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Improving Safety Against Fall from Height (FFH) Accidents in the Malaysian Building Construction Industry

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Abstract

Around the world, the construction business has grown remarkably over the past few decades. On the other hand, when compared to other industries, it is also among the most dangerous places to work. The construction sector experiences a high annual rate of fatal accidents due to various hazardous dangers, one of which is falls from height (FFH). Despite existing safety regulations, FFH accidents remain the leading cause of construction fatalities. Adequate research, however, is lacking on improving safety prevention measures for FFH. Hence, this paper emerges with the objectives of (i) identifying the trade works exposed to FFH accidents, (ii) investigating the factors contributing to FFH accidents, and (iii) proposing strategies to improve the safety of workers from FFH accidents in the building construction industry. Questionnaire surveys were conducted with local professionals from 132 building construction companies in Shah Alam, Malaysia. Data were analysed by using descriptive analysis, reliability analysis and relative importance index (RII) analysis. Findings from this paper indicate that roofers, scaffolders and power-line installers are at the highest risk of FFH accidents due to a lack of supervision, monitoring and inspection, as well as low levels of workers' safety knowledge. It was found that the most recommended strategies to improve safety include providing continuous training, ensuring equipment and machinery are in good condition, and conducting toolbox meetings. These findings suggest that identifying high-risk work trades and their contributing factors can help propose effective strategies for safety improvements to prevent FFH accidents.

1. Introduction

The global construction industry has expanded significantly in recent decades, contributing notably to Malaysia's economic growth [1]. However, it remains one of the most hazardous sectors worldwide [2]. The construction industry has a high rate of fatal accidents each year caused by multiple serious hazards, one of which is falls from height (FFH) [3]. FFH is described when a construction worker is injured after falling from an elevated height onto a lower elevation. FFH is usually involved in working on scaffolds, ladders, and rooftops and has become a major safety concern in the construction industry.

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The construction sector is also a major contributor to Malaysia's Gross Domestic Product (GDP) and is projected to increase almost threefold from 2020 to 2050 [1]. Despite this, the construction industry is among the most hazardous industries, as it involves complex, dynamic workplaces. Workplace injuries and fatalities are also very common in this industry. According to the 2023 occupational accident statistics reported to the Department of Occupational Safety and Health [4], 45 of 141 deaths are related to the construction sector, which accounts for the highest number of fatalities across all industries in Malaysia. Falls, strikes by, and being caught in between and electrocutions in construction are the top causes of construction fatalities, which occur due to their occurrence frequency and severity.

However, FFH is consistently the leading cause of construction accidents. For instance, an analysis of data on fatal construction accidents in China found that the most critical cause of fatalities is falls from height, with a 98.28% score, indicating the highest predictive performance [5]. Another research on cases of fatal accidents within five years in Malaysia has discovered that FFH has the highest number of occurrences by 43% [6]. Given that FFH is the leading cause of fatal accidents in the construction industry, effective safety improvement strategies to prevent them are urgently needed. In doing so, further identification of the trade works involved and the factors leading to FFH is necessary, which will be covered in this report.

Considering that FFH accidents may vary across different trade works in the construction industry, the specific incidents and severity of falls should be addressed by trade, such as roofing, scaffolding, steel erection, and others. Each trade involves specific tasks, equipment, and work environments; therefore, recognising which trades are exposed to FFH will enable a targeted understanding of the risks associated with FFH accidents in each trade. Prior to the occurrence of fatal accidents caused by FFH at an alarming rate, it is necessary to conduct a focused study on the contributing factors. Some of the key factors that may be addressed are human factors and behavioural challenges [7], equipment deficiency and technology gaps [7], as well as inadequacy of safety measures [8], which includes issues related to enforcement, compliance, and the practical application of safety guidelines on construction sites [9]. Hence, by providing an overview of the key factors contributing to FFH accidents, solutions can be made to enhance the overall safety outcomes. Multiple studies have shown that FFH continues to pose significant threats to the well-being and safety of construction workers despite existing safety standards and regulations.

Therefore, the problem at hand demands urgent attention and comprehensive safety improvements to mitigate the risks of working at elevated heights. The efficacy of current safety measures and regulatory enforcement needs to be evaluated. In doing so, recognising the objectives of the safety improvement plan for FFH accidents in the construction industry is crucial, as it serves as a bridge between identified problems and proposed solutions. It outlines specific, measurable goals that, once achieved, can contribute to a safer working environment in an elevated workspace. Therefore, the research objectives of this study are to identify the trade work activities exposed to FFH accidents, investigate the factors contributing to FFH accidents, and propose strategies to improve workers' safety from FFH accidents.

Comprehensive safety improvements aim to address falls from height (FFH), the leading cause of fatal accidents in the construction industry. This study examines the current state of FFH accidents among construction companies in Shah Alam, Selangor. This study will identify trade workers exposed to FFH and investigate the factors that can lead to FFH among construction workers. Additionally, the data will be collected through a quantitative survey of respondents from companies in the building construction industry, particularly construction professionals with extensive experience and knowledge of on-site fall-from-height (FFH) accidents. The questionnaire will explore high-risk trade work, contributing factors, and safety improvements related to FFH. Then, the highest-ranked safety recommendations discovered through the data analysis will be proposed in the hope that they can serve as a benchmark for widespread implementation in Malaysia.

