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WORKERS' SAFETY DURING CONSTRUCTION: INVESTIGATING THE INTEGRATION OF SAFETY FEATURES INTO DESIGN PROCESS IN MALAYSIA CONSTRUCTION INDUSTRY

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Abstract
Previous construction safety studies in Malaysia addressed current activities and conditions at the construction site but did not consider potential factor or sources involved in the design phase. As safety has been part of an integrated into contractors' core business activities, previous construction safety studies in Malaysia were focusing solely on the role of the contractor rather than adopting the broader view of accident causality that looks at upstream including the design process. Although construction safety has traditionally rested on the main contractor's shoulders, architects have been identified as parties to the project team who have a significant influence on construction workers' safety features and can positively influence construction site safety. The reason is because, an architect is a person trained in the planning, design and oversight of the construction of buildings. Professionally, their decisions during design phase affect construction safety. For this reason, this research attempts to identify and determine the current practices of integrating construction workers safety during designing. A survey, as well as semi-structured interviews were used as methods for data collection. Result revealed that there was some practice in the integration of Construction Workers' Safety Features during Design Process among Malaysian Architects although the implementation was insignificant. However, the practices were done through individual initiative and informal basis.

Keywords: Construction Workers Safety, Design Phase, Safety Features, Design forSafety.

1. Introduction

Throughout the history of the construction industry, safety has been part of an integrated into contractors' core business activity. Construction specifically is widely recognised as one of the most hazardous occupations for those who work in the industry. Up until now, with the rapid increase of Malaysian construction activities, construction safety has become a big concern because workers injuries cause tremendous losses. In light of the previous study conducted, Teo et. al., (2011) highlighted that construction accidents may incur considerable financial losses for building contractors, which would in turn motivate contractors to prevent construction accidents. Thus, in order to prevent major construction accidents, the accident factor identification and risk assessment is an essential requirement (Lin et. al., 2011). Statistics from the Social Security Organization (SOCSO) showed that Malaysia, recorded a worrying increase in the numbers of accidents occurring at the construction sites indicating the number of permanent disabilities and fatalities from year 1996 to 2008 (Dayang et. al., 2010). Based on the record, on the average, five thousand accidents occurred in construction sites annually between 2000 and 2004 (Onn, 2006). Onn further explained that this figure represents about 5 to 6.5 percent of the total number of accidents reported over the period and an average of eighty workers were killed in such accidents. On the other hand, remain one party that has not been involved in safety. According to Gambatese et al (1998), no one has previously considered the role that designers play in influencing construction safety. Toole, (2005), Baxendale et. al (2000), stated that designers should have responsibility for recognizing that safety and constructability are important considerations when preparing construction plans and specification. To date, no research about the idea been studied in Malaysia. Thus, it sparks an interest to do research on the subject matter in order to identify whether Malaysian architectural body corporate firms have exercised some sort of checklists or specific approach in addressing safety in their design.

2. Literature Review

Construction workers are clearly at the high risk when carrying out their tasks and duties on site. They are directly involved with the construction design, construction materials, construction process and etc. Across the globe, people are now more concern about the safety of construction workers. More and more people are talking about the needs of safety precaution in the design and construction process to cater the effect of safety hazard in construction industry, NIOSH (1996), A. Che Ahmad & I. Bahari (2008). In some developed countries, serious efforts had been taken towards sustainable development, and this includes the needs to protect construction workers during construction. Simple guidelines have been developed for construction industries to play their part towards ensuring the workers' safety during construction. It is to ensure that the employees are healthy physically, mentally and socially and are safe against any risks or work hazards or illness (M. Sharif. S., 2007). Previous construction safety studies in Malaysia addressed activities and conditions at the construction site but did not consider potential factor causes in the design phase. They were focusing solely on the role of the contractor rather than adopting the broader view of accident causality that looks at upstream including the design process (A. Che Ahmad & I. Bahari, 2008). Architects can positively influence construction site safety by integrating construction workers safety consideration into the design process such as hazards Prevention through Design (CHPtD) before any construction activities take place (M. Gangolells et. al., 2010). This is backed up by a study (Behm, 2005 and Haslam et. al. 2005) that there is a strong correlation between deaths at construction site with design concept because faulty designs can be a significant contributing factors towards accidents in this particular industry. There are various definitions by scholars and authors about the concept of integration of safety features into design process for Construction Workers. Behm, M. (2005) in his paper, academically defines the concept as the consideration of construction site safety in the design of a project. He further explains that the concept includes modifications to the permanent features of the construction project in such a way that construction site safety is considered. He believes the concept needs the utilization of specific design for construction safety suggestions and also the communication of risks regarding the design in relation to the site and the work to be performed. Other researchers, Mroszczyk, J.W. (2006), Bluff (2003), Lingard et. al. (2005) and M. Gangolells et. al. (2010) also agreed that the concept is about integrating appropriate design features which consider site safety as early as possible in the design process.

