

# An investigation into occupational health and safety of scaffolding practices on construction sites in Malaysia

Scaffolding accidents

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## Abstract

**Purpose** – Statistics show that the construction sector has the second-highest number of accident cases in Malaysia. A total of 100,000 construction workers suffer from work-related bad health each year. Scaffolding accidents are the second cause of accidents on construction sites. Therefore, this present research provided answers to the following questions: (1) what are the causes of scaffolding accidents and (2) what are the possible measures to reduce scaffolding accidents?

**Design/methodology/approach** – The research developed a questionnaire instrument that included 24 causes of scaffolding accidents and 21 remedial actions. The research was based on a cross-sectional survey questionnaire administered to 129 members of construction organizations.

**Findings** – Data revealed that scaffolding-related cases caused a total of 70% of the deaths/injuries on sites. Furthermore, scaffolding accidents were mainly caused by a lack of guard rails on scaffoldings, poor inspections, improper assembly, a poor safety culture, poor attitudes towards safety, poor footing of scaffoldings and unsecured planking. To reduce scaffolding accidents, there must be a lifeline on scaffolding, proper guardrails and proper assembling of scaffoldings, and preventing access to incomplete or defective scaffoldings. The 24 causes are structured into six factors through factor analysis and the 21 remedial actions into six factors.

**Originality/value** – This research serves as the first attempt to conduct broad research on the causes and remedial actions concerning scaffolding accidents on construction sites in Malaysia. Theoretically, the research has provided fresh insights into the impact of scaffolding accidents.

**Keywords** Claims, Height, Insurance, Physical injuries, Malaysia

**Paper type** Research paper

## 1. Introduction

The construction sector plays a significant role by demanding a large-scale workforce in the labour market, and it contributes about 10% to the gross domestic product in many countries (Schilling, 2013; Research and Markets, 2020). However, the safety levels within the construction sector are low, and accidents on construction sites are increasing and have remained a global phenomenon (Olanrewaju and Abdul-Aziz, 2015; Zhou *et al.*, 2015; Chong and Low, 2014; HSE, 2019). Between 2014 and 2017, close to 30% of all fatal accidents at work in the EU-28 took place within the construction sector (Eurostat, 2019). Similarly, the construction sector has the highest fatalities in Singapore at 29% (OSHD, 2017). The cost of

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workplace injuries in the UK construction sector was £1,204 m in 2018 (HSE, 2019b). The annual compensation for industrial accidents in Malaysia is RM 1.034 bn (Bakar, 2018). Therefore, a reduction in accidents on sites will lead to a reduction in workers' compensation, insurance claims, a decrease in litigation charges, reduced time loss and increased productivity.

Most construction site accidents are caused by scaffolding erection, dismantling, malfunctioning and collapsing (Zhou *et al.*, 2015; Winge and Albrechtsen, 2018; Eurostat, 2019). Like in most countries, the rates of accidents on Malaysian construction sites due to scaffolding are increasing (Olanrewaju *et al.*, 2021). For instance, in 2012, the number of accidents due to scaffolding totalled 30 and that number increased to 227 in 2016 (Social Security Organization Annual Report, 2012–2016). Ayob *et al.* (2018) found that 46.28% of the accidents are related to scaffolding. Furthermore, government-sponsored research shows that work at height is the biggest single cause of accidents in the Malaysian construction sector (CIDB, 2018). The alarming rate of scaffolding accidents led to a special committee (the Position Paper Committee) in 2013 by the Institution of Engineers Malaysia (The Institution of Engineers, Malaysia, 2015). Yet, there have been more studies and reports on accidents relating to scaffolding on construction sites in Malaysia (Abas *et al.*, 2020; Ayob *et al.*, 2018; Williams *et al.*, 2017; Ulang *et al.*, 2014; Keng and Abdul Razak, 2014; Lee *et al.*, 2018; CIDB, 2018). As much as the findings and recommendations for the studies are helpful, the studies tend not to go into the level of detail necessary to provide systemic explanations of the causes and remedial actions required for scaffolding accidents on construction sites. This research has emerged to commence a detailed investigation on scaffolding accidents on construction sites in Malaysia. This research examined the causes of scaffolding accidents and possible remedies to reduce scaffolding accidents to achieve this aim.

## 2. Background and literature review

The costs of accidents on construction projects are enormous and comprise both latent and explicit costs. The explicit costs of accidents on construction sites are medical bills, compensation, claims and fines. The latent costs include losses of productivity, costs of retraining new staff, delays in project completion and loss of morals, social discrimination and grief of the families of the victims. Despite various measures taken to improve construction site safety records, existing research revealed that accidents and injuries continued to plague the industry (Zhou *et al.*, 2015; Pieko *et al.*, 2018; Dogan *et al.*, 2021; Wang *et al.*, 2020; Rubio-Romero *et al.*, 2019; Czarnocka *et al.*, 2020). The census data from the USA showed that a total of 774 workers died from injuries suffered on construction sites in 2010 (BLS, 2012). Similarly, 38 deaths and 64,000 injuries were recorded in the UK construction sector in 2017 (Lucas, 2018). According to Sawacha *et al.* (1999), for every pound paid by insurance companies, the contractor paid between £5 and £50. Anecdotal data show that total losses due to construction activities-related accidents were 10% of the total turnover. Analysing the latest data on work-related ill-health in the UK, Lucas (2018) found a loss of 1.9 million working days within the construction sector, equating to around 8,000 construction workers being absent from work for an entire year. In Malaysia, the accident rates in the construction sector are the second largest, representing 23.70% of the total accidents in all the major economic industries and number one in terms of the cause of fatalities (Social Security Organization Annual Report, 2018). Every year, at least 95 deaths are documented on construction sites.