This paper on safety improvements for FFH accidents in the construction industry holds several significant benefits. For instance, identifying high-risk trade works exposed to FFH is critical for targeting specific vulnerabilities associated with this issue. Hence, it helps to prioritise safety interventions and focus the study where it is most needed. It also helps ensure that the proposed safety initiatives are practical, relevant, and capable of addressing the source of risk. Furthermore, understanding the factors contributing to FFH accidents within the specified high-risk work trades will allow effective formulation of mitigation measures. This can be achieved through a better understanding of the safety regulations and procedures applied in building construction companies. By prioritising safety improvements based on identified risk factors, the companies can direct their efforts towards the most critical areas, thereby increasing the efficiency and impact of the improvements implemented.

2. Literature Review

This literature review establishes a comprehensive foundation for examining the existing body of knowledge and research pertinent to the critical safety issue of falls from height (FFH). Specifically, it aims to identify high-risk

trades, analyse the factors contributing to FFH incidents, and evaluate relevant strategies to improve safety. These insights will serve as a guiding framework to achieve the objectives of this study.

2.1 Trade Works Exposed to FFH Accidents

The construction industry is notorious for its high rates of fatal accidents, particularly those involving falls from heights (FFH). Each year, approximately 300 to 400 individuals working in the construction industry are involved in fatal accidents, most of whom work at heights on roofs, ladders, and scaffolds [10]. In Malaysia, Abd Samad et al. [11] support this trend, identifying falls from scaffolds, ladders, and roofs as the leading causes of fatalities. An investigation on scaffolding safety practices revealed that scaffolding-related cases account for 70% of fatal injuries on Malaysian construction sites [12]. This highlights a critical gap in safety management practices, particularly in scaffolding safety, which has been under-researched despite its significant impact on worker safety. Quantitative analyses conducted in various Malaysian regions, such as Kuching, have consistently shown that falls from scaffolds and roofs are the most prevalent causes of FFH accidents [13]. In relation to the work conditions mentioned, some of the trades most susceptible to FFH include roofing and finishing contractors, manual construction labourers, and speciality trade contractors. The data indicate that roofing contractors are particularly vulnerable, with NIOSH [10] stating that roofers face the highest risk of fatal falls due to the inherent dangers of working on sloped surfaces. Simpson [14] reinforces this by noting that the fatal fall rate among roofers is significantly higher than that of other construction workers.

Moreover, the risk is not limited to roofers; manual construction labourers, including both skilled and unskilled workers, also experience a significant number of FFH accidents, accounting for a notable percentage of fatalities [16]. On the other hand, Rafidandi et al. [15] conducted an analysis using the frequency distribution method based on DOSH data from 2010 to 2018 and found that the most affected trade groups are construction labourers, carpentry workers, bricklayers, and scaffolders. Additionally, speciality trade contractors, such as electricians, plumbers and HVAC technicians, are highly exposed to FFH accidents. According to CPWR [18], which uses OSHA recordable case data, the number of fatal falls among speciality trade contractors continues to increase, whereas the other two industries show a significant decrease over the years. CPWR [18] also discussed that speciality trade contractors have the highest percentage of fatal injuries by 71.5%, with an average of 246 injuries from 2011 to 2021. Table 1 summarises the trade workers exposed to FFH accidents in the building construction industry. All relevant trade work was used to identify those most exposed to FFH accidents in the Malaysian construction industry in Shah Alam through a questionnaire survey.

Table 1 *Trade works exposed to FFH accidents*

No	Trade works exposed to FFH accidents	References
1	The majority of construction workers exposed to fatal accidents are working on roofs, ladders and scaffolds	[10], [11]
2	Scaffolding-related cases cover high rates of fatal injuries in Malaysia	[12]
3	Scaffolding falls and roof falls are the most exposed to fall accidents	[13]
4	Fatal falls among roofers were ten times higher than among other construction workers construction	[14]
5	The most affected trade workers are labourers, carpentry workers, bricklayers and scaffolders	[15]
6	Both skilled and unskilled workers, carpenters and roofers, are exposed to FFH accidents	[16]
7	Fatal falls among speciality trade contractors have increased over the years	[17], [18]

2.2 Factors Contributing to FFH

The construction industry is fundamentally demanding and characterised by dynamic, risky tasks performed at varying elevations. Hence, it is critical to understand the factors that can contribute to FFH as it can result in severe injuries and fatalities. It has been found that the leading factors in construction accidents in most countries worldwide are management factors, workers' behaviours, and unsafe site conditions.

Table 2 summarises the key findings for the factors contributing to FFH accidents in the building construction industry. Management factors on the construction site include inadequate work standards, unsafe working conditions or practices, and a lack of supervision. Firdaus et al. [19] highlighted several management-related sub-factors leading to FFH, including insufficient inspections, lack of training programs, non-compliance with safety

regulations, and cost-cutting measures. Rookey et al. [20] further emphasise that improper job practices and inadequate monitoring significantly contribute to fatal accidents in Malaysia. In addition, an analysis of 105 fatal fall accident data from DOSH Malaysia was conducted to identify the factors contributing to FFH. The analysis revealed that management and human factors accounted for a substantial portion of the contributing factors, underscoring the importance of effective management strategies in mitigating risks associated with FFH [16], [18], [19].