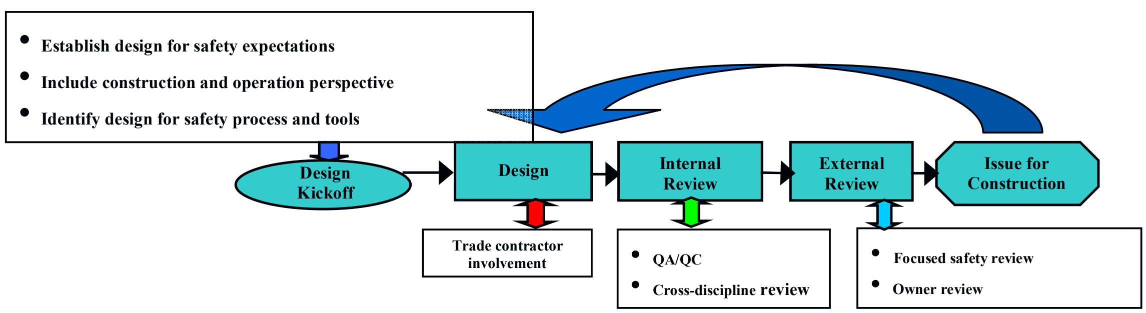

Figure 1: The Process in Integration of safety features into design process
Sources: Gambatese (1997)

Figure 1 depicts the typical process in integrating safety features into design process. The key component of this process is the incorporation of site safety knowledge into design decisions. Ideally, site safety would be considered throughout the design process. It is recognized, however, that a limited number of progress reviews for safety may be more practical. The required site safety knowledge can be provided by one or more possible sources of such safety constructability expertise, including contractors, in-house employee or an outside consultant (Jillings, et. al, 2005). They quoted that, "Drawings and technical specifications on the integration concept will likely at least initially look the same as typical documents, but they will reflect an inherently safer construction process. Eventually, it is hoped that construction documents resulting from the integration of safety features will include safety enhancing details and notes that are not currently found on standard plans and specifications". There was various safety measures developed by the previous researchers to aid the designers consisting architectural, civil and structure and also electrical and mechanical discipline developed by Berger, (1999), Gambatese and Hinze, (1999), Hecker and Gambatese, (2003) as cited in Bluff (2003), Gambatese (1996) and Behm (2006). Generally, their sources of compilation on the safety measures were from incident investigation reports from National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment Control and Evaluation (FACE) United Kingdom program.

There was various basis design developed by the previous researchers to aid the designers as the baseline safety measures. The basis designs were developed by Berger, (1999), Gambatese and Hinze, (1999), Hecker and Gambatese, (2003), Lorent, (1999) cited in Bluff (2003), Gambatese (1996) and Behm (2006). Generally, their sources of compilation on the basis design consideration were from incident investigation reports from National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment Control and Evaluation (FACE) United Kingdom program. In this study only fall protection will be taken into considerations. Many work activities involve working at height. Working from ladders, scaffolds and platforms are obvious examples, but there are many more activities where people are required to work at height. Examples include roof work and working over tanks, pits and structures. Falls from height are responsible for many serious and fatal injuries every year. If fall from a height above two metres the likelihood is that we will sustain a serious injury. Statistics revealed by Haslam, et. al. (2005) showed that the most common causes of major injuries were falls from height which contribute about 38%. Followed by slips, trips and falls on same level and struck by moving (flying/falling) object, each about 19%. Many workers in maintenance and construction, but many other people in a variety of jobs could be at risk of falling from height at work. Examples include: painters, decorators and window cleaners and those who undertake one-off jobs without proper training, planning or equipment. The main hazards associated with working at height are people falling, and objects falling onto people. These may occur as a result of inadequate edge protection, or poor securing of people or objects in storage (Construction Industry Council, 2004). Under the heading of fall protection, the variables that will be highlighted are guardrails, permanent anchorage, parapet wall, openings demolition or renovation of roof structure.