While the rate of accidents on construction sites is large and increasing unabated, the primary cause of accidents is related to the operations of scaffolding (Olanrewaju *et al.*, 2021; Hola *et al.*, 2018; Rubio-Romero *et al.*, 2019; Czarnocka *et al.*, 2020; Dogan *et al.*, 2021). Scaffoldings are provided where work cannot be safely done from the ground or a part of a building or other permanent structures (ILO, 1992). It is estimated that 65% of construction

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workers use scaffolding on construction sites (OSHA, 2019). Occupational safety and health administration's (OSHA) data found that 13.03% of the 1,215 falls in the USA were due to scaffolding (OSHA, 2019). Falling from scaffolding, ladders and fixed platforms are the most hazardous scaffolding in Greece (Aneziris *et al.*, 2012) scaffolding. Falls from scaffoldings are the major types of falls and causes of death in the Turkish construction sector (Gürcanlı and Müngen, 2013). Recent research shows that the number of accidents involving scaffolding contractors has increased from 89 in 2017 to 113 in 2018 in the UK (Construction Manager, 2019). This represents 27%. Based on an analysis of 1,630,452 construction accidents in Spain, López *et al.* (2008) found that accidents due to scaffoldings and ladders topped the list in terms of fatalities and severity. Similarly, scaffolding accidents have led to many fatalities and injuries in Belgium (Global Construction Review, 2021). Consistent with findings in most economies, scaffolding-related accidents, injuries and fatalities are the dominant causes of injuries and deaths on Malaysian construction sites (Olanrewaju *et al.*, 2021). Scaffolding accidents have increased by about 800% over five years (Social Security Organization Annual Report, 2018). Furthermore, while scaffolding accidents only accounted for 2.68% of the total causes in 2012, they increased to 23.35% in 2016. Therefore, protecting workers from scaffolding-related accidents may prevent the loss of many lives, claims, disputes, project delays and cost overruns. In Malaysia, it will avoid over 5,000 injuries and over 100 deaths every year. It will also reduce claims, litigation, productivity loss and loss of profit margin. These gaps justify the need for appropriate research.

Therefore, there is a systemic need to answer the question of “What are the causes of scaffolding accidents on Malaysian construction sites?” and find remedies to prevent or eliminate scaffolding accidents on sites. To provide answers to these questions, a cross-sectional survey questionnaire was conducted. Extant academic literature suggests these can be achieved by examining the causes and measures to reduce accidents on construction sites (Olanrewaju *et al.*, 2021). There have been numerous research accidents on construction sites worldwide (Hamdan and Awang, 2015; Szóstak *et al.*, 2021; Zhou *et al.*, 2015; Awwad *et al.*, 2016; López *et al.*, 2008). However, empirical studies on scaffolding accidents on sites, especially in Malaysia, are scanty despite the continuous increase and impact of scaffolding accidents. The previous studies were primarily concerned with the ranking of the causes. Research on remedies from the perspective of the site operative is nascent.

However, because the causes interact, it is essential to examine the relationship among the causes of the accidents and between the remedies. To close this knowledge gap, there is a systemic need to answer the questions of “What are the causes of scaffolding accidents on Malaysian construction sites” and what? And what are the remedies to prevent or eliminate scaffolding accidents on sites? This research identified, prioritized and categorized the causes and remedies. Categorizing the causes and remedies will help streamline and enhance decision-making on the performance of construction operations (Olanrewaju and Idrus, 2020). Analyses of interactions between causes and remedies pose a clustering problem due to the lack of labelling in the data. A clustering problem is a situation where the machine is trained on unlabelled data without prior guidance. Some algorithms for uncategorized learning include K-mean, C-mean and factor analysis. Factor analysis is used here because it is consistent with the aim of this research. Whilst there is no definitive list of causes and remedies to scaffolding accidents, Tables 1 and 2 contain a list of causes and potential measures to reduce the accidents. The lists are not prescriptive and comprehensive but indicative of the nature of the causes and remedies. The causes and remedies are not specific to scaffolding *per se*.

### 3. Research methodology

The primary data were based on convenience sampling. The method is appropriate where sufficient information on population size and sample frame is not available. While the

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## FEBE

Factors	Author
Structural failure of scaffolds	Heckmann (1995), Hamdan and Awang (2015)
Improper assemble of scaffolds	Heckmann (1995), Abu Bakar <i>et al.</i> (2008)
No lifeline on the lifeline-required scaffolds	Heckmann (1995), Hamdan and Awang (2015)
No guardrails installed on scaffolds	Heckmann (1995), Hamdan and Awang (2015), Abu Bakar <i>et al.</i> (2008)
Poor footing of scaffolds	Heckmann (1995), Hamdan and Awang (2015)
Bad weather	Hamdan and Awang (2015), Nadhim <i>et al.</i> (2016)
Misjudgement of a hazardous condition	Heckmann (1995)
Weight of equipment in use	Abu Bakar <i>et al.</i> (2008)
Excess load on scaffold	Hamdan and Awang (2015), Heckmann (1995)
Weight of materials in use	Abu Bakar <i>et al.</i> (2008)
Weight of scaffolding components	Abu Bakar <i>et al.</i> (2008)
Lack of personal protective equipment	Hamdan and Awang (2015), Nadhim <i>et al.</i> (2016), Bennett <i>et al.</i> (2018)
Scaffolding design flaws	Halperin and McCann (2004)
Distractions of operators	Hamdan and Awang (2015)
Improper leaning against on scaffold	Hamdan and Awang (2015), Ismail and Ghani (2012)
Lack of understanding about hazards	Bennett <i>et al.</i> (2018)
Lack of proper training towards operators	Hamdan and Awang (2015), Nadhim <i>et al.</i> (2016)
Operators lack of experience	Bennett <i>et al.</i> (2018)
Poor management of work at height	Bennett <i>et al.</i> (2018)
Poor inspection of scaffolds	Ali <i>et al.</i> (2010), Olanrewaju <i>et al.</i> (2021)
Poor safety culture	Olanrewaju <i>et al.</i> (2021)
Poor attitude towards safety	Olanrewaju <i>et al.</i> (2021)
Poor communication	Hamdan and Awang (2015)