Table 2 *Factors contributing to FFH accidents*

No	Factors contributing to FFH accidents	References
1	Insufficient inspection, lack of training programs, non-compliance with safety regulations and cost-saving purposes	[19]
2	Improper job practices and a lack of monitoring are the major contributors to fatal cases	[20]
3	Workers' behaviours are the most significant factor, followed by hazardous site conditions and management factors	[15]
4	Negligence of the workers in safety devices	[23]
5	Low level of safety knowledge among workers	[22]
6	Defects on work surfaces	[16]
7	Unsafe site conditions	[11], [20]
8	Improper management and human factors	[4]

Worker behaviours are another critical factor influencing FFH. The physical and psychological aspects of workers, including their experience, attitudes, and adherence to safety protocols, are significant determinants of safety outcomes. Rafidandi et al. [15] found that worker behaviour accounted for a significant share of fall accident contributing factors, indicating a strong correlation between behaviour and safety outcomes. Based on a study conducted in Singapore involving 1,085 patients who fell from heights in the construction industry, 94.1% did not use safety devices. This shows the workers' negligence, as they do not adhere to safety practices that prevent falls [23]. Additionally, low levels of safety knowledge among workers contribute to their failure to recognise hazards and to utilise protective equipment effectively [19], [21], [22].

Unsafe site conditions further worsen the risk of FFH. Nadhim et al. [16] identified various site-related hazards, including unprotected walkways, improperly installed guardrails, and slippery surfaces, that can lead to falls. Abd Samad et al. [11] documented critical sub-factors related to unsafe site conditions, including poor housekeeping, unprotected edges, and broken or unsafe tools. Rookey et al. [20] supported these findings, indicating that poor site housekeeping is a leading contributor to unsafe conditions, followed by exposure to high levels and adverse weather [11], [23], [24].

2.3 Strategies to Improve the Safety of Workers from FFH Accidents

The construction industry poses significant risks to workers, particularly concerning falls from height (FFH). Effective strategies to mitigate these risks are essential for enhancing worker safety. A comprehensive approach to improving safety involves rigorous training, proper equipment use, and the establishment of robust safety management systems. Table 3 summarises the key findings on strategies to improve worker safety from FFH accidents in the building construction industry. Safety training is a fundamental component in reducing FFH incidents. It is crucial for all construction workers, especially newcomers, to receive thorough training on fall prevention measures, including the correct use of personal protective equipment (PPE) and the ability to recognise potential fall hazards. Abukhashabah et al. [22] emphasise the necessity of having qualified safety and health supervisors on-site, alongside well-maintained equipment, to foster a safe working environment. Continuous training and awareness programs are vital to ensure that workers are knowledgeable about safety protocols and the importance of PPE [11], [25]. Proper PPE and continuous training should be practised to raise safety awareness. Moreover, Zerguine et al. [28] advocated for mandatory toolbox briefings at the start of each workday, which can reinforce safety practices and ensure that all workers, especially new hires, are adequately informed about potential hazards and safety measures.

In addition to training, implementing a comprehensive safety management system is critical. This system should systematically identify and manage safety risks associated with construction operations. Safety initiatives can be implemented by construction management to ensure sufficient safety awareness and adherence to precautions among construction workers. Firdaus et al. [19] highlighted the importance of enforcing penalties for noncompliance with safety regulations, such as failing to wear safety harnesses when working at heights.

Moreover, employers need to provide complete personal protective equipment (PPE) for workers and enforce penalties for those who do not wear a safety harness when working at heights [29]. This is in line with DOSH guidelines, which require workers to wear PPE, as failure to do so could result in serious injuries.

Table 3 *Strategies to improve the safety of workers from FFH accidents*

No	Strategies	References
1	A qualified safety and health supervisor must be provided, equipment and machines in good condition, proper PPE and continuous training should be practised	[22]
2	The toolbox briefing should be made compulsory every morning	[28], [30]
3	Provision of complete personal protective equipment (PPE) for workers and carrying out penalty enforcement for those who do not wear safety harnesses when working at heights	[19], [29]

Despite the wealth of existing literature, there is a significant gap in understanding the specific safety practices and training needs of high-risk trades within the Malaysian context. Previous studies have documented the prevalence of falls from heights (FFH) accidents; however, research evaluating the effectiveness of safety training programs and their direct impact on reducing these incidents remains limited. While some researchers have highlighted the importance of safety management practices in enhancing safety performance, the application of these principles in the Malaysian construction sector has not been thoroughly explored.

This study aims to fill these gaps by investigating the specific safety practices that can mitigate FFH risks among various trades. The research employs a questionnaire survey to investigate trade workers exposed to FFH accidents, to extract key factors contributing to FFH accidents based on a comprehensive literature review, and to identify effective strategies for improving worker safety in the Shah Alam construction industry.

3. Methodology

3.1 Questionnaire Survey Design

The questionnaire of the survey is divided into four sections, section A, B, C and D. Section A will be covering the demographic profile of the respondents, Section B will discuss the trade works exposed to FFH accidents, Section C covers the factors leading to FFH accidents with respect to the respondents' opinions and Section D covers recommendations on strategies to improve safety of workers from FFH accidents. In addition, Sections B, C and D will be prepared in the form of the Likert Scale, where 1=Strongly Disagree, 2=Disagree, 3=Moderately Agree, 4=Agree, and 5=Strongly Agree.

3.2 Population and Sampling Design

According to the Construction Industry Development Board (CIDB), there are 204 registered construction companies under the building construction category in Shah Alam, Selangor. This amount includes all grades of contractors registered with CIDB: G1, G2, G3, G4, G5, G6, and G7, specialising in building construction, and reflects the population size of the respondents, assuming one response per company. According to the Krejcie &Morgan [31] sample size determination table, the target respondent pool was 132.

3.3 Data Analysis

Data analysis was conducted after receiving the responses. In this study, four methods are used to analyse the data: response rate analysis, descriptive analysis, Reliability analysis, and Relative Importance Index (RII) analysis. The initial step of the analysis will be to calculate the response rate. This method is selected to accurately represent the actual response rate achieved in this study. By providing a response rate analysis for online surveys in this study, potential biases and limitations can be identified [32]. The response rate will justify whether the data is adequate for analysis and reporting.

