Recent Trends in Civil Engineering and Built Environment Vol. 2 No. 1 (2021) 105–114

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

A Study of Fall Arrest Fatalities at Construction Site in Malaysia

Dewi Norfitry Bujang Rookey[1], **Muhammad Fikri Hasmori**[2]

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn, Parit Raja, Johor, 86400, MALAYSIA

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn, Parit Raja, Johor, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rtcebe.2021.02.01.012
Received 30 January 2021; Accepted 28 April 2021; Available online 30 June 2021

Abstract: Construction fall incidents have significant financial and humanitarian consequences for the construction industry since the construction industry plays a crucial role in economic development, improving safety in the construction sector is very important. In comparison with other types of accidents, fall from height tends to have the highest level of construction incidents relative to other types of accidents. The aim of this study is to investigate the construction safety on fall arrest at the construction site in order to investigate current methods of fall protection, identify issue in their selection use and to produce guidance on best practice for designers and constructors. The method use for this study is quantitative method by sending structured questionnaires to construction industry professionals as targeted respondents and the data obtained will be analyzed using descriptive analysis. As much as 104 construction workers in Malaysia have completed the questionnaires. Based on the findings, main causes of fall from height accidents can be seen in this survey as majority of the respondents strongly agreed that it is important for a construction worker to undergo training in order to stimulate the employee to follow safety regulations. The role of designers and constructors also play a huge role in preventing fall from height at construction site. Risk assessment should also be undertaken in order to determine the degree and duration of workers expose to risk as well as the lack of capability of contractors or sub-contractors can lead to fall from height. Based from the result, the use of personal protective equipment for construction workers shall be calculated by three separate variables which are awareness, training and experience. Cognitive visualisation of interviews and serious events can be helpful in collection specifics of how fall from height injuries occurred without oversimplifying the issues or sacrificing relevant details.

Keywords: Fall From Height, Construction, Fall Arrest

1. Introduction

**Corresponding author: mfikri@uthm.edu.my*

Construction industry is one of the main hazardous industries in worldwide[1]. It is abundantly obvious that construction fall incidents have significant financial and humanitarian consequences for the construction industry. The most widely known types of accidents in construction is due to fall accidents. Malaysia is one of the country that facing this problem as well[2]. It also indicated that construction fall accidents were one of the greatest problems leading to the rising number of deaths. Based on statistic issued by Malaysia's Department of Occupational Safety and Health (DOSH), there were 11 deaths cases that occurred due to falling from height in the year 2012 and the number of death is increasing as the year goes by. Improper job practices and lack of monitoring are the major contributing factors of the situation. Many companies have not set out detailed plans for avoiding injuries, but rather concentrate on optimizing income. They do not prioritize safety as they underestimate how high the real expense of an incident is before it happens.

Undesirable event statistic in the construction industry reveal that the incidence of accidents in the construction industry in Malaysia is still soaring and it gives an image that the construction industry is part of the vital industries that require a major and prompt reconstruction of current site safety practices[2]. Therefore, preventive steps must be taken to avoid such incident. To avoid, the causes of the accident must be known, more precisely the root cause of the accidents.

The objectives of this study is to investigate current methods of fall protection, to identify issues in their selection and use and to produce guidance on best practice for designers and constructors. In order to achieved the objectives, this study will refer to the European Standard by using BS 361, 2002 edition. Since this study is rarely conducted in Malaysia, this will create awareness and provide a safe working conditions at construction site for the worker before they start doing their work according to their work scope.

2. Literature Review

In general, fall is defined as downward motion all the way down to the earth. A fall hazard is a type of physical hazards that cause the worker's body poise to be lost while working on a construction site. Falls are major cause injuries on construction site. Internationally, falls from heights are the leading cause of occupational injuries. Data recently released by Department of Occupational Safety and Health (DOSH) [3] showed that work-related incidents occurred between 2011 and 2016, indicating that 37.85% to 51.50% of injuries resulting in non-permanent injury, long-term disability and fatality happened on the construction site.