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**Table 1.**  
Summary of factors causing scaffolding accidents on construction sites

findings may not be generalizable, the conclusion can be representative of the population with many respondents. This is consistent with the central limit theorem (CLT). Based on the CLT principle, the distribution of sample means approximates a normal distribution as the sample size increases (Olanrewaju and Idrus, 2020). For the CLT principle to be valid, a sample size of 30 or more is statistically required. The questionnaires were administered to the respondents between 6/08/2018 and 19/08/2018. The surveys were administered to site operatives (site operative denotes all those that work on construction) through online and face-to-face methods. Respondents were asked based on evidence to tick the degree to which they disagreed or agreed that each of the causal factors/remedies would lead to or reduce scaffolding accidents. The degrees of disagreement or agreement were measured on a four-continuum scale, where 4 denoted “strongly agree” and 1 denoted “strongly disagree”. 2 and 3 were located in between. The causes and remedies were developed from an extensive literature review (Tables 1 and 2) and a discussion with those involved in the use/manufacture/supply of scaffolding. It should be noted that the causes and remedies listed in Tables 1 and 2 are not the same as the causes and remedies submitted to the respondents for evaluations. This is related to ontological as well as epistemological considerations. During the pilot survey, it became clear that some of the causes and remedies included on the survey form were either irrelevant to the local environment or would require different interpretations. As a result, while some of the causes and remedies were eliminated, others were adjusted. In some cases, new ones were included in response to the respondents’ suggestions during the pilot survey. Altogether, 24 causal factors and 21 remedies were included in the survey form after two pilot surveys. The questionnaire went through three pilot surveys comprising construction operatives on three different sites visited separately

Remedies	Author
Use a lifeline on a lifeline-required scaffold	Heckmann (1995)
Install proper guardrails	Heckmann (1995)
Prevent access to incomplete or defective scaffolds	CIDB (2009)
Ensure there is at least a competent	Halperin and McCann (2004)
Eliminate low quality scaffold	Bennett <i>et al.</i> (2018)
Provide proper personal protective equipment	Nadhim (2016)
Provide education and training to operators	Nadhim (2016), Oladiran <i>et al.</i> (2008), Bennett (2018)
Improve site supervision	Howarth and Watson (2009), Bennett <i>et al.</i> (2018)
Know the maximum load that the scaffolds can safely support	Goetsch (2013), CIDB (2009), Oladiran <i>et al.</i> (2008)
Apply job safety analysis	Howarth and Watson (2009)
Keep the required distance between scaffolds and power lines	Goetsch (2013)
Conduct regular inspection	CIDB (2009), Oladiran <i>et al.</i> (2008)
Ensure proper housekeeping	Goetsch (2013), Oladiran <i>et al.</i> (2008)
Promote open communication	Goetsch (2013), CIDB (2009)
Follow the government standards	Bennett <i>et al.</i> (2018)
Install safety net	Abu Bakar <i>et al.</i> (2008), Goetsch (2013)
Enhance the accident reporting regime	Goetsch (2013), Oladiran <i>et al.</i> (2008)
Using digital technology such as drones to reduce the needs of using scaffolds	Bennett <i>et al.</i> (2018)
Sanction company that violates safety regulation	Bennett <i>et al.</i> (2018)
	Olanrewaju <i>et al.</i> (2021)

**Table 2.** Summary of remedies to reduce scaffolding accidents in the construction sites

within a week. The extent of the cause or remedy is determined by an Average Relative Index (ARI) (Eqn 1).

$$ARI = \frac{\sum_{i=0}^4 a_i x_i}{4 \sum_{i=0}^4 x_i} \times 100 \quad (1)$$

The constant  $a_i$  was the index of a group, which expressed the weight given to the group;  $x_i$  was the frequency of response;  $i = 1, 2, 3$  and  $4$  and described as below:  $x_1, x_2, x_3, x_4$  where the frequencies of the responses corresponding to  $a_1 = 1, a_2 = 2, a_3 = 3, a_4 = 4$ . For interpretation purposes, an ARI score of 1.00–25.00 denotes not common at all; 26.00–50.00 denotes not common and 51.00–75 and 76.00–100.00 denote very common. There is a pooled difference of 1.0% between each of the scales. The causal factor with the highest ARI score was considered to be the major cause of scaffolding accidents. The prioritization of the remedies followed similar methods of analysis. Other computed statistical tests are the one-way  $t$ -test, Cronbach alpha's reliability tests, convergent validity tests, factor analysis, mode test and standard deviation. The  $t$ -test was conducted to test the hypothesis of whether each of the causes could lead to scaffolding accidents or if each remedy would aid the reduction of scaffolding accidents or not. A factor analysis was conducted to identify the association among causes and remedies of scaffolding accidents to facilitate systemic decision-making rather than analytical decision-making on ranking/prioritization. Analytical decision-making is fragmented and biased in a multi-criteria decision-making situation where conflicting criteria require holistic evaluation. Structuring complex criteria explicitly lead to more informed and better decisions. Factor analysis is an unsupervised machine learning algorithm used in grouping constructs that are not obvious or labelled before the computations. Some classifications were previously conducted (Chi and Wu, 1997; Chi *et al.*, 2005;

Hinze *et al.*, 1998). However, the classifications were not based on surveys; instead, they were based on epidemiological studies. The SAS Enterprise Guide 7.1 was used to analyse the data.