Descriptive analysis is a part of good research practice to reduce the possibility of presenting misleading results. In this study, descriptive analysis is to be used for Section A - Respondents' Demographic Profile to summarise and describe the key findings from the section. From the descriptive analysis, the frequency can be expressed as a percentage for each variable [33]. These percentages will be further defined to show the distribution of the responses collected in section A.

Reliability analysis will be conducted for Sections B, C, and D of the questionnaire to assess internal

consistency using Cronbach's alpha in the Statistical Package for the Social Sciences (SPSS). This method will calculate the average correlation among the items in each section. By referring to George & Mallery [34], a Cronbach's alpha above 0.70 indicates greater internal consistency. This reliability analysis is very important to conclude whether the data is reliable for decision-making in this study. This method also helps identify potential sources of measurement error, thereby improving the credibility and quality of the data.

Relative Importance Index (RII) analysis will be used for Sections B, C, and D of the questionnaire to assess the relative importance of variables within each section. The value of RII ranges from 0 to 1, with higher values indicating greater relative importance of a particular variable [35]. This method is selected as one of the most suitable for effectively rating the importance of various variables on a 5-point Likert scale, which is used in this study. After the RII scores for the variables are obtained, the variables or items in each section will be ranked, and the most important variables can be determined.

4. Results and Discussion

4.1 Response Rate

The selected respondents are construction professionals who are involved in building construction in Shah Alam, Selangor. The population comprises 204 companies of all grades registered with CIDB. A total of 132 respondents is needed based on a sample size determination table by Krejci & Morgan [31]. However, this study collected data from 99 respondents, yielding a response rate of 75%. According to Miller [32], the response rate is considered to have a very good adequacy for analysis and reporting. The 75% response rate indicates strong engagement by respondents in providing their feedback. It also suggests that the risk of non-response bias is lower, while a large majority of respondents found the survey relevant.

4.2 Descriptive Analysis of Respondents' Demographic Profile

The descriptive analysis consists of the respondents' demographic profile analysis from section A – Respondents' Demographic Profile. The respondents' demographic profile includes four types of information: the organisation's registered grade with CIDB, the respondent's designation, years of working experience in Malaysia, and the respondent's background.

Fig. 1 shows the registered grade of the respondents' organisation with CIDB. There are 3.0% of respondents from G6, 4.0% from G4, 17.2% from G3, 29.3% from G5, and the highest at 46.5% from G7. This study targeted construction companies in the building category registered with CIDB across various grades, ranging from G1 to G7. However, no responses were obtained from G1 and G2, likely due to their size and capabilities. G1 and G2 companies are typically smaller than higher-grade companies.

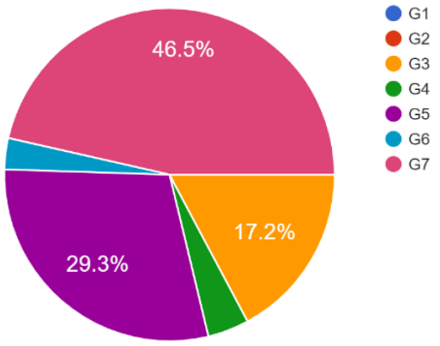


Fig. 1 *Organisation's registered grade with CIDB*

Therefore, they may have fewer resources or personnel available to participate in this survey. There are also challenges in effectively reaching out to G1 and G2 companies via email. On the other hand, G5, G6 and G7 companies are typically well-established firms with significant market presence; they are much easier to reach out to. As for the low percentage of G6, it is due to the small number of companies registered at the G6 grade. Overall, the high response rate among G7 and G5 companies highlights the importance these firms place on safety, driven by their operational scale and regulatory responsibilities.

Fig. 2 shows the registered grade of the respondents' designation. From the pie chart, 1.0% of the respondents are project directors, 26.3% are engineers, 27.3% are senior engineers, and the largest share, 45.5%, are project managers. Most of the respondents, as shown in the chart, are project managers, suggesting that these professionals are often the driving forces behind safety improvements and are likely responsible for directing the

implementation of safety procedures on site. Their significant involvement reflects their pivotal role in operational and safety management. Meanwhile, 27.3% of the respondents are senior engineers, indicating that experienced technical professionals are also highly engaged in the survey. Their involvement is crucial as they provide expert insights into the technical and safety aspects of construction projects. On the other hand, engineers account for 26.3% of respondents, indicating they were heavily engaged in the survey as well. This reflects the importance of including both senior and junior engineering staff in discussions about safety improvements at FFH, as they are directly involved in day-to-day operations and can offer practical insights into safety factors and solutions.

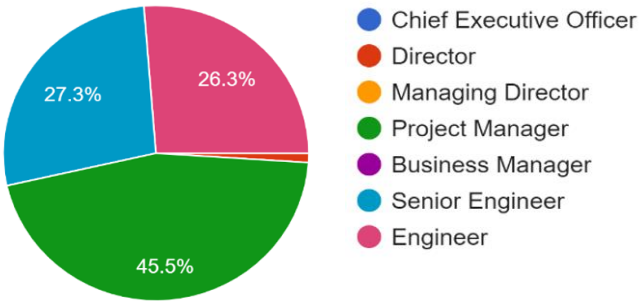


Fig. 2 *Respondents' designation*

The low percentage (1%) of project directors indicates that higher-level executives might assign the responsibility of participating in such surveys to those directly involved in project management and engineering roles. The absence of responses from Chief Executive Officers, Managing Directors, and Business Managers may suggest that these roles are more centred on strategic and administrative matters, leaving technical and safety concerns to project managers and engineers. The distribution, taken as a whole, emphasises the crucial role of project managers and engineers in the safety improvement process, highlighting their direct involvement and expertise in ensuring workplace safety.