Four primary causes of deaths have been reported by Occupational Safety and Health Act (OSHA,2011) in the construction sector, namely fall, caught-in or-between, struck and electrocution. Given a slight overall decrease in the United States between 1992 and 2006, falls from height usually accounted for 32% of fatal workplace injuries and 50% of fatalities in construction [4]. Falls represent 44.6% of the injuries reported in the OSHA IMS database between 1997 and 2012 [5]. The construction industry is noteworthy, however, as it continues to report a high rate of casualties due to accidents. Construction employees who work in the construction industry face a greater risk of death than jobs in other industries.

2.1 Types of fall from height

View of the fact that the seriousness and frequency, slipping, tripping and falling accidents in construction have gained substantial attention and were thoroughly investigated.[5]. Nevertheless, fall from height also have historically the highest rates compared to other forms of accidents. Table 2.1 below shows the type of falls accident and mean score of agreement [6].

Table 2.1 Types of fall accident and mean score of agreement

Types of falls	Mean score
Roof falls	4.15
Scaffolding falls	4.33
Falls through opening (except roof)	3.98
Ladder falls	3.78
Falling from elevated work platform	2.73
Falls from vehicles (bulldozers, diggers, excavator)	3.2
Falls from building girders or other structures	3.5

The result is consistent with results from past studies[7], which are the most common falls on the construction site were scaffolding falls and roof falls. This provide further evidence that the most important forms of falls occur at the construction sites are scaffolding falls and roof falls. Meanwhile, Table 2.2. below shows the category of fall and the types of fall from height at construction site [8].

Table 2.2 Categories of fall and the types of fall

Category	Types of fall
Fall from formwork structure	z Fall together with formwork structure
	z Fall from formwork structure
	z Fall from formwork structure during dismantling
Fall from ladders	z Fall from vertical access ladder
	z Fall from fixed ladder
Fall from roofs	z Fall through roof opening
	z Fall through roof skylight
	z Fall of sloping roof
Fall from scaffold	z Fall from scaffold during dismantling
	z Fall from scaffold
Fall from structure	z Fall from opening of a hopper
	z Fall from top of ISO Tank
	z Fall from lift landing of a building
	z Fall off storage rack
Fall from vehicle	z Fall from lorry bed

2.2 Risk of fall from height

Falls are a major public health concern for construction workers worldwide, and a leading cause of non-fatal and fatal injury. To avoid falls in the construction industry, a more detailed understanding of the casual factors contributing to fall accident is vital. The construction industry faces multiple

workplace accidents and chances of fatality, making research both special and demanding. Construction is often risky because of outdoor activities, operating at high altitudes and sometimes in diverse and complex settings with their working conditions and materials. Figure 2.1 below provide a description of causal factor synthesis following the mentioned synthesis process [4]. 21 macro-variables and 32 causal links between them were provided as an overview of causal pathways. Noted that ranges in legend reflect the number of instances of macro-variable relationships and implications obtained from the literature and continuity of causal relationship is summarized from coded studies through different line types.

