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## CONSTRUCTION SAFE DESIGN APPROACH

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### Abstract

*Safe design approach is a new scenario in Malaysia. In common practice, construction safety is only emphasized during the construction phase. Hence, the most effective method in enhancing construction safety during design phase was not realised. Developed countries have practiced construction safe design to boost their safety level. Lack of awareness and the involvement of construction stakeholders in safe design practices have caused this approach to be marginalized. This study was conducted to determine the level of awareness on construction safe design among Malaysian professionals. Additionally, this study also identifies the party that should play key role in implementing this approach. Questionnaires were used as research instrument. 295 construction professionals were identified as respondents in this study by the chosen purposive sampling technique. From the analysis, the awareness level among the construction professionals was at moderate level. The authorities were identified as the parties that should play the central role in implementing this approach comprehensively.*

**Keywords:** awareness, construction, professionals, safe design.

### 1. Introduction

Malaysian construction industry recorded high fatality rate due to accidents at workplace compared to other sectors (CIDB 2005). Assessment by CIDB (2007) showed that construction industry recorded the highest percentage of accident fatality compared to agriculture, forestry and fishery as well as manufacturing industry. Although the overall figure of the fatal accident had decrease, the mortality rate was still unacceptable. Mortality rate in construction industry was 26 people per every 100,000 employees (CIDB 2007). This figure proved that the issue of construction safety is in critical stage. Moreover, construction industry was also labeled as 3D image namely **dirty**, **difficult** and **dangerous** (CIDB 2007). In the effort to improve construction safety, diverse efforts, strategies and operations were implemented involving the stakeholders. One of the safety approaches with less attention in construction industry was safe design. Safe design is an approach to eliminate hazards and mitigate risks earlier at design phase in order to improve construction safety. Study has been carried out to determine the awareness of construction professionals and identify the party that hold major responsible in implementation of this approach.

### 2. Literature Review

Construction safe design approach is an intervention to prevent construction accident by considering design related hazards during design phase of construction project (Workcover 2009). This approach begins at conceptual and design phase with integration of design choice, material utilized and construction method along with the initiative to enhance construction safety (ASCC 2006). Designers will take into consideration of safety aspect in every phase in construction lifecycle including construction, occupancy, maintenance, refurbishment and demolition phase. In other words, designers will allow for construction safety in all factors for instance feasibility, function, technical and finance in design decision of a construction project (RIBA 2007). There are five principles in implementing construction safe design approach. Table 1 defines the safe design principle i.e. human control, lifecycle, risk management, knowledge and experience as well as information transfer.

Table 1: Principles of construction safe design

Principle	Element	Description
1	Human control	Responsibility on all stakeholders who are related to design and construction projects.
2	Lifecycle	Emphasis at all phases of construction projects from conceptual phase to demolition phase.
3	Risk management	The usage of systematic risk management approach i.e. identification, assessment & hazard control.
4	Knowledge and experience	Requires knowledge and experience to be practiced by parties involved.
5	Information transfer	The need of effective documentation and communication between the parties involved in construction projects.

Source: Adapted from Workcover 2009, ASCC 2006

Construction safe design approach is a design initiative to prevent construction accident prevention (Gambatese et al. 1997, Mroszczyk 2006). It was generated from decision of the design team during the early phase of construction project lifecycle. Photo 1, Photo 2 and Photo 3 are the examples of construction safe design practiced. Photo 1 shows a hook fitted to beam for construction workers to suspend lanyard of their safety harness as fall from height protection. Photo 2 shows a flat roof equipped with anchorage point for construction and maintenance worker to suspend lanyard of their safety harness as fall from roof protection. Photo 3 is a walk able route at steep roof. Handrails were design along the walk able route to eliminate hazard of stepping on brittle or unsuitable roof material.



Photo 1: Beam with hook for workers to suspend lanyard of their safety harness as fall from height protection  
 Source: <http://www.anchorsafe.com.au>



Photo 2: Flat roof with anchorage point for workers to suspend lanyard of their safety harness as fall from height protection  
 Source: <http://www.anchorsafe.com.au>



Photo 3: Walk able route with handrails at steep and brittle roof  
Source: <https://millrace.uoregon.edu/uopress/index.cfm>

There are several construction safe design approaches that have been practiced in developed countries such as Design for Construction Safety Toolbox (DfCS), Construction (Design and Management) Regulation 2007 (CDM 2007), Construction Hazard Assessment Implication Review (CHAIR) and Guidelines on Design for Safety in Building and Structures (GUIDE).

