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Identifying Root Causes and Mitigation Measures of Construction Fall Accidents

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Abstract The construction industry is one of the most hazardous industries. It is because those who spend their working lives on construction sites have a higher probability of being killed at their workplace. Based on the statistics issued by the Social Security Organization (SOCSO) Malaysia, the number of fatality and permanent disabilities due to fall from height accidents at the construction sites is one of the highest rates as compared to other sectors. Therefore, this research intends to identify the causes and safety measures of construction fall accidents in Shah Alam construction sites because there are a lot of high rise building projects in this state. This study is carried out by doing literature review and getting feedback through questionnaires. In order to find out causes and mitigation measures of fall accidents at the construction site, this study used SPSS test such as Spearman's Rho to analyze the data. The finding of this study indicates that "poor safety attitude and behavior of workers" are the main problems in obstructing the implementation of safety procedures and guidelines for construction sites. The responses from the survey also show that "sufficient safety training" and "equipment for working at height" are the adoptable mitigation measures to enhance the workers' safety performance. It is believed that

appointing safety officers in inspection and maintenance works and by applying risk assessment in identifying fall hazards could reduce the number of fall accidents.

Keywords Fatality; risk assessment; safety measure; Social Security Organization (SOCSO) Malaysia.

1 Introduction

The construction industry plays an important role in any country's economic development. It establishes the infrastructure required for socioeconomic development while being a major contributor to overall economic growth (Drewer, 1980). However it is also one of the most hazardous industries (Chua & Goh, 2004). According to Gibbs, Hide, Haslam and Hastings (2001), it is commonly known that construction fall accidents have serious implications to the construction industry both in financial and humanitarian terms. Construction fall accidents may cause many problems, such as demotivation of workers; disruption of site activities; delay of project progress; and adversely affecting the overall cost, productivity and reputation of the construction industry (Mohamed, 1999). Therefore it is very important to improve safety in the construction industry. Nowadays, Malaysia is one of the developing countries in the world where it is moving towards an approach that believes all occupational hazards can be controlled through detailed regulations (Fadhlin, 2004).

In the year ahead, the construction industry would be challenged by increasingly difficult and complex problems in both engineering and management. According to Hsiao (2006), construction industry is a high risk industry because there is a high risk of accident occurrence. Based on Dangelzer, Francais and Jacquin (2002), common types of construction accident occurred is due to fall accidents. According to the previous study, Abdul Rahim (2003) stated that Malaysia is also one of the countries that encounter this problem. He also stated that construction fall accident becomes as one of the major problems that contributes to the increasing number of fatalities

and injuries in construction industry. Based on Occupational Safety and Health Act 1994 (OSHA) division report, 75% of fatalities were from construction site falls. Fall from height is the number one accident type which contributed to workplace fatalities in the construction sector for the period of 2004 to 2009, which is 34% followed by struck by falling objects (25%) and step on, strike against or by objects (10%). Fall from height accident is mainly due to fall from scaffolds, fall from platform, fall from ladder, fall from roof and also fall from aerial lifts (Huang & Hinze, 2003).

Based on the statistics provided by Department of Occupational Safety and Health (DOSH) Malaysia, in the year 2012, there are 11 fatalities cases occurred due to fall from height. Improper work procedure and lack of supervision is the main factors contributed to this situation. Below are the accidents data recorded from the case study by Dayang Nailul (2011). According to this data, fall from height can be classified as common type of construction accidents happened in Malaysian construction industry.

Table 1: Accident Records by DOSH

No	Date	Case	Location
1	28 Aug 2008	Fall from roof	Construction site,Kedah
2	23 Aug 2008	Slip from roof	Construction site, Kedah
3	01 Aug 2008	Death due to fall from 6^{th} floor	Construction site, Penang
4	28 Jul 2008	Slip from platform	Construction site, Johor
5	28 Jun 2008	Fall from 9th floor	Construction site, Johor
6	20 Aug 2007	Fall from scaffolding	Construction site, Negeri Sembilan
7	14 Apr 2007	Fall from 6th floor	Construction site, Selangor
8	12 Mar 2007	Fall from 7th to 2nd floor	Construction site, KL
9	06 Mar 2007	Fall from 16th floor	Construction site, Selangor
10	31 Jan 2007	Fall from 23rd floor	Construction site, KL