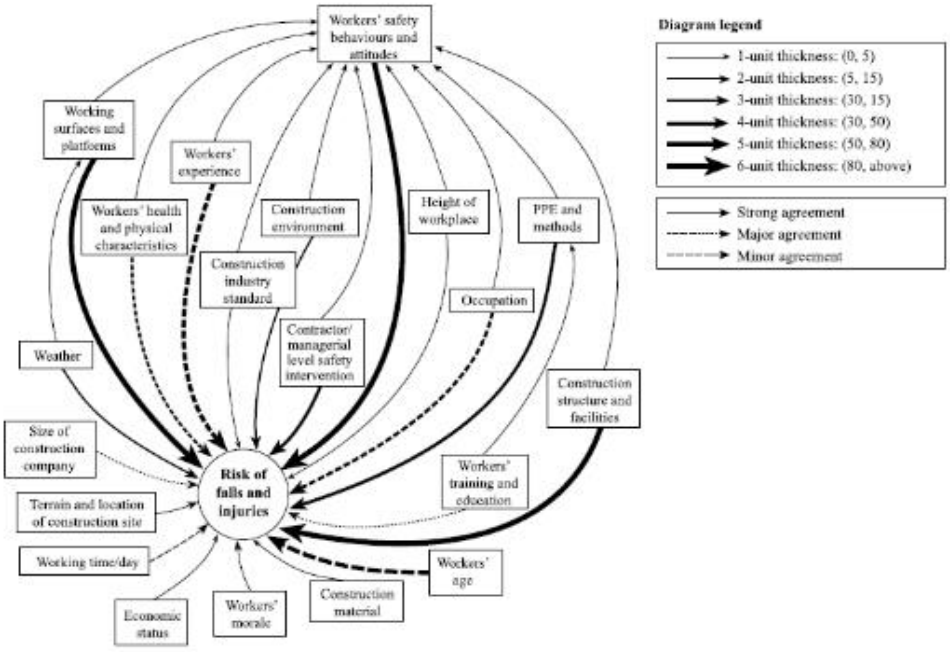

Figure 2.1 Causal relationship of macro-variables supported by qualitative and quantitative studies [4]

2.3 Fall from height factors

Construction industry remains one of the significant sectors in Malaysia, which comprises 9.1% of total employment in 2017, providing jobs for about 1.33 million people. In the other side, falls have been reported to take 36.3% of injuries [9]. Based on data from the Department of Occupational Safety and Health [3], 106 fatalities in the construction industry were registered in 2016, compared with 88 in 2015. These details particularly those involving fatalities are concerning because they covered only the cases investigated by DOSH and the number would be higher if the unreported incidents are included. The International Labor Organization (ILO) reports that about 30% of deaths are caused by falls due to unstable footing, exposed holes, ladders and slips off scaffolding [10]. According to the summarize cases by DOSH, there are several common factors that attributes to the accidents such as:

- Lack of attention to safety in the construction site community
- Lack of corporate initiative in the field of staff recruitment
- Improper posture at work and the time taken to complete the work
- Unfitting work environments
- Insufficient preparation and supervision
- Lack of sufficient arrest system
- Poor building construction and facilities
- Unsuitable protection action by the manager or contractor
- Un-use of protective equipment
- Lack of order at the site

2.4 Impacts of accidents on individual, company and project

Many impacts have been documented on the accidents that can be divided into three groups, which are the individual effects, company effects and effects on the construction project[11]. Individual consequences include decreasing family incomes and their living standards, increasing in debt, increasing medical costs, increasing family distress, loss of social security, loss of quality of life and loss of income. Impacts of company on the accidents include the effect on credibility of the company, need for extra OSH enforcement work, loss of sales, increase of expenditures, increase of fine and legal expenditures, increase of insurance cost, distress of workers, damage of plants and equipment properties and assets, legal fines, increase of investigation cost, decrease of profitability, loss of production and decrease of morale and quality of work. Meanwhile, the impact of accidents to the project include loss of times in project execution, delay of job progress, interruption of job, loss of customer satisfaction and worker absenteeism. Project quality can be assessed by delivering productive outcomes in terms of profitability, avoidance of fraud waste that helped to minimize cost, and intrinsic satisfaction with the professional outlook of managers and their employees as workplace injuries and ill health are clearly harmful to productivity [12]. In addition, safe and health workplaces are extremely important not just for protecting workers but also for increasing productivity.

2.5 Personal and Protective Equipment (PPE)

Personal protective equipment (PPE) is equipment that employees wear to guard against pollutants, physical damages, fire and mitigate revelation to certain hazards [13]. PPE includes safety glasses, protection against hearing, hard hats, protective boots, fall security devices, respirators and full body suits [14].While PPE does not minimize the danger itself and does not provide full protection for employees, the use of PPE is seen as an effective way to protect worker's safety and health. Working in the absence of a PPE will significantly increase the risk of any unexpected accident occurring. The different explanations why workers refuse to wear PPE during their job are such that they feel disturbed with the gears when conducting their work on site and find it a distracting part in their work performance [15]. Figure 2.2 shows the complete set of PPE for workers who work at height.