Fig. 3 shows the registered grades by respondents' years of working experience in Malaysia. Most respondents (39.4%) have more than 21 years of experience, suggesting that the survey has reached a mature, highly experienced group of professionals. This high level of experience indicates that these respondents have a deep understanding of industry practices and safety protocols; their insights are particularly valuable for this study. The second-largest group, with 23.2% of respondents, has 11 to 15 years of experience. This number represents mid-career professionals who have gained extensive experience and are likely to hold influential positions within their organisations. Their insights are crucial, as their expertise is highly relevant to current industry practices. Respondents with 16 to 20 years of experience account for 20.2% of the total respondents. These individuals can also provide valuable insights and stability to the survey, having presumably witnessed various safety developments and industry changes over the years. The group with 6 to 10 years of experience comprises 13.1% of the respondents. These individuals are still relatively early in their careers, yet they have enough experience to provide valuable insights on current safety practices and areas for improvement.

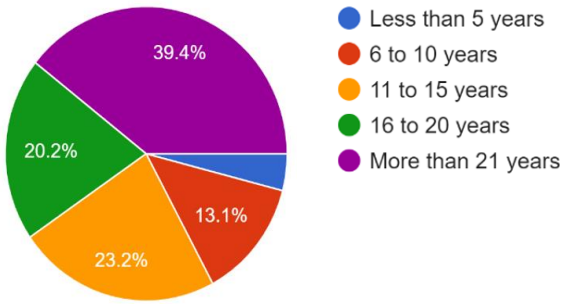


Fig. 3 *Years of working experience in Malaysia*

Lastly, 4% of the respondents have less than 5 years of experience. While this is the smallest group, their input is still valuable as they may offer new perspectives. Overall, the distribution of working experiences suggests a strong representation of experienced professionals, which is likely to result in comprehensive and knowledgeable feedback on safety improvements from FFH accidents in the building construction industry.

Fig. 4 shows the respondents' professional background. The overwhelming majority (93.39%) of respondents

are civil and structural engineers. This dominant presence is likely attributed to the nature of the construction industry, which relies heavily on civil and structural engineering in most projects. These professionals are typically responsible for designing, constructing, and maintaining infrastructure, making them highly relevant to discussions on safety improvements for FFH accidents, which are common on construction sites. Electrical engineers account for 6.1% of the respondents. While they are indeed small, their engagement is significant, as electrical work is an important aspect of construction projects. Interestingly, none of the respondents (0%) are mechanical engineers. This absence could be attributed to the survey's specific focus on safety improvements related to FFH accidents, which are less directly associated with mechanical engineering. Mechanical engineers typically engage with machinery and mechanical systems, which may not be as relevant for this survey. Overall, the distribution illustrates the importance of civil and structural engineering professionals in the construction industry, especially regarding safety issues related to FFH accidents. The data indicate that the insights and opinions of these engineers are critical to developing effective safety measures in building construction projects.

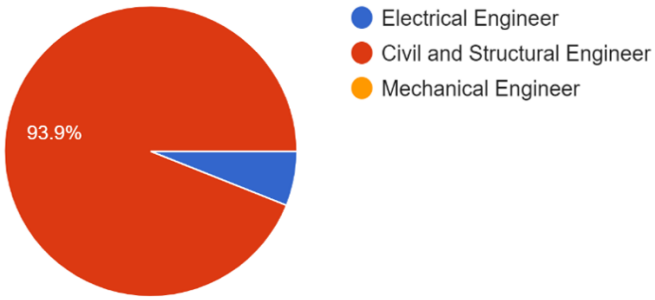


Fig. 4 *Respondent's professional background*

4.3 Reliability Analysis

Table 4 presents the results of the reliability analysis for section B, which contains 15 items. The value obtained for Cronbach's alpha is 0.788, indicating that the items in the Likert scale are reasonably consistent with each other. The slight increase of Cronbach's alpha to 0.791 on standardised items implies that the scale's reliability might improve with standardisation. Considering that both Cronbach's values are above 0.7, it is considered acceptable. Cronbach's alpha value for section C is 0.759, containing 19 questions, which falls into an acceptable range, indicating that the items in the Likert scale have a good level of internal consistency. Again, the slight increase from 0.759 to 0.771 indicates small differences in the item means and variances; standardisation will only slightly enhance consistency. Both Cronbach's alpha values suggest that the items align well in measuring overall satisfaction with the scale. However, changes have been made to increase Cronbach's alpha in section C by deleting item C2 (Unsafe work standards), as shown in Table 5, because the item is redundant and similar to C1 (Inadequate work standards).

Table 4 *Reliability analysis – Section B: trade works exposed to FFH accidents*

Section	Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
B	.788	.791	15
C	.759	.771	19
D	.728	.731	7

Table 5 *Reliability analysis if item is deleted – Section C: factors contributing to FFH accidents*

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.763	.775	18

According to Table 5, Cronbach's alpha value of 0.763 is slightly higher compared to the previous value of 0.759. The standardised Cronbach's alpha also increased from 0.771 to 0.775. This increment indicates that the internal consistency of the 18-item scale is better than that of the 19-item scale in section C. Despite having fewer items, the current Cronbach's value improves. This implies that the removed item was not contributing positively to overall consistency; therefore, its removal is appropriate. The reliability statistics for Section D consist of 7

items. The value of Cronbach's alpha is 0.728, whereas the value of Cronbach's alpha on standardised items only has a slight increase compared to 0.728, meaning that the standardisation does not significantly affect the consistency measurement in section D. Both values are above 0.7, suggesting that the items have an acceptable level of internal consistency.