Guardrail system defined by University of North Carolina as a barrier erected to prevent employees from falling to lower levels. Whereas they describe that Standard railing consist of a top rail, intermediate rail, toe board and posts and shall have a vertical height of approximately 42" from upper surface of top rail to the floor. The basic design considerations of guardrails involved (a) design handrails, guardrails to be built as part of erection process, (b) schedule handrails, guardrails to be built as part of erection process, (c) construct permanent guardrail system sequence early in to the schedule to allow their use by construction workers during ventilation system, trash chutes, elevator etc. (d) design fall protection mechanism guardrails systems (permanent guardrails, anchor point) when designing atrium of building, (e) design permanent guardrail system for use by all contractors during designing ventilation system, trash chutes, elevator which cause floor openings to occur during construction, (f) design permanent guardrails around skylights (a window built into a roof to allow light in) and (g) construct fall protection mechanism in to the schedule to allow their use by construction workers during constructing atrium. Anchorage means a secure point of attachment for lifelines, lanyards or deceleration devices (University of North Carolina, 2004). In order to limit the construction workers exposure to these hazards or mitigate the consequences of them, architects should designing elements which allow the attachment of anchorage lines where appropriate. This is because when erecting structures, construction workers often find themselves, in precarious position, e.g. straddling unattached beam, working towards an open edge, etc (Construction Industry Council, 2004). In addition constructing a roof creates an advancing unprotected leading edge and the risk from falling off this edge (Construction Safety Association of Ontario, 2001). Therefore, the anchorage points should be integrated by architects in their design (see Figure 2).

Parapet wall incorporated into designed as edge protection to prevent harm to the person who slides into it. According to Construction Industry Council, 2004, the parapet wall should be provided wherever there is an edge e.g. building parameters, stair and lift well. The design of parapet wall and window sills is suggested 1000mm high above floor level. It is also recommended that the warning for the ventilation system, trash chutes, elevator which causes floor openings during construction plans and specification is provided. According to University of North Carolina, opening is define as a gap of size 760mm high x 480mm wide or greater in walls, partitions and floors, through which construction workers can fall to a lower level (see Figure 3). Roofs are another hazardous places to work due to height, sloping surface, lightweight, fragile and deteriorating covering materials. While construction activities on roof are infrequent, however, the opportunities for fatal or serious accident are high. People are often killed or injured when falling from roofs thus it is recommended to determine condition of roof, trusses, purlins structure before demolish or renovate roof structure which is damage to evaluate how fall protection devices will be incorporated into a damaged structure. Thus, designers can play a major part in ensuring that hazards associated with roof constructions can be minimised.

Figure 2: Illustration of an anchorage point on top of roof

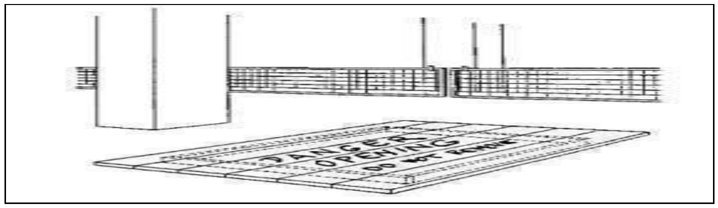

Figure 3: Illustration of an anchorage point on floor surface

3. Methodology

This research commenced by reviewing the relevant literature review on construction safety from journals, conference paper, books, internet etc. This was followed by questionnaire survey to assist in the data collection process. Architect personnel were randomly selected from 100 out of 107 architectural body corporate consultant companies listed in Lembaga Arkitek Malaysia (LAM). They were selected due to their past experiences on high scale projects. The questionnaires are divided into three (3) sections; Section A which consists of general information of the respondents and the companies, Section B purposely designed to investigate the respondent implementation and acceptance on the approach. Whilst Section C was aimed to identify and determined the constraints face or may face by the organisation towards implementing the approach. A total of 30 companies were responded within the time frame and were analyzed using the Statistical Packaging for Social Science (SPSS) version 12.0. Semi structured interview was another method to identify the integration of safety into design process. A total of six (6) architects consultants out of the 70 consultants which not participated in the survey initially were contacted to participate in the interview session.

4. Result and Analysis

This section presents the analysis and interpretation of data gathered from the questionnaires and semi-structured interview regarding the integration of construction workers' safety features during design process in the construction industry. The analysis was presented in the form of frequencies and mean. Whilst, the semi-structured interview was interpreted using the content analysis method.