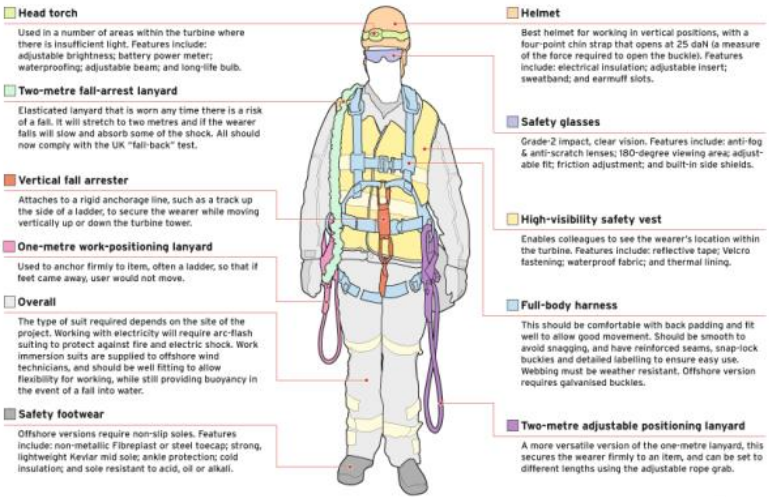

Figure 2.2 PPE use by employee who works at height [16]

2.6 EN 361 and other standards for safety harness

Fall protection harness are an important piece of workplace safety equipment where employees perform high-level activities, mandated by both OSHA legislation and industry best practices. Any failure in a harness may have serious consequences. The European Standard defines the specifications,

test methods, labeling, manufacturer's detail and covering for full body harness. Further classification of support for body as specified in other European Standards, for example the full body harness integrate EN 358, EN 813 or EN 1497 [17]. Systems for case arrest are stated in EN 363. Table 2.3 below shows the various of PPE fall arrest requirements and norms.

Table 2.3 PPE of fall arrest requirements and norms

BS EN 341 :1993	PPE – Descending machinery	Escape or rescue equipment, for safe decent at restricted speed
BS EN 353-1:2014	PPE – Guided arresters in fall	Vertical travel device which is locked onto a rail following a fall
BS EN 353-2:2002	PPE – Guided arresters in fall (on a rope or cable)	Vertical travel device that works on a wire cable or rope, locking in a fall
BS EN 358:2002	PPE – Energy absorbers	Shock absorbers on lanyard and tear site parts
BS EN 360:2000	PPE – System for positioning the work	A mixture of parts to make up a device such as pole harness
BS EN 360: 2002	PPE – Retractable type	Blocks of inertia reels (not retractable lanyards of 2.4m car seat belt style) originally called "fall arrest blocks"
BS EN 361: 2002	PPE – Full body grip	Full body support which is not a belt
BS EN 362:2004	PPE- Connectors	Carabiners, pins and other connections
BS EN 363 :2002	PPE – Fall arrest systems	Combination of a system for example a harness with a lanyard and an energy absorber
BS EN 364:1993	PPE – Test methods	Description of research methods to be conducted in an approved research house laboratories to ensure product conformity with the standard requirements

BS EN 365:2004	PPE – General requirements	Guidance for labeling goods with inspection times and re-testing guidance for users

2.7 Typical design of safety harness

Fall protection harnesses are an important piece of safety equipment on job sites where employees perform high-level tasks mandated by both OSHA regulations and best practices in the industry. Figure 2.3 below shows the example of a full body harness with back attachment for work positioning. The following terms and definition apply for full body harness [18] :

- Full body harness: Full body harness system mainly support fall arrest. It consists of braces, fitting, buckles or other components which properly designed and assembled to support a person's entire body and to impede the wearer during a fall and after a fall
- Secondary straps: Certain straps of a full body harness intended by the manufacturer to protect the body or to exert pressure on the body during a person's fall and after the fall has been arrested
- Attachment element: Connecting point to components or sub systems

Figure 2.2 Full body harness with back attachment [19]

3. Materials & Methods

This study was conducted using the quantitative method by sending structured questionnaires to construction industry professionals as targeted respondents who work in construction site in Malaysia. The questionnaire was distributed using an online survey tools known as Google Form and the responses obtained are stored in Google Drive Data Storage.