4.4 Reliability Importance Index (RII) Analysis

4.4.1 RII Analysis for Trade Works Exposed to FFH Accidents

Table 6 shows a detailed ranking of various trade works based on their Relative Importance Index (RII) scores, which represent the relative risk of exposure to FFH accidents. The findings on the risk factors for falls from heights (FFH) in Shah Alam, Malaysia, offer several novel insights that distinguish them from prior research. The study identifies roofers (B2) as the most critical trade, with the highest Relative Importance Index (RII) score of 0.9434, indicating their significant exposure to FFH risks. It is most likely because their main job requires them to work at considerable heights, where there is a risk of slips, trips, and falls on rooftops. This finding aligns with existing literature that recognises roofers as among the most vulnerable workers due to their work at elevated heights [36]. However, the unique construction environment of Shah Alam, characterised by distinct local practices and workforce dynamics, introduces complexities that may not have been fully addressed in previous studies. For instance, while existing research emphasises general risks associated with roofing, this study specifically identifies conditions in Shah Alam that exacerbate these risks, such as inadequate safety training and supervision.

Table 6 *RII analysis for trade works exposed to FFH accidents*

Trade work	RII	Rank
B1. Scaffolder	0.8869	2
B2. Roofer	0.9434	1
B3. Ironworker	0.7131	8
B4. Power-line installer	0.8465	3
B5. Welder	0.7010	10
B6. Helper	0.7495	5
B7. Painter	0.7212	7
B8. Foreman	0.7253	6
B9. Drywall	0.6364	14
B10. Laborer	0.8263	4
B11. Carpenter	0.6909	12
B12. HVAC mechanic	0.6949	11
B13. Electrician	0.7030	9
B14. Plumber	0.6848	13
B15. Construction Manager	0.5313	15

Furthermore, scaffolders (B1) are identified as the second highest-risk group, with an RII score of 0.8869. This finding is consistent with existing literature that recognises the dangers associated with scaffolding work [37]. However, the study offers new insights by illustrating how the frequent need for scaffolders to maintain balance on temporary structures at construction sites in Shah Alam can increase their vulnerability to falls. This localised perspective underscores the need for tailored safety protocols that address the specific challenges scaffolders face in this region. The results for B1 and B2 are in line with NIOSH [10], who stated that most workers involved in fatal accidents are those working at heights on roofs, ladders, and scaffolds, especially roofers, who have the highest risk of fatal falls.

In addition, the third-highest exposure to FFH accidents is among power-line installers (B4), followed by labourers (B10) and helpers (B6), with RII values of 0.8465, 0.8263, and 0.7495, respectively. Power-line installers mostly work on utility poles and elevated structures, while general labourers frequently operate at heights and on different surfaces, therefore contributing to their high RII score. On the other hand, helpers are also susceptible to the FFH, depending on the tasks they perform during construction, such as carrying materials or working at heights alongside other high-risk trades. In contrast, the construction manager (B15) has the lowest RII score, 0.5313, suggesting that respondents perceive this role as less exposed to FFH accidents. This finding challenges some prior assumptions that managerial roles are equally at risk, indicating a need for further investigation into

the actual safety practices and perceptions within managerial positions in construction [37]. The mid-ranking trades, such as welders and electricians, with RII scores around 0.70, also indicate a moderate exposure to FFH risks, consistent with earlier studies and emphasising the need for ongoing safety training and awareness across all trades [24].

4.4.2 RII Analysis for Factors Contributing to FFH Accidents

Table 7 presents the RII scores and ranking of various factors contributing to FFH accidents in the building construction industry. These factors are categorised into three main groups: Construction Management, Human Factors and Site Conditions. However, the analysis considers all items to identify the primary factors contributing to FFH accidents across the three main groups. Therefore, it is evident that the most critical factor leading to FFH accidents is a lack of supervision (C2), with the highest RII score of 0.9212. This finding underscores the crucial role of supervision in safety. It can happen when there are not enough supervisors to oversee a particular number of workers on site, or the supervisors are not adequately trained in safety supervision. This finding aligns with previous studies that highlight the critical role of effective supervision in reducing safety risks [38]. However, the specific context of Shah Alam presents a unique challenge: the shortage of adequately trained supervisors, a factor that may not have been thoroughly addressed in earlier research. For instance, while Oswald et al. [38] discussed the broader issue of unqualified personnel in the construction industry, this study specifically emphasises the insufficient number of supervisors and their lack of training, which exacerbates safety risks in Shah Alam. Lack of supervision can lead to harmful situations and unsafe behaviours that go uncorrected, leaving workers without prompt guidance on managing risks during construction.