2 Literature Review

This study adopted Drury and Brill's (1983) scenario analysis to characterize the causes of work-related fatal falls in terms of the individual, the task, tools and equipment used, and managerial and environmental factors. Each accident report was reviewed several times to itemize the detailed causes of fall under each factor. According to Drury and Brill (1983), individual factors would be classified as bodily actions such as climbing, walking and leaning against, distraction, insufficient capacities, and the improper use of personal protective equipment (PPE). Task factors include overexertion and unusual control, poor work practices, and the removal of protection measures. Tools and equipment factors include mechanical failure, unsafe ladder and tools, or being pulled down. Management and environmental factors include unguarded openings, lack of complying scaffolds, unauthorized access to hazard areas, contact with falling object, and harmful substances.

A review of the literature indicates that finding the factors and causes that influence construction fall accidents has been the passion of many researchers. Previous researchers analyzed the causes of fatalities and injuries that were due to construction site fall from five main perspectives, which are unsafe conditions, unsafe actions, human-related factors, equipment and management inactions (Huang & Hinze, 2003).

Reasons such as time, cost and quality are always the main factors considered ahead of safety. Safety issues are always considered secondary and took a back seat in construction (Mbuya & Lema, 2002). Based on the research undertaken by Sophie Hide and Sarah Atkinson (2003), they stated that employer's attitude towards safety is also a problem in reducing the number of construction fall accidents.

The Deputy Minister of Human Resources, Datuk Maznah Mazlan has also shown concern on this situation. She said that the problem still happened because many employers did not emphasize on construction workers' safety (Harian

Metro, 2010). Besides, the increase in the number of construction fall accident in Malaysia is due to lack of safety awareness among employees that are involved in the construction industry. (Abdul Rahim, 2003). The attitude of workers that are unwilling to follow the rules and regulations in construction is also the cause for influencing fall accidents to occur (Donald, 1995). The inability of a responsible person to identify the risk hazard in working at height and to provide proper training for the workers has also become an obstacle in mitigating this problem (Abdel Hamid & Everett, 2000). In order to reduce the number of deaths and injuries related to fall accidents at construction sites, preventive action needs to be taken. According to the Occupational Safety and Health Act 1994 (OSHA), there are two types of systems to prevent and protect workers from falls which are passive system and active system. Passive system can prevent workers from falling by placing a physical barrier between the worker and the falling hazard such as parapet walls and guardrails. The active systems could protect workers that have already fallen by limiting the fall to a specified distance and also limiting the force that the worker is subjected to such as personal fall arrest systems (Abdelhamid & Everett, 2000).

3 Methodology

For this research, questionnaires have been distributed to the persons who are very well versed in construction work and in the particular accidents at sites such as project manager, contractor, resident engineer, safety and health officer, site supervisor, site engineer and foreman. Respondents from 79 construction companies were approached in order to achieve the objectives of this study. There were 34 responses received, giving a success rate of 43 percent. From the 34 responses used in the analysis, 23 of them were from Class A contractor companies and the rest from Class B contractor companies. The questionnaires proposed the objective and the relevant information to achieve the information for this study. The type of questionnaires selected for this study is personally administered questionnaires as this study was confined within

the organization. The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 18.0 for Windows and Excel. All the outputs were interpreted to get the results and further on to get a conclusion. Based on the data, the analyses were mean, variances and standard deviation. For this test of the data, non-parametric test and parametric test were used.

4 Result and Discussion

From the findings, there are five major factors that are contributing to construction fall accidents which are due to construction tools and equipment, workers factors, unsafe actions, unsafe conditions and management factors. For these findings, the collected data were analyzed using a relative index which is used specifically for the ordinal scale measurement.

4.1 Investigate the Causes of Construction Fall Accident in Shah Alam Construction Area

There were a lot of factors that were related to construction fall accidents in Shah Alam Construction Industry. From Table 2, it shows the mean response to the factors of construction fall accidents in term of level of agreement for the clarity and ease of presentation. Overall, factor 1.3 "Insufficient and nonexistent guardrails or personal fall protection equipment" has shown the highest relative index (0.853) of respondents for equipment factor with "Agree towards strongly agree" mean response. The ranking is followed by factor 1.2 and 1.1 which also received "Agree towards strongly agree" and "Agree". Both of these factors need to be taken into account in order to reduce the number of fatalities and injuries related to the construction fall accidents.