The questionnaires are divided into 4 sections to meet the study's goals. Section A covers the background of the respondents, Section B discuss the current methods of fall protection and issues in

their selection and use, Section C covers the views of designers and constructors on the guidance on best practice in construction sites and Section D offers recommendations and suggestions on preventive measures. The questionnaire was constructed using Likert Scale where the respondents need to score of range 1 to 5 which is from being strongly disagree to being highly agree upon.

After the questionnaire has been completed, a set of questionnaire was distributed to an expert from Universiti Tun Hussein Onn Malaysia before carrying out the main survey. This is to identify potential practical problems in implementing the research procedure such as the questionnaire should be piloted such as the wording and the order of the questions or the selection of responses on multiple-choice questions. A final pilot should be performed to test the testing process where as the different ways the questionnaires are delivered and collected.

The data obtained were then analyzed by using descriptive analysis. The data collected from the respondents will be analyzed according to the ranking order which were extracted from the average index to analyze for each response from the respondent's choices by using likert scaling method.

4.0 Findings & Conclusion

Based on the findings, main causes of fall from height accidents can be seen in the survey. Majority of the respondents strongly agreed that it is important for a construction worker to undergo training in order to stimulate the employee to follow safety regulations. It can be a huge concerned that can lead to the causes of fall from height too when the respondents strongly agreed that they would not say anything if their work environment was unsafe. In addition, the role of designers and constructors also play a huge role in preventing fall from height at construction site. The respondents strongly agreed that designers have a duty to provide building and foreseeable maintenance should be planned before a building is constructed and the designs should not be signed off until maintenance activities are included in the design risk assessment.

It is evident from the study of fall incidents in the construction industry that falls are the cause of multiple significant injury and fatalities. Simultaneously, the study of the data reveals that there are some features that can assist of fall prevention approaches. The use of personal protective equipment for construction workers shall be calculated by three separate variables which are awareness, training and experience. The result obtained shows that each of the independent variables is influenced by the dependent variable which is the impact of the personal protective equipment on construction workers.

Hazards at sites that can trigger falls should be identified through thorough inspection of construction sites and removed by successful preventive approaches. Accumulation of information on past injuries can reveal which hazards are known as most prevalent in construction sites. The accident can be prevented if designers have a duty to provide a building which is safe to maintain and refurbish and foreseeable maintenance should be planned thoroughly before a building is constructed.

In addition, the range of equipment required for fall prevention continues to grow and upgrade to current equipment such as advanced scaffolding guard rails can be accommodated in the potential extension of guidelines on particular equipment selection issues. This can be supported by the employees who are concern about their susceptibility and preventability of falls when they are working. While it is also impossible to recognise how many falls are actually cause by improper structures, safer policies established by specific design choices will minimise the incidence of falls. Hence, a company need a fall protection plan and personal fall arrest system to make sure that the employee will perform their job in a safe manner.

References

[1] Chua, D. K. H., & Goh, Y. M. (2004). Incident causation model for improving feedback of safety knowledge. *Journal of Construction Engineering and Management*, *130*(4), 542–551. https://doi.org/10.1061/(ASCE)0733-9364(2004)130:4(542

[2] Abdul Rahim, A. H., Muhd Zaimi, A. M., & Bachan, S. (2008). Abdul Rahim Abdul Hamid , Muhd Zaimi Abd Majid , Bachan Singh. *Malaysian Journal of Civil Engineering*, *20*(2), 242–259

[3] *Official Website Department Of Occupational Safety And Health - Fatal Accident Case*. [online] Dosh.gov.my. Available at: <https://www.dosh.gov.my/index.php/fatal-accident-case-1>