DfCS has been developed in United States as tool to prop up the integration of worker safety in design (CII 2011). DfCS is interactive computer software with construction safe design databases. The database of construction safe design are classified according to building category, project size and building elements i.e. structural, roof, staircase, electrical and piping works. Suitability of the safe design could be verified by DfCS user through a graphic system. (Marini 2007). Safe design consideration during design phase could control hazards as well as reduces risks of construction accidents (Marini 2007). Furthermore, DfCS could contribute in increasing safety level during maintenance, occupancy and demolition phase of a project (Gambatese et. al. 1997).

CDM 2007 has been enforced in United Kingdom's construction industry to integrate safety and health with design. This regulations emphasized on integration of project management, design, coordination, communication with construction safety (Summerhayes 2008). Approved Code of Practice (ACoP) was developed in line with CDM 2007 as practical guide to stakeholders. Project that exceeded 30 days of construction or involve more than 500 workers per day had to be reported to Health Safety Executive (HSE) (HSE 2010). CDM Coordinator should be elected as to handle information management before construction works begin. The CDM Coordinator also responsible to prepare Safety and Health File where it must be kept and updated after the project kick off (HSE 2010).

CHAIR was introduced at Australia as a framework to eliminate or minimized construction risks (Workcover 2001). CHAIR is conducted by facilitators who assist all construction stakeholders to identify hazards related to design. Reasonable actions and design changes will be carry out for the safety of construction, repair, maintenance and demolition works (Workcover 2001). CHAIR consists of 3 stages namely (Workcover 2001):

- i. CHAIR 1 – implemented during the conceptual phase i.e the best opportunity for early design changes.
- ii. CHAIR 2 – implemented after design has been produced but before the construction starts. It focuses on construction and demolition issues.
- iii. CHAIR 3 – implemented together with CHAIR 2. It focuses on maintenance and repair works issues.

A regulation called GUIDE was put into practice in Singapore in line with Workplace Safety and Health Act 2006 (WSH Act). GUIDE provides guidance in construction safe design practice through the whole project life cycle. GUIDE lists the roles of all construction stakeholders and encourages design review through an orderly framework. Design review process should be chaired by Safety and Health Coordinator who has qualification in safety and construction aspects. Risk identified during the design review process will be recorded in Safety and Health Risk Register (SHRR) for future reference (WSH 2008). Apart from that, risk that could not be eliminated by design changes will be also recorded to be highlighted to the potential contractors during tendering process.

### 3. Methodology

This study was undertaken through secondary and primary data collection. Secondary data collection occupies published and unpublished manuscript. Published manuscript includes books, academic journals, proceeding papers, professional's articles and government publications. Unpublished manuscript includes working papers, dissertations and theses. Primary data collection was carried out base on survey perceptions. Questionnaire was used as the research instrument and ordinal scale was applied as the scale of measurement. The respondents are construction professionals from various working fields and experience in construction industry. 295 respondents with technical, management and academic background had given feedback in this study.

Relative important index (RII) was used to analyse the primary data. The purpose of this index is mainly to determine RII of the respondent's perception. Aggregate scores obtained from the study were changed to RII (Tam et al. 2000). RII value was set between 0 to 1. Increasing RII value approaching the maximum value of 1 describes the higher level of the item. RII value can be arranged according to the leveling that depends on the suitability of the item. In this study, RII leveling of item was adapted based on five standards as suggested by Kometa et al. (1994) (Table 2). The equation of RII is as follows (Kometa et al. 1994, Tam et al. 2006):

$$RII = \frac{\sum W}{AN}$$

Where,

- RII = Relative Important Index
- W = Weightage for every item
- A = Highest weightage (for this study is 5)
- N = Number of respondents