Table 7 *RII analysis of factors contributing to FFH accidents*

Factors contributing to FFH accidents	RII	Rank
Construction Management		
C1. Inadequate work standards	0.8424	9
C2. Lack of supervision	0.9212	1
C3. Insufficient monitoring and inspection	0.9192	2
C4. Lack of training program	0.7818	15
C5. Non-compliance safety regulations	0.8364	10
C6. Cost-saving purpose	0.8101	14
C7. Improper job practices	0.8485	8
Human Factors		
C8. Worker's inadequate work experience	0.9010	4
C9. Workers do not use safety devices	0.8343	11
C10. Low level of safety knowledge among workers	0.9030	3
C11. Worker's physical health	0.8141	13
C12. Worker's mental health	0.7475	18
Site Conditions		
C13. Defects in work surface	0.8343	11
C14. Poor management on housekeeping	0.7556	17
C15. Unprotected edges	0.8545	7
C16. Broken equipment	0.7657	16
C17. Unstable working structure	0.8667	5
C18. Insufficient personal protective equipment	0.8586	6

Moreover, the second-highest ranked factor is insufficient monitoring and inspection (C3), with an RII score of 0.9192. This factor can be associated with C2, as previously discussed, since insufficient monitoring and inspection can result from infrequent site visits and the absence of a systematic inspection schedule or techniques. Failure in monitoring and inspection leads to failure to identify and mitigate on-site hazards, allowing them to persist and increasing the risk of falls. Previous studies have noted the significance of monitoring in safety management [39], yet the current findings suggest that the frequency and systematic nature of inspections are critical in this specific locale. This indicates a gap in the existing literature, which may not have sufficiently explored the frequency of site visits and their direct impact on safety outcomes in Malaysian construction sites.

Next, the third prime factor contributing to FFH accidents is the low level of safety knowledge among workers (C10), with an RII score of 0.9030, which contributes to unsafe behaviours. This finding resonates with the work of Huang et al. [40], who noted that inadequate safety knowledge is a pervasive issue in the construction industry. However, the current research adds a new dimension by linking this lack of knowledge to cultural pressures within the Shah Alam construction workforce, where efficiency is often prioritised over safety. This cultural aspect may not have been adequately addressed in previous studies, underscoring the need for targeted safety training that accounts for local work culture. This is because low levels of safety knowledge among workers can lead to poor decision-making and unsafe behaviour, such as improper equipment handling and failure to follow on-site safety practices. In certain workplaces, there may be a cultural emphasis on efficiency and speed over safety; workers are not urged to prioritise safety, but rather face pressure to cut corners to meet deadlines.

This factor is also interrelated to the respective factors, which is the worker's inadequate work experience (C8), with an RII score of 0.9010. The reason is that the construction industry usually has high turnover rates, especially among labourers, which means new workers join and leave the workforce regularly. Hence, it is highly likely that these new workers do not possess the same level of safety knowledge, given that they also lack sufficient work experience in height-related work compared to more experienced workers. This phenomenon has been acknowledged in prior research by Asilian-Mahabadi et al. [41], but the specific implications for Shah Alam's construction sites, where new workers may struggle to identify hazards, provide a fresh perspective on the challenges faced in this region. Workers with less experience may be less able to identify hazards or even comprehend the significance of safety precautions, thus increasing their risk of falling.

Lastly, the next critical factor is an unstable working structure (C17), ranked fifth with an RII score of 0.8667, which contributes to FFH accidents and reflects a localised concern that may not have been emphasised in broader studies. This factor strongly reflects the trade work exposed to FFH accidents, as discussed in section B. This is because scaffolding and platforms are examples of unstable structures that can result from poor construction, improper assembly, or failure to maintain structural integrity. Falls may result from these unstable structures shifting or collapsing. While previous literature has discussed the risks associated with scaffolding and other structures [42], the current findings suggest that construction practices in Shah Alam may require stricter adherence to safety protocols to prevent accidents caused by poor construction. The RII analysis in this section reveals that the prime factors are present in each of the three groups: Construction Management, Human Factors, and Site Conditions. This proves that these main groups are correlated, emphasising that FFH accidents are a complex issue requiring attention across multiple dimensions. Overall, the results of this analysis are in line with DOSH Malaysia's analysis of fatal accidents, which found that management and human factors are the leading contributors to FFH accidents.

4.4.3 RII Analysis for Recommendation on Strategies to Improve Safety of Workers from FFH Accidents

The findings from the study on strategies to improve worker safety from falls from heights (FFH) in Shah Alam, Malaysia, offer several significant insights into safety management in the local construction context. Table 8 presents the RII analysis of respondents' recommendations for strategies to improve workers' safety from FFH accidents. The highest recommended strategy, providing continuous training for workers (D4), with a Relative Importance Index (RII) score of 0.9475, underscores the critical role of ongoing education in enhancing safety knowledge and behaviours. This finding aligns with previous studies that emphasise the importance of training in reducing workplace accidents [43]. However, the specific emphasis on continuous training in Shah Alam highlights a localised need for regular updates on safety protocols and emergency responses, which may not have been as explicitly addressed in broader studies. For instance, while Mosly et al. [43] discussed the necessity of training for less-experienced workers, the current study emphasises the dynamic nature of construction work in Shah Alam, which necessitates frequent retraining to adapt to evolving safety challenges.

Table 8 *RII analysis for trade works exposed to FFH accidents*

Trade work	RII	Rank
D1. Appoint a qualified safety and health officer	0.8848	5
D2. Provide equipment and machinery in good condition	0.9111	3
D3. Provision of complete PPE	0.8828	6
D4. Provide continuous training for workers	0.9475	1
D5. Conduct a toolbox meeting every morning	0.9414	2
D6. Conduct regular safety audits and inspections	0.8869	4
D7. Carry out penalty enforcement against workers who fail to conform to safety practices	0.8768	7

This is likely because this strategy can directly influence workers' knowledge and behaviours regarding the safety practices on construction sites. Construction work is hazardous and dynamic, requiring regular updates on safety protocols, equipment use, and emergency response to hazards. Continuous training will ensure that the workers are well informed about the current safety procedures and strengthen their capability to identify and respond to risks. Not only that, but continuous training also helps cultivate their awareness of the need to adhere to safety guidelines and procedures. This recommendation also directly addresses the primary factors causing FFH, namely C8 and C10, by increasing safety knowledge and guiding workers with limited experience working at elevated heights.