In this part of the survey, priority of characteristic being considered during designing was done. According to Hecker, et. al. (2005), they discovered that quality was the highest priority of their respondents followed by end user (which they used term final occupant safety), project cost, project schedule and aesthetic value of the building. In their survey, construction workers' safety features were the lowest priority to be considered by their respondents.

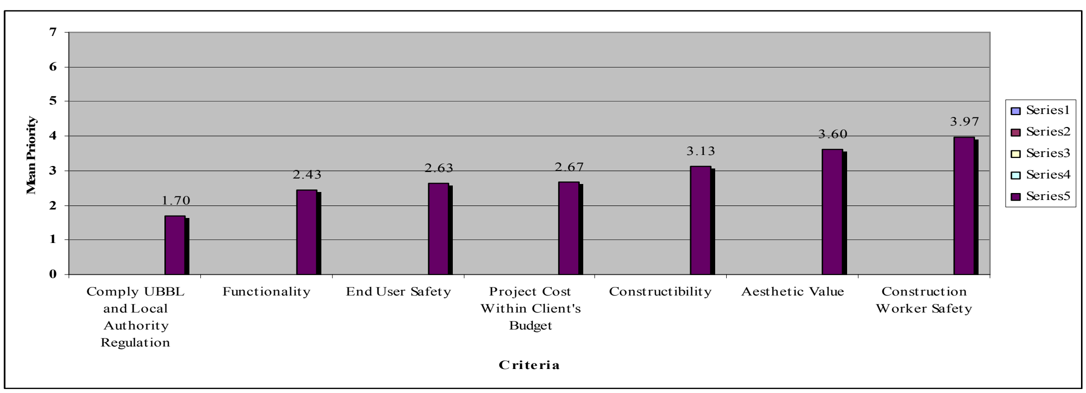

Figure 4: Priority Characteristic during Designing

In this study, in order to identify the characteristic considered during designing in the Malaysian context, the respondents were asked to ranked in order of 1 to 5 which the lowest point indicated the highest priority. The result is shown in Figure 4, which depicts that being compliance to UBBL and Local Authority Regulation was the highest priority criteria to be considered during designing (Hecker et. al. (2005) terms it as "quality"). The second ranked in order of priority during design was the functionality and followed with the end user safety. Project cost is the third priority being considered during design process. This criterion is to ensure that the architects were not over designs which may distract the client's budget. However, this criterion depends on clients' need statements. Constructability and aesthetic value respectively ranked fourth and fifth criteria to be considered during design process. It should also be noted here that, consistent to the Hecker et. al. (2005) findings, construction workers' safety features was the last criterion being considered by the respondents. This reflects that the construction workers' safety features were not emphasized on the higher scale priority during designing process by Malaysian architects. This scenario was also consistent with Haslam et. al. (2005) who stated that many designers were still fails to acknowledge their influences on the safety of the construction process. An analysis using five-likert scale was used in each of the three (3) design phases; schematic phase (Figure 5), design development phase (Figure 6) and contract document phase (Figure 7) in order to determine whether the integration of construction workers' safety features was emphasize during those three design phases. The lower figure show the lower emphasize on the characteristic being considered during design phase.