Table 2: Level of relative important index

Relative important index (RII)	Level
0.00 - 0.20	Very low
0.21 - 0.40	Low
0.41 - 0.60	Moderate
0.61 - 0.80	High
0.81 - 1.00	Very high

#### 4. Result and analysis

The survey on perception of construction professionals was conducted to identify their awareness level on construction safe design and Occupational Safety and Health Act (OSHA). OSHA is the act that enforced as to ensure safety and health of workers in Malaysia. The result shows a significantly high level of awareness towards OSHA (RII = 0.816) (Table 3). However, the average awareness of construction safe design approaches was only at moderate level (RII = 0.518). Table 3 illustrates the details of awareness level on the construction safe design approaches namely CDM (RII = 0.535), CHAIR (RII = 0.521), GUIDE (RII = 0.508) and DfCS (RII = 0.506).

From this research, it was revealed that the awareness level on the approach of construction safe design among Malaysian construction professionals was at moderate level. Impact on the lack of awareness of construction safe design approach was pathetic performance on safety (Suraji et al. 2001 & Haslam et al. 2005). Jefferey and Douglas (1994) also proved that performance on site safety associated with design decision made in construction project. In other words, the awareness level of construction safe design should be raised in order to improve safety performance. Related ministries and training providers should take immediate action to enhance awareness level and promote construction safe design among construction professionals. As government linked training providers, NIOSH and CIDB could organise seminar and courses to educate as well as encourage the application of construction safe design.

Table 3: Awareness level on construction safety and construction safe design approaches

Awareness	RII	Level
<b><i>Construction safety</i></b>	<b><i>0.816</i></b>	<b><i>Very high</i></b>
Akta keselamatan dan kesihatan 1994 (Akta 514)	0.816	Very high
<b><i>Construction safe design approaches</i></b>	<b><i>0.518</i></b>	<b><i>Moderate</i></b>
Construction (Design and Management) Regulation 2007 (CDM 2007) - United Kingdom	0.535	Moderate
Guidelines for safe design (GUIDE) - Singapore	0.508	Moderate
Construction Hazard Assessment Implication Review (CHAIR) - Australia	0.521	Moderate
Design for Construction Safety Toolbox (DfCS) - United States of America	0.506	Moderate

Apart from the awareness on the implementation of construction safe design, the party that should play the major role was also identified. Table 4 shows the construction stakeholders ranking based on the RII magnitude in identifying the major role. Generally all stakeholders have very high importance on the implementation of construction safe design (RII = 0.912). Based on the interposition, authorities (RII = 0.925) are the key player followed by safety and health officers (RII = 0.919) and design consultants (0.915).

This research analysis found that authorities should play as the key role to recognize implementation of construction safe design in Malaysian construction industry. They should give attention to this issue through enforcement of act or regulations in a comprehensive manner. Adaptation of CDM 2007 to fit within Malaysia's context may be a good approach as a start. This findings in Malaysia scenario was contrast to other countries. Gambatese (1998), Toole et al. (2006) and Mrosczyk (2009) found that the major role for the implementation of construction safe design is design consultants. The role of authorities is merely giving guides and encouragement of the implementation to stakeholders (Workcover 2001, WSH 2008).

Table 4: The ranking of construction stakeholder's roles on construction safe design implementation

Roles	RII	Level	Ranking
<b><i>Construction stakeholders</i></b>	<b><i>0.912</i></b>	<b><i>Very high</i></b>	
Design consultants	0.915	Very high	3
Developers	0.906	Very high	4
Safety and health officers	0.919	Very high	2
Contractor s	0.894	Very high	5
Authorities	0.925	Very high	1

## 5. Conclusion

Construction safe design approach has been practiced by developed countries more than ten years ago. On the contrary, this approach was a new scenario in Malaysia construction industry. Lacks of awareness among construction professionals constitute restriction towards the implementation. In order to increase the level of awareness, safety and construction training provider should conduct appropriate courses and seminar to educate the relevant construction stakeholders especially the professionals as they are the decision makers in of construction projects. Apart from that, the authorities should play the central role to boost the implementation of construction safe design. Regulations and enforcement related to this approach are important measures towards the success of this approach. It is hope that the implementation of construction safe design able to enhance the construction safety in future.

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