[4] Dong, X. S., Fujimoto, A., Ringen, K., & Men, Y. (2009). Fatal falls among Hispanic workers. Accident Analysis and Prevention, 41(5), 0471052.https://doi.org/10.1016/j.aap.2009.06.012

[5] Hu, K., Rahmandad, H., Smith-Jackson, T., & Winchester, W. (2011). Factors influencing the risk of falls in the constructionindustry: A review of the evidence. *Construction Management and Economics*, *29*(4), 397–416. https://doi.org/10.1080/01446193.2011.558104

[6] Nadhim, E. A., Hon, C., Xia, B., Stewart, I., & Fang, D. (2016). Falls from height in the construction industry: A critical review of the scientific literature. *International Journal of Environmental Research and Public Health*, *13*(7). https://doi.org/10.3390/ijerph13070638

[7] Liy, C. H., Ibrahim, S. H., Affandi, R., Rosli, N. A., & Nawi, M. N. M. (2016). Causes of fall hazards in construction site management. *International Review of Management and Marketing*, *6*(8SpecialIssue), 257–263

Goetsch, D. L., & Hassan, Z. (2012). *Managing workplace hazards*. Petaling Jaya: Pearson Malaysia.

[8] Workplace Safety and Health Council. (2017). Case Studies: Accidents Involving Work At Height. *National Work-at-Heights Safety Taskforce*.

[9] Huang, X., & Hinze, J. (2003). Analysis of construction worker fall accidents. *Journal of Construction Engineering and Management*, *129*(3), 262–271.

https://doi.org/10.1061/(ASCE)0733-9364(2003)129:3(262)

[10] Simon Fass, Rami Yousef, Divakaran Liginlal, Priyanka Vyas,Understanding causes of fall and struck-by incidents: What differentiates construction safety in the Arabian Gulf region, Applied Ergonomics, Volume58,2017, Pages515526, ISSN00036870, https://doi.org/10.1016/j.apergo.2016.05.002

[11] AZIZ, Nurul Ayuni Abdul, Rumaizah Mohd NORDIN, Zulhabri ISMAIL, and Julitta YUNUS. 2016. “Identifying Factors and Impacts of Occupational Safety and Health (Osh) Towards Work Accident in Achieving,” 32–37

[12] Vitharana, V. H. P., De Silva, G. H. M. J. S., & De Silva, S. (2015). Health hazards, risk and safety practices in construction sites – a review study. *Engineer: Journal of the Institution of Engineers, Sri Lanka*, *48*(3), 35.

[13] Kang, Y., Siddiqui, S., Suk, S. J., Chi, S., & Kim, C. (2017). Trends of Fall Accidents in the U.SConstruction Industry. *Journal of Construction Engineering and Management, 143*(8), 1–7. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001332

[14] Guan, L. R., Xian, G. J., Rajendran, S. D., & Wahab, S. N. (2019). A study on the effectiveness of Personal Protective Equipment (PPE) on Building Construction Workers. E3S Web of Conferences, 136, 04090. doi:10.1051/e3sconf/201913604090

[15] Ulang, N. M., Salim, N. S., Baharum, F., & Salim, N. A. (2014). Construction Site Workers' Awareness on Using Safety Equipment: Case Study. MATEC Web of Conferences, 15, 01023. doi:10.1051/matecconf/20141501023

[16] Green, S. (2014, April 24). A guide to wind industry safety gear, from https://www.windpowermonthly.com/article/1049572/guide-wind-industry-safety-gear

[17] British EN Standards working at height - Fall Arrest Protection Systems. (n.d.). Retrieved from https://www.safety-height.co.uk/products-services/performance-standards/

[18] British Standards Institution. (2002). Personal protective equipment against falls from *height - retractable type fall arresters.*

[19] Werner Fall Protection "PROFORM F3" Standard Harness. (n.d.). Retrieved January 02, 2021, from https://industrialladder.com/werner-fall-protection-proform-f3-standard-harness/