The second-highest recommendation is to conduct a toolbox meeting every morning (D5), with an RII score of 0.9414, which also provides new insights. While prior research has acknowledged the value of toolbox meetings in promoting safety communication [44], the current findings emphasise their role in facilitating immediate feedback and addressing specific daily safety concerns on construction sites in Shah Alam. This localised perspective suggests that regular, short meetings can significantly enhance safety awareness and responsiveness among workers, a point that may not have been sufficiently highlighted in previous literature. In contrast to D4, which takes a longer time to execute, usually ranging from two weeks to several months, the toolbox meeting runs for only 10 to 15 minutes on a regular basis. However, it is equally important because this short, focused meeting serves as a platform for discussing specific safety concerns and daily updates. For instance, toolbox meetings encourage open communication between supervisors and workers to address potential hazards, enabling immediate feedback and real-time improvements in on-site safety practices.

The third most important recommendation is to provide equipment and machines in good condition (D2), with an RII score of 0.9111, which reinforces the importance of maintaining operational safety standards. This strategy is undoubtedly important because equipment and machinery should be well-maintained to prevent operational failures that could lead to falls from elevated heights. This finding is consistent with earlier studies that have pointed out the risks associated with faulty equipment [45]. However, the specific context of Shah Alam, where construction practices may vary, suggests the need for tailored maintenance protocols that account for local conditions and equipment usage patterns. Therefore, regular maintenance and inspection are required to ensure that all equipment and machinery are safe to use, so workers can rely on their tools to perform tasks safely and effectively.

Furthermore, the fourth recommendation is conducting regular safety audits and inspections (D6), with an RII score of 0.8869. This strategy is crucial for identifying and mitigating risks before they result in accidents. This includes a systematic approach to evaluating the safety of the work environment, including the condition of tools and machinery (as mentioned in D2), safety practices, and compliance with safety regulations. This will help to ensure potential hazards related to heights, such as unprotected edges or faulty equipment, are identified and addressed promptly. These strategies must also be carried out by qualified safety and health officers (D1), as shown in Table 8, having an RII score of 0.8848. This means that it is crucial to have a qualified safety and health officer to manage and oversee safety practices on construction sites, ensuring continuous attention to safety issues, safety training, and regulatory compliance, which directly address the prime factors C2, C3, and C17.

In summary, the findings from Shah Alam not only confirm existing research on safety training and equipment maintenance but also provide new insights into specific strategies to enhance worker safety in the local construction industry. The emphasis on continuous training, toolbox meetings, and the role of qualified safety personnel reflects a nuanced understanding of the unique challenges faced in Shah Alam's construction environment, thereby contributing to the broader discourse on occupational safety.

5. Conclusion

In conclusion, the respondents were primarily from larger construction companies with CIDB grades G5 to G7, which typically place greater emphasis on safety due to their operational scale and regulatory requirements. Project managers and senior engineers constituted the majority of respondents, emphasising their critical role in implementing safety procedures on-site. Their insights are valuable because they are directly involved in day-to-day operations and safety management. Most of the respondents were very experienced, with a considerable number having more than 21 years in the profession. This significant expertise provided a solid framework for the study, ensuring that the input was grounded in real, long-term industry knowledge.

Furthermore, the study found that roofers, scaffolders, and power-line installers are at the highest risk of FFH accidents due to their work at heights. Construction managers, on the other hand, are less exposed to FFH risks due to their supervisory role rather than direct involvement in high-risk activities. Subsequently, the most contributing factors to FFH incidents are apparent in all three categories. Firstly, in construction management, the main contributing factors were a lack of supervision and insufficient monitoring and inspection. Therefore, a qualified safety and health officer should be appointed to oversee the workers on-site. In terms of the human aspect, workers' lack of safety knowledge and inadequate work experience have been identified as key contributors to FFH accidents. This emphasises the importance of proper, continuous training and of conducting regular toolbox meetings. On the other hand, in terms of site conditions, defects in work surfaces and unstable working structures were major site-related issues. Proper maintenance and safety audits are required to reduce these dangers. All equipment and machines must also be provided in good condition and safe to use. Furthermore, the integration of technology, such as IoT systems for monitoring PPE usage, can enhance compliance and safety oversight on construction sites [43], [44].

However, the study is not without its limitations. The sample primarily consisted of respondents from larger construction companies (CIDB grades G5 to G7), which may not fully represent the safety challenges faced by smaller contractors, who often experience higher accident rates. Future research should aim to include a broader range of respondents from various company sizes and consider a mixed-method approach to gain a more comprehensive understanding of safety practices across the industry. Additionally, longitudinal studies could provide valuable insights into the effectiveness of implemented safety strategies over time, allowing for continuous improvement in safety management practices.

In conclusion, the insights gained from this study can serve as a foundation for enhancing safety practices in the construction industry in Shah Alam. By implementing the recommended strategies and addressing the identified limitations, stakeholders can work towards creating a safer work environment that significantly reduces the risk of falls from heights and other accidents, ultimately contributing to the well-being of all construction workers.

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Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Wan Habibah Wan Mohd Nasir, Nur Izzati Ab Rani;* ***data collection:*** *Wan Habibah Wan Mohd Nasir;* ***analysis and interpretation of results:*** *Wan Habibah Wan Mohd Nasir, Ainarull Assikin Abdul Hadi;* ***draft manuscript preparation:*** *Wan Habibah Wan Mohd Nasir, Nur Izzati Ab Rani. All authors reviewed the results and approved the final version of the manuscript.*

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