time of the survey.

During the survey, it was realized that many of the respondents misunderstood the automatic ordering feature for ranking type questions. This resulted in many respondents not responding

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