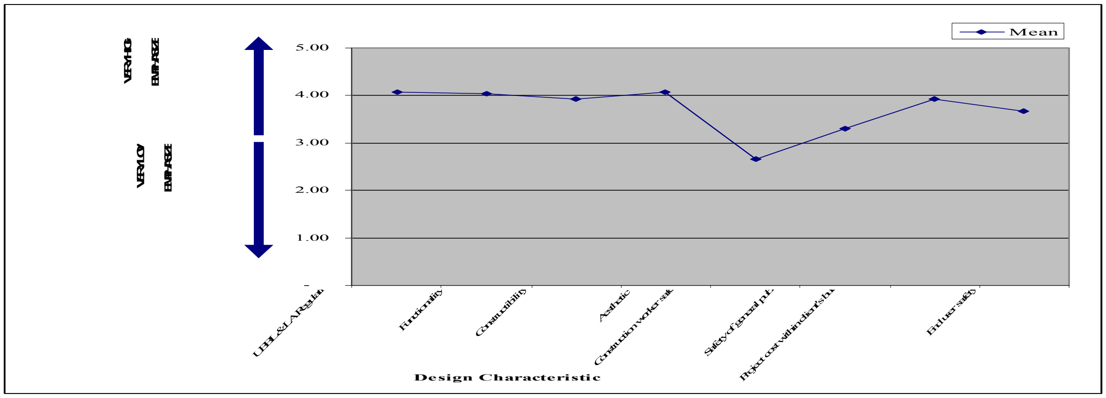

Figure 5: Characteristic Consideration during Schematic Phase

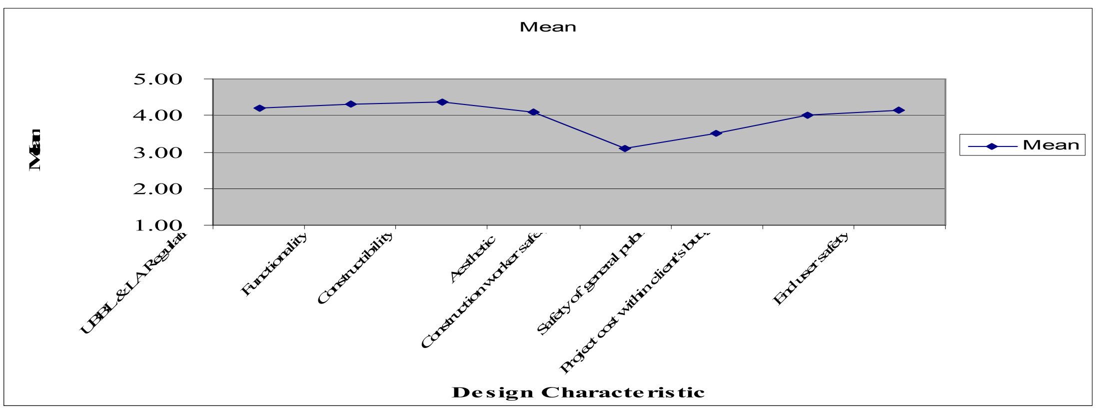

Figure 6: Characteristic Consideration during Design Development Phase

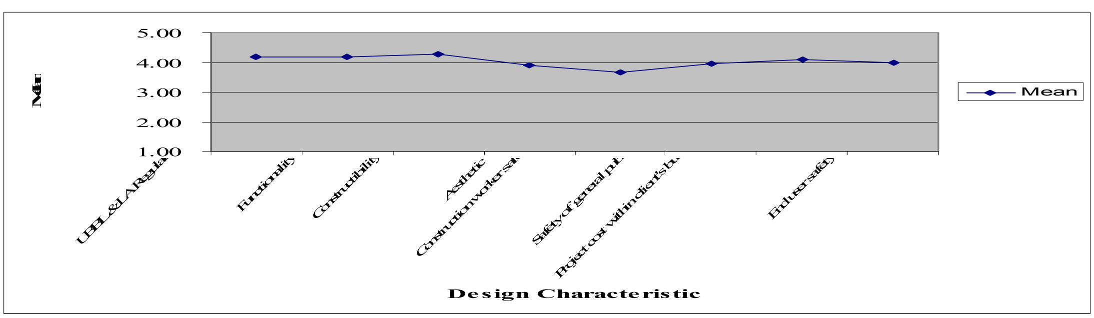

Figure 7: Characteristic Emphasis during Design Review; Contract Document Phase

From the survey, it revealed that the integration was ranked last in every design phase. In Figure 5 shows that the integration of construction workers' safety was given at a low emphasize level during the schematic where the mean score was fewer than 3.00. During design development phase, the integration of construction workers' safety still remain the lowest emphasize with the mean above 3.00 but closing to neutral response (See Figure 6). Whilst in contract document phase (Figure 7), yet, still the integration of the construction workers' safety remained the last emphasized. However, the mean score was above 3.00 which close to high emphasized scale. Based on those three phases, it can be disclosed that the integration of construction worker safety was ranked in lowest emphasized. It reveals that the integration was implemented insignificantly which was only take into high emphasize during the third phase of design; contract documentation phase.

In order to identify design basis which coherent to the integration of the construction workers' safety features, the respondents were asked to answer based on a Five (5) Likert scale of 1-5. Scale 1 indicates very low emphasis and the scale increases in level of significance where 5 is very high emphasis.