#### 4. Analysing the results of the survey

The face-to-face survey pooled 100 forms, but only 37 completed responses were received during the survey period. The online survey forms were administered to more than 2000 respondents, including architects, engineers, construction managers and others that work on construction sites. However, by the cutoff date, 92 online responses were received after several reminders.

##### 4.1 Analysing the respondents' profiles

The results show that more than 70% of the respondents worked on construction sites. The 30% may be accounted for by those that received the survey forms from their friends/colleagues. More than 76% of the respondents worked with contracting companies, and 20% worked with housing developers (Figure 1). The results showed that more than 90% of the respondents had a minimum of a bachelor's degree, and more than 70% had more than three years of working experience. It is not surprising that most of the respondents held bachelor's degrees, and a total of 40% of the survey respondents have been injured on construction sites (Table 3), and around 95% of respondents' work was related to using scaffolding. In the USA, 65% of construction workers' work involves scaffolding (Collins *et al.*, 2014). Furthermore, the results show that one-fourth of the respondents have been injured while working with scaffolding on sites. This result is supported by the government report that shows that scaffolding contributed 23.35% of the site accidents (Social Security Organization Annual Report, 2018).

##### 4.2 Analysing the hierarchy of the causal factors

The combined average Cronbach coefficient alpha for the 24 causes of scaffolding accidents was 0.760. The combined validity results for the scaffolding accidents were 0.669. The Kaiser's measure of sampling adequacy was significant  $\chi^2(276) = 644.898, p < 0.001, N = 0.668$ . A one-way *t*-test was conducted to examine the measurements of the sample concerning the population. The null hypothesis was that each of the causes would not lead to scaffolding accidents ( $H_0: U = U_0$ ), and the research hypothesis was that each of the causes would lead to scaffolding accidents ( $H_r: U \geq U_0$ ).  $U_0$  was the population mean. The *t*-test results show that all the causes ( $H_r: U \geq U_0$ ) were significant. The standard errors are

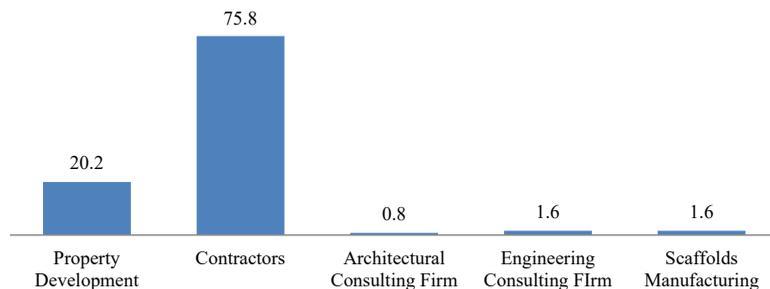


Figure 1.  
Respondent's profile

approximated to zero. A small standard error is an indication that a sample mean is a more accurate replication of an actual population mean. However, for design flaws (0.46), lack of experience (0.379), poor management of work at heights (0.911) and not following CIDB (Construction Sector Development Board Malaysia) standards (0.141), the  $H_0$  were accepted. This happens because there are some disagreements among the respondents on the impact of these causes on scaffolding accidents. In general, the interpretations of these statistics are that the causes of accidents and their measurements were appropriate to achieve the designed objective. In total, 20% of the respondents disagreed that the causal factors could lead to scaffolding accidents, but the remaining 80% measured that the causes would lead to accidents. The cumulative average ARI for all the causes was 77.74, and the combined standard deviation was 18.43. Measured on a scale of 1–4 and considering the profiles of the respondents and the number of cases, these statistics are significant. Considering the relationship between mean and standard deviation, the results imply that 70% of the respondents estimated that the causes would lead to accidents. In particular, applying the distributive scale under the research methodology section, none of the causal factors fell under 50 ARI (Table 4). Specifically, 15 causal factors cluster under “strongly agree” and 9 under “agree”.

#### 4.3 Results of the factor analysis on the causes of scaffolding accidents

The overall root mean square off-diagonal residuals of 0.0584 indicates a lack of multicollinearity. The commonalities except for shortages of material (0.402) were all above 0.5. The data were subjected to a principal component analysis. The Kaiser’s MSA (a measure of sampling adequacy) was approximately 0.833, which was very high. The results found that the 24 causal factors for scaffolding accidents may be structured or organized into six meaningful components for effective decisions. The six factors explained 62% of the total variance (Table 5), and this was also evident in Figure 2, as the function appeared to level off with the 6th factor.