Table 2: Mean Responses of Level of Agreements for Factor Relative to the Construction Fall Accidents in Shah Alam Construction Industry

Factor	Elements	Relative Index	Mean Response
1.	**Tools and equipment**		
1.1	Defective or improper scaffolding or others structures	0.794	Important
1.2	Unstable scaffolds	0.812	Important towards most important
1.3	Insufficient or nonexsistent guardials or PPE	0.853	Important towards most important
2.	**Personal Factors (workers)**		
2.1	Improper use of fall protection equipment	0.956	Important
2.2	Lack of safety awareness	0.888	Important towards most important
2.3	Careless	0.847	Important towards most important
3.	**Unsafe action**		
3.1	Fail to obey work procedure.	0.875	Important towards most important
3.2	Improper installation and operation of work.	0.812	Important towards most important
3.3	Adopting unsafe position or posture.	0.735	Important

Table 2 (continued): Mean Responses of Level of Agreements for Factor Relative to the Construction Fall Accidents in Shah Alam Construction Industry.

Factor	Elements	Relative Index	Mean Response
4.	**Unsafe condition**		
4.1	Inadequate working space / platform	0.818	Important towards most important
4.2	Poor site management	0.879	Important towards most important
4.3	Poor ventilation	0.647	Moderate towards important
5.	**Management**		
5.1	Lack of maintanence of access equipment and structures	0.853	Important towards most important
5.2	Insufficient training of works	0.812	Important towards most important
5.3	Inadequate supervision	0.83	Important towards most important

In term of key factor related to the workers factor, improper use of Personal Protection Equipment (PPE) came out as "Strongly agree" in their mean response with 0.956 in Relative Index. On the other hand, lack of supervision and knowledge among involved parties also lead to improper use of PPE problem. Factor 3.1, "Fail to obey work procedure" has shown the highest mean response of respondent with "Agree towards strongly agree" and with Relative Index value of 0.875. Besides that, in the aspect of unsafe condition, poor site management has shown the highest index value with 0.879 compared to other factors such as unsafe process or job method.

Appropriate site management is important to ensure proper housekeeping in the workplace in order to provide clean and safe working environment.

In management aspect, most of respondents tend to choose "Lack of maintenance of access equipment and structures" as a major cause that contributed to construction fall accidents. This factor came out as the highest mean response of respondent with "Strongly agree" and 0.853 in Relative Index. Inadequate designated person to supervise and to carry out the inspection work also leads to this problem.

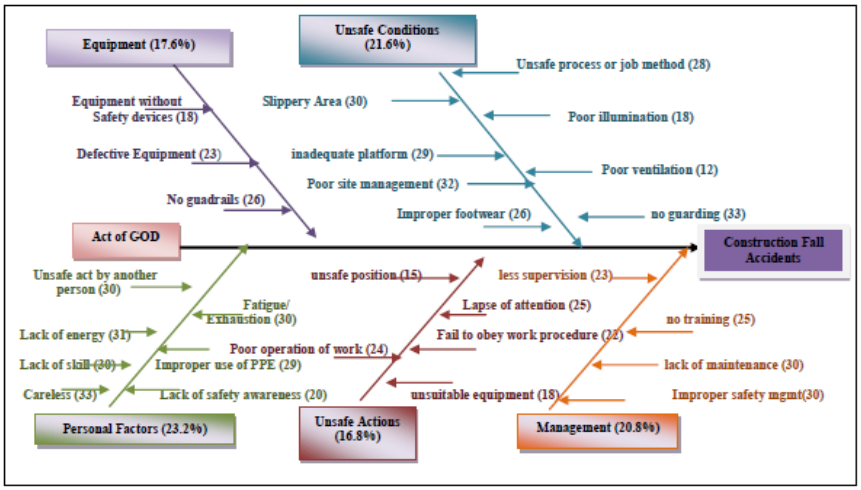

Figure 1: Summary of Causes of Construction Fall Accidents from 34 Respondents

Figure 1 shows the causes of fall accidents are more related to the employees rather than the employers as indicated by the result to the Personal Workers Factor (23.2%) as compared to management (20.8%). Besides, the other factors are equally important as their average percentage of respondent's agreement is quite close such as equipment factor (17.6%), Unsafe Action (16.8%) and Unsafe Condition (21.6%).