Table 1: Basis Design Consideration Based on Mean score

Mean Score Less Than 3.00 **Description**	**Mean Score**	**Mean Score More Than 3.00** **Description**	**Mean Score**
Fall Protection		**Fall Protection**	
Design permanent guardrail system for use by all contractors during designing ventilation system, trash chutes, elevator which cause floor openings to occur during construction.	2.67	Design handrails, guardrails, stair rails to be built as part of erection process.	3.23
Construct permanent guardrail system sequence early in to the schedule to allow their use by construction workers during ventilation system, trash chutes, elevator etc.	2.77	Schedule handrails, guardrails, stair rails to be built as part of erection process.	3.23
Design fall protection mechanism guardrails systems (permanent guardrails, anchor point) when designing atrium of building.	2.93	Design window sills 42 inches above floor.	3.50
Construct fall protection mechanism in to the schedule to allow their use by construction workers during constructing atrium.	2.80	Design permanent guardrails around skylights.	3.13
		Design 42 inches parapet wall.	3.37
		Provide warning in the plans construction of ventilation system, trash chutes, elevator which causes floor openings during construction.	3.10
		Provide warning in the specification construction of ventilation system, trash chutes, elevator which causes floor openings during construction.	3.07
		Determine condition of roof, trusses, purlins structure which is damage to evaluate how fall protection devices will be incorporated into a damaged structure.	3.30

The literature review suggested that this basis design consideration were used as a guideline or outline for the integration of the construction workers' safety features in design process compiled agreed by Berger, (1999), Gambatese and Hinze, (1999), Hecker and Gambatese, (2003), Lorent, (1999) in Bluff, L (2003) and Bluff, L (2003), Gambatese (1996), Behm (2006) and Construction Industry Council CDM Guidance (2004) as an effort to the approach. Table 1 depicts that the result of basis design consideration was categorized into more or less than mean score of 3.00. This effort is done to determine which categories on basis design consideration the respondents scored in the low scale. The result shows that there were six (6) basis design consideration under two (2) main headings that were under mean score less than 3.00. As noticed, the mean score less than 3.00 showed that the basis design consideration was in the low emphasized while mean score more than 3.00 showed that the basis design consideration was in the high emphasized. A few basic designs were taken into high emphasized which are designing and scheduling handrails and guardrail which to be built as part of erection process, designing permanent guardrail around skylight, designing 42 inches parapet wall, provide warning in the plans and specification for the construction of ventilation systems, trash chutes, elevator which causes floor openings during construction and determine condition of roof, trusses, purlins structure which is damage to evaluate how fall protection devices will be incorporated into a damaged structure. This result also describes that the implementation other basis design was insignificant among the respondents as only certain basis design consideration were taken in low emphasized which are tabulated in Table 1 in column "means score less than 3.00". Besides that, outcome from the semi-structured interview shows almost all the interviewees responded that the construction workers' safety was the responsibility of the main contractor. This is due to the Malaysian contract and regulation requirement which spell out the responsibility of the contractor on the safety of their workers. Four of the interviewees (66.66%) explained that their design was safe to be constructed as prior to the approval of a design, several submission and design review need to be undergone which should complies with UBBL, BOMBA regulation and other Malaysian standard regulation. Another two interviewees (33.33%) noted that they taken into consideration on constructability during designing. By considering the criteria, they believed, their design is ease to be constructed subsequently minimize the construction accidents exposure. Nevertheless, most of the interviewees emphasized that to ensure their design is constructed safely; it is all depends on the experience and knowledge of the contractors' construction method.

5. Conclusion

Up until now, the findings discovered that there was some practice in the integration of Construction Workers' Safety Features during Design Process among Malaysian Architects although the implementation was insignificant. The practices were done through owned initiative and informal basis. It is highlighted that the practices were only seems considered during third phase of design review which was in contract documentation phase. Certain design basis consideration which leads to the integration of construction workers' safety features had been taken into their emphasized during contract documentation phase. Only a few basic designs were under their emphasized namely, designing and scheduling handrails and guardrail which to be built as part of erection process, designing permanent guardrail around skylight, designing 42 inches parapet wall, provide warning in the plans and specification for the construction of ventilation systems, trash chutes, elevator which causes floor openings during construction and determine condition of roof, trusses, purlins structure which is damage to evaluate how fall protection devices will be incorporated into a damaged structure. The research suggests that designers should provide and take into consideration the best safety practices such as preparation of plans and specifications. Besides, the communication of risk regarding design and utilization of specifics safe design can also be integrated to reduce hazards during construction stage; hence, there is a need to come out with solutions that can be implemented and checklists to monitor the design afterwards.

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