*4.3.1 Analysing the hierarchy of remedial measures.* The combined average Cronbach coefficient alpha results for the 21 remedies of scaffolding accidents were 0.760. The combined validity results for all the scaffolding remedies were 0.669. The Kaiser’s measure of sampling adequacy was significant  $\chi^2(276) = 644.898, p < 0.001, N = 0.668$ . The remedies ( $H_r: U \geq U_0$ ) were generally statistically significant. However, the  $H_0$  was accepted for holding weekly toolbox meetings (0.144), maintaining the required distance between scaffolding and power (0.812), promoting open communication (0.566), introducing a licencing system for scaffolding work similar to that used by the government for asbestos work (0.482) and imposing sanctions on companies that violate safety regulations (0.415). The results revealed that 13% of the respondents disagreed that the remedies could reduce accidents. A total of

Question		Frequency	Percentage
Have you experienced injury on this site?	Yes	51	39.5
	No	78	60.5
Does your works on this site involve using scaffoldings?	Yes, to a large extent	99	76.7
	Yes, to a small extent	24	18.6
	No	6	4.7
Have you experienced injury on this site while using scaffolding on before?	Yes	32	24.8
	No	97	75.2

**Table 3.**  
Incidence of accidents and injury on site

## FEBE

Cause	Strongly disagree	Disagree	Agree	Strongly agree	ARI	SD
No guardrails installed on scaffolds	1	12	40	76	87.02	17.43
Poor inspection of scaffolds	1	11	43	74	86.82	17.14
Improper assemble of scaffolds	0	6	59	64	86.24	14.64
Poor safety culture	2	10	49	68	85.47	17.59
Operators ignore safety procedures	2	10	52	65	84.88	17.52
Poor attitude towards safety	2	11	50	66	84.88	17.79
Poor footing of scaffolds	1	12	53	63	84.50	17.17
Planking unsecure	0	14	58	57	83.33	16.63
Lack of personal protective equipment	0	15	58	56	82.95	16.58
Poor maintenance of scaffolds	2	13	58	56	82.56	17.84
Improper leaning against on scaffold	2	20	47	60	81.98	19.51
Improper climbing on scaffold	5	16	55	53	80.23	20.17
Structural failure of scaffolds	4	15	63	47	79.65	18.95
Lack of proper training towards operators	3	15	66	45	79.65	18.16
No lifeline on the lifeline-required scaffolds	0	23	61	45	79.26	17.71
Improper use of personal protective equipment	6	30	58	35	73.64	14.94
Misjudgement of a hazardous condition	3	25	77	24	73.64	17.20
Scaffolding design flaws	6	30	58	35	73.64	20.80
Operators lack of experience	5	30	62	32	73.45	19.95
Insufficient capacities of scaffolds	5	27	69	28	73.26	19.06
Lack of understanding about hazards	6	34	59	30	71.90	20.49
Distractions of operators	8	41	47	33	70.35	22.27
Poor communication	2	48	53	26	69.96	19.36
Bad weather	12	50	48	19	64.34	21.37

**Table 4.** Descriptive statistics of the causes of scaffolding accidents

87% of the respondents measured that the remedies could help to reduce accidents. The cumulative average ARI for all the remedies was 81.98, and the standard deviation was 16.83. A total of 70% agreed or strongly agreed (i.e. ARI = 65.14–98.81) that the remedies would reduce scaffolding accidents. None of the remedies fell under 50 ARI (Table 6). More than 86% of remedies cluster under the “strongly agreed” category and the remaining 14% cluster under the “agreed” category.

#### 4.4 Results of the factor analysis on the remedies to scaffolding accidents

The overall root mean square off-diagonal residuals was 0.0637, and the root mean square off-diagonal partials: Overall was 0.1801. This indicates a lack of multicollinearity. The Kaiser’s MSA for the remedies was approximately 0.80. This result implies that the respondents were drawn from similar backgrounds and that the remedies suit their designed objective. The results found that the remedies may be structured or organized into six meaningful factors (Table 7 and Figure 3).

## 5. Discussion of findings

In the following sections, the findings are discussed. Due to space constraints, only the first five causes and remedies will be discussed. Similarly, only the summary of the factor analysis results will be provided.

Rotated factor pattern	Behaviours	Experience	Component		General	PPE
			Structure	Capacity		
Poor attitude towards safety	0.730					
Poor safety culture	0.725					
Poor inspection of scaffolds	0.704					
Lack of proper training towards operators	0.631					
Operators ignore safety procedures	0.630	0.775				
Improper climbing on scaffold	0.606	0.673				
Poor maintenance of scaffolds	0.519	0.599				
Operators lack of experience						
Poor communication						
Lack of understanding about hazards						
Improper assemble of scaffolds			0.762			
Structural failure of scaffolds			0.662			
Poor footing of scaffolds			0.650			
Insufficient capacities of scaffolds				0.765		
Scaffolding design flaws				0.678		
Distractions of operators				0.533		
Bad weather					0.589	
Improper leaning against on scaffold					0.573	
Planking unsecure					0.559	
No guardrails installed on scaffolds					0.509	
No lifeline on the lifeline-required scaffolds					0.485	
Misjudgements of a hazardous condition					0.469	0.829
Improper use of personal protective equipment						0.758
Lack of personal protective equipment						1.06
Eigenvalue	7.06	2.13	1.93	1.36	1.26	0.794
Variance explained (%)	29.43	8.89	8.05	5.67	5.25	4.42
Internal consistency	0.649	0.682	0.691	0.659	0.531	0.794

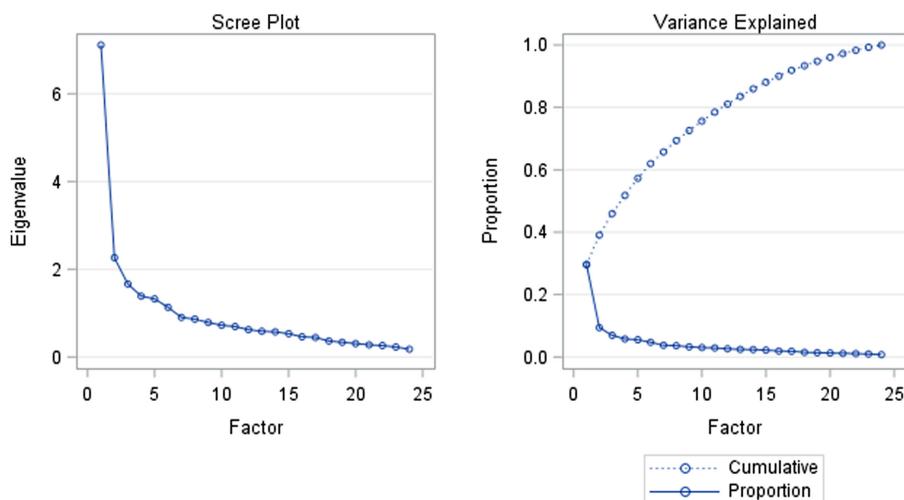
(continued)

Scaffolding accidents

**Table 5.**  
Distribution of rotated factor pattern

Table 5.