In a similar study by Abdelhamid and Everett (2000), they also stated the major factor of construction accident is human factor especially workers. This is because lack of safety awareness and lack of knowledge and skills in job procedure will lead to unsafe actions. Unsafe action can be defined as incorrect procedures and method that have been practiced by construction workers. This problem may be due to insufficient information to workers from the management before they enter the jobsite.

In addition, Lubega et al. (2000) stated that lack of safety awareness and poor thinking of workers in safety and health issue are the main point why these accidents happened. For instance, many workers think that Personal Protection Equipment is not necessary for those who have a lot of experience in construction site. It is because since they were involved in construction work, there had been no accidents that occurred. This type of thinking must be eliminated in order to ensure all construction workers know that safety is their priority.

4.2 Investigate the Mitigation Measures of Construction Fall Accidents in Shah Alam Construction Area

Based on Table 3, the respondents identified 'Provide sufficient guardrails or personal fall protection equipment' as the most important safety measure likely to prevent construction fall accident especially falls of person from height. According to the OSHA 1994, it is required that a 42-inch (1.1m) guardrail or other fall protection be present when working at elevated heights. This finding supports Hinze's and Raboud's notion in that sufficient guardrails and proper use of Personal fall protection such as fall arrest system can reduce the probability of fatalities and injuries that are due to falls from height accidents.

Besides, most respondents also tend to choose "Ensure stable footing of scaffolding" as an important aspect. It is supported by Schriver's (1997) findings, where employer needs

to do inspection work in order to ensure that all equipment used in carrying out the work at height is in good condition especially for scaffolds footing.

Based on the result, both of the classes perceived that the five top most mitigation measures were (1) Provide a training program in order to improve the workers' performance, (2) Employer needs to provide sufficient Personal Fall Equipment, (3) Scaffolds should be set on the base plates and mud sills to provide adequately firm foundation, (4) Guardrail systems should be installed along all open sides and ends of the platforms, and (5) Each platform on all working levels of scaffolds should be fully planked or decked between the front uprights and the guardrails support.

Table 3: Mean Responses of Level of Agreements for Mitigation Measures of Construction Fall Accidents in Shah Alam Construction Industry

Factor	**Elements**	**Relative Index**	**Mean Response**
1.1	Effective maintenance (requires frequent inspection of equipment use to work at height such as scaffolds, platform, ladders, aerial lifts)	0.841	Important towards most important
1.2	Each platform on all working levels of scaffolds shall be fully planked or decked between the front upright and the guardrail support	0.853	Important towards most important

Table 3 (continued): Mean Responses of Level of Agreements for Mitigation Measures of Construction Fall Accidents in Shah Alam Construction Industry

Factor	Elements	Relative Index	Mean Response
1.3	Employer need to send their employees to safety training in order to provide safety education regarding to the uses of Personal Fall Protection such as body belt and body harness and to ensure that their employees are able to identify the fall hazards when work at height.	0.859	Important towards most important
1.4	Employer needs to ensure that they are provide sufficient Personal Fall Protection and this equipment needs to be tested before use.	0.871	Important towards most important
1.5	Responsible person need to observe their workers when working at high elevation and give a penalty to workers that failed to obey the safety rules.	0.776	important

5 Conclusion

From this finding, it was found that all respondents were aware of the main causes of construction fall accidents. The causes of construction fall accidents in Shah Alam Construction Industry are not significantly different from those in the other countries as stated in previous research findings. Similar with previous research findings, it is found that workers factor and management inactions were the main factors that would contribute to this problem. In addition, all of the respondents

agreed that worker's negligence and carelessness were the main causes that led to the occurrence of the construction fall accidents.

In order to mitigate the construction fall accident, employer needs to ensure that all their workers have enough knowledge and skills regarding their job method before entering the jobsite. As a result of this action, we can increase the safety awareness and also workers' performance. Good understanding in safety will eliminate the cause of construction accidents especially due to workers factor. Besides that, employers also need to send their workers to training programs in order to provide them with the knowledge and skill on how to work at height and this action could minimize the number of construction fall accidents. Other than that, the employers, employees and other relevant parties must join forces and try to prevent future construction fall accidents by addressing the root causes of accidents.

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