Rotated factor pattern	Behaviours	Experience	Component			PPE
			Structure	Capacity	General	
<i>MSA for second-order factor analysis</i>	0.844, $\chi^2$ (21) = 320.511 <0.001	0.666, $\chi^2$ (3) = 66.606 <0.001	0.654, $\chi^2$ (3) = 57.111 <0.001	0.669, $\chi^2$ (3) = 70.115 <0.001	0.722, $\chi^2$ (150) = 126.357 <0.001	0.500, $\chi^2$ (1) = 48.44 <0.001
<i>p for second-order factor analysis</i>	52.63	62.40	60.29	63.16	58.52	78.20
<i>Variance explained for second-order factor analysis (%)</i>	0.848	0.698	0.666	0.706	0.685	0.721
<i>Cronbach's alpha for second-order factor analysis</i>	0.526	0.624	0.603	0.632	0.585	0.782
<i>Validity for second-order factor analysis</i>						



**Figure 2.** Scree plot and variance explained of the causes

Remedy	Strongly disagree	Disagree	Agree	Strongly agree	ARI	Sd
Install safety net	1	5	35	88	90.70	15.01
Install proper guardrails	0	3	46	80	89.92	13.45
Assemble scaffolds properly	0	0	53	76	89.73	12.35
Eliminate low quality scaffold	1	8	42	78	88.18	16.26
Provide proper personal protective equipment	0	10	45	74	87.40	15.97
Ensure there is at least a competent person in the operation of scaffold	1	6	54	68	86.63	15.64
Conduct regular inspection	1	6	56	66	86.24	15.61
Provide education and training to operators	2	6	55	66	85.85	16.49
Improve site supervision	1	11	60	57	83.53	16.68
Know the maximum load that the scaffolds can safely support	1	11	65	52	82.56	16.42
Enhance the accident reporting regime	1	15	55		82.36	17.51
Use a lifeline on a lifeline-required scaffold	0	15	70	44	80.62	16.01
Apply job safety analysis (JSA)	3	17	64	45	79.26	18.52
Adopt HIRARC (Hazard identification, risk assessment, risk control)	2	18	67	42	78.88	17.80
Ensure proper housekeeping	2	20	64	43	78.68	18.25
Conduct toolbox meeting weekly	2	27	56	44	77.52	19.48
Sanction company that violates safety regulation	3	24	65	37	76.36	18.83
Introduce a licensing system of scaffolding works similar to that used for asbestos work by government	3	24	66	36	76.16	18.71
Keep the required distance between scaffolds and power lines	3	25	68	33	75.39	18.48
Promote open communication	5	25	69	30	74.03	19.11
Using digital technology, such as drones, to reduce the needs of using scaffolds	11	46	48	24	66.47	21.99

**Table 6.** Descriptive statistics of the remedies of scaffold accidents

FEBE

Remedy	Element	Testing	Component			
			Behaviour	Regulation	Maintenance	Training
Install proper guardrails	0.7353					
Assemble scaffolds properly	0.7324					
Use a lifeline on a lifeline-required scaffold	0.6979					
Provide proper personal protective equipment	0.6593					
Adopt HIRARC (Hazard identification, risk assessment, risk control)		0.7564				
Conduct toolbox meeting weekly		0.7552				
Apply job safety analysis (JSA)		0.6892				
Keep the required distance between scaffolds and power lines		0.4965				
Improve site supervision			0.7131			
Introduce a licensing system of scaffolding works similar to that used for asbestos work by government			0.5672			
Know the maximum load that the scaffolds can safely support			0.5487			
Install safety net			0.5466			
Eliminate low quality scaffold			0.5175			

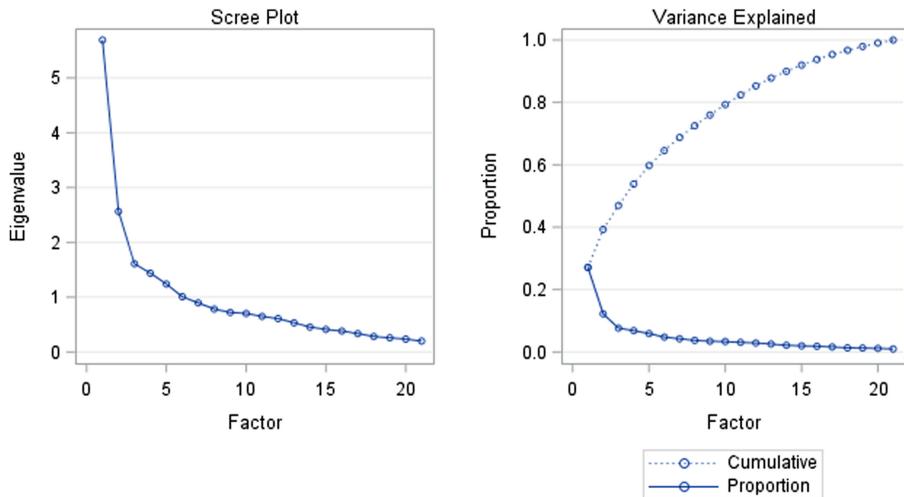
**Table 7.** Distribution of Rotated Factor Pattern of the remedies

(continued)

Scaffolding accidents

Remedy	Element	Testing	Component Behaviour	Regulation	Maintenance	Training
Ensure there is at least a competent person in the operation of scaffold			0.4958			
Use digital technology such as drones to reduce the needs of using scaffolds				0.7176		
Sanction company that violates safety regulation				0.7058		
Promote open communication				0.5568		
Ensure proper housekeeping					0.7678	
Conduct regular inspection					0.6076	
Enhance the accident reporting regime						0.77138
Provide education and training to operators						0.6045
<i>Eigenvalue</i>	5.70	2.51	1.64	1.41	1.26	0.95
<i>Variance explained (%)</i>	27.11	11.97	7.78	6.71	6.02	4.53
<i>Internal consistency</i>	0.706	0.674	0.678	0.660	0.688	0.688
<i>MSA for second-order factor analysis</i>	0.749, $\chi^2$ (6) = 119.027	0.749, $\chi^2$ (6) = 141.717	0.723, $\chi^2$ (15) = 131.298	0.669, $\chi^2$ (3) = 62.2	0.500, $\chi^2$ (1) = 11.862	0.500, $\chi^2$ (1) = 30.83
<i>p for second-order factor analysis</i>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<i>Variance explained for second-order factor analysis (%)</i>	57.80	60.13	58.37	61.68	64.96	73.25
<i>Cronbach's alpha for second-order factor analysis</i>	0.746	0.775	0.708	0.686	0.456	0.634
<i>Validity for second-order factor analysis</i>	0.578	0.601	0.700	0.617	0.650	0.733

Table 7.



**Figure 3.** Scree plot and variance explained of the remedies

### 5.1 Discussion of the hierarchy of causes of scaffolding accidents

Lack/inadequate guardrails were found to be the major cause of scaffolding accidents. A total of 59% of the respondents concurred that the lack of guardrails was a major factor in the scaffolding accidents. This finding is interesting because guardrails can prevent and protect scaffolding users from falls and slips (ILO, 1992). Major causes of slips and falls include wet floors, debris on floors, irregular surfaces and poor personal protective equipment (PPE) (like clothing, helmets, goggles or other garments or equipment designed to protect construction workers from injury or infection). Research in the UK revealed that the main causes of accidents and injuries are due to slips and falls (Construction Manager, 2019). A lack of “edge protection” is a major cause of scaffolding accidents on many Norwegian construction sites. Many of the workers “forgot” that there was no edge protection on the scaffolding (Winge and Albrechtsen, 2018). The research also found that improper assembling of scaffolding is a major cause of accidents. Not only should the scaffolding components be fastened together, but they should also be adequately assembled to avoid collapsing if loads are placed on them. This is because if scaffoldings are poorly assembled, the scaffolding may not be stable. Haslam *et al.* (2005) found that several construction injuries in the UK were due to the operatives striking their body parts against protrusions, mainly caused by the poor assembly of scaffoldings. Hence, scaffolding should not be assembled without the presence and supervision of a competent person (ILO, 1992). Many scaffolding accidents occur due to poor assembly or lack of supervision during its erection. It is found that poor safety cultures of construction are responsible for many falls, which lead to fatal accidents (Hamdan and Awang, 2015). Therefore, it was anticipated to find that many scaffolding accidents were due to poor safety cultures. A total of 53% of the respondents measured that poor safety culture was a major reason for scaffolding accidents. Related to the lack of safety culture as a good reason for scaffolding accidents was scaffolding users’ attitude. The survey revealed that poor attitudes toward scaffolding safety were the fifth causal factor of scaffolding accidents, and 51% believed it was the main cause. This finding is similar to a conclusion reached on Norwegian construction sites (Winge and Albrechtsen, 2018).

### 5.2 Discussion of the factor analysis on the causes of scaffolding accidents

Second-order factor analysis for each component revealed that the causes were related to their respective component. Behaviours (1) of the workers constituted the major factor

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leading to scaffolding accidents. In other words, attitudinal behaviour-related elements rather than structural or technical elements were the major causes of scaffolding accidents. Apart from operatives' behaviours, the *experience* of the operatives (2) was also critical. Imperatively, it is one argument to have correct attitudes, but without experience, accident-free notions may not be possible. This is logical, as experiences and attitudes are interwoven. However, experiences and behaviours are related to the quality and completeness of the scaffolding itself. Therefore, it is not surprising that *structure* is the 3rd component. Missing parts or incorrect assembly of the scaffolding would lead to accidents (Gürçanlı and Müngen, 2013) regardless of the experience and behaviours of the site operatives. This will especially be the case if the capacity (4) of the scaffolding is not determined and excessive loads are placed on the scaffolding. *General* is the fifth component. The second-order factor analysis reclassified the six causes into two sub-components; the first sub-component comprised no guardrails installed on scaffolding, unsecured planking and no life on lifeline scaffolding; the second sub-component involved improper leaning against scaffolding, bad weather and misjudgements of hazardous conditions. The investigation of the sub-factors showed that they were highly related at the sub-component level. To illustrate, operatives that underestimated the extent of risks on scaffolding tended to lean on scaffolding, and it is not safe to work on scaffolding when the weather is bad. Furthermore, research has shown that most scaffolding accidents occur during the rainy season or at night or in the latter part of the evening. "PPE" is the sixth major component in the variance. While PPE is meant to protect operatives, if the PPE is not available or not used properly, it will lead to accidents. While the designer teams can collectively reduce scaffolding accidents, a significant amount of responsibility lies with the contractor organizations. To summarize, most of the causes of accidents stem from the culture of those working on sites and the construction organizations' health and safety practices.

### 5.3 Discussion of the hierarchy of remedies for scaffolding accidents

The results revealed that the ARI classified the remedies into two classes. The first remedy to prevent scaffolding accidents was installing safety nets, and the second remedy was installing guardrails. The results were anticipated as both were protective measures and, in fact, complementary to each other. Aneziris *et al.* (2012) suggested using the net as one of the main measures to protect workers from falling objects. Guardrails should be provided as far as practicable on all scaffolding. However, where guardrails and toe-boards cannot be provided, adequate safety nets or safety sheets should be provided. While guardrails are an active method to prevent workers from falling, a safety net is a passive method because it is meant to reduce injuries after falls. This finding is interesting because guardrails are usually provided on scaffolding more than 4 m above the ground level in Malaysia. The government-sponsored committee recommends that guardrails be provided on the scaffolding at 2 metres and above (CIDB, 2018).

It is not surprising that "assemble scaffolding properly" was rated 3rd because it was rated as a significant cause of scaffolding accidents. Therefore, this finding confirms the importance of assembling scaffolding to reduce accidents and claims and increase productivity. Poor or defective materials/components should not be used to construct scaffolding parts and accessories. Because scaffolding needs to perform its designed functions, high-quality components and accessories should be used on scaffolding. Again, PPE is regarded as a major remedy for reducing scaffolding accidents. This is consistent with Keng and Abdul Razak's (2014) and Ulang *et al.*'s (2014) findings. These studies show that using PPE will reduce accidents on sites. However, PPEs must be correctly used (Aneziris *et al.*, 2012). Unsuitable PPE will lead to accidents and injuries. Scaffolding should be

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assembled and certified by a competent person (i.e. qualified safety officers/supervisors (Keng and Abdul Razak, 2014). Access should not be given if scaffolding is not well assembled. Multiple agencies may require certifications for a big project, like the firefighting department, work departments and manufacturers. It serves to underscore the importance of a competent person in the erection and use of the scaffolding. For instance, in Malaysia, the MS 1462 standard stipulated that scaffolding should not be used until certified by a Chief Inspector.

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#### *5.4 Discussion of the results of the factor analysis of the remedies*

Factor analysis grouped the remedies into six components. Poor assembly (1) of scaffolding components denominated the remedial measure “scaffolding”. A lack of guardrails, lifelines, PPEs and the poor assembly of guardrails will lead to accidents or will complicate accidents when they occur. For instance, many scaffolding collapses on construction sites due to the poor assembly of guardrails, lifelines and lack of PPE will increase fatalities. However, even if scaffolding is adequately assembled, accidents can occur due to other reasons. For instance, the workers may be vulnerable without adequate guardrails, lifelines or PPEs. Therefore, proper testing (2) is required to avoid breakdowns and accidents. Inspection of scaffolding and other tools for safety will reduce accidents on construction sites. The “behavioural” component (3) has diverse yet related remedies. Sites with proper supervision with competent staff that have knowledge of scaffolding would be able to determine the safe loading of the scaffolding. They will also likely use preventive measures like safety nets and ensure that scaffoldings adhere to all regulations and standards. A regulation [framework] is the fourth component. There are many regulations and standard operating procedures to reduce scaffolding accidents (CIDB, 2018). However, implementations are always difficult. To deduce this difficulty, contractors could develop in-house regulations to ensure open communication among site operatives to ensure that those that violate the guideline on the erection and operation of the scaffolding are penalized. Scaffoldings, like other equipment or tools on-site, have definite lifespans. Scaffolding components wear and tear at different rates and times. Therefore, a proactive maintenance strategy (5th component) must be developed for routine and corrective repairs. Decisions have to be made if maintenance is to be outsourced or performed by the in-house organization. However, a well-developed in-house maintenance policy will be more rewarding, especially for the big contractors. Furthermore, contractor organizations need to provide *training* (6th component) to operatives on preventing scaffolding accidents and accident reporting procedures. This may be in the form of a simple flow chart that indicates how to make a specific report and who to report an accident to. A complex reporting system can create more problems as operatives may not want to conduct reports. Thus, some may not make reports if the accidents are not fatal. Technology can also be used to monitor the performance and safety of scaffolding.

## **6. Research implications and causation framework**

The results generated from this research provide some implications. Below are the main implications:

- (1) Scaffolding users, supervisors and construction managers do not perform scaffolding inspections, repairs and maintenance proactively but rather reactively.
- (2) Implicit in the findings of this research were that scaffolding accidents were due to behavioural issues of the site workers and contractor organizations.
- (3) There is a lack of enforcement and low fines imposed on errant violators by the government. Contractors, governments, policies, consultants and clients only take

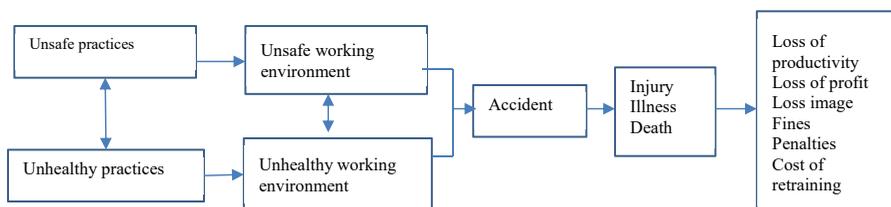
scaffolding seriously when deaths or fatal accidents occur. This only lasts for a short term, after which activities return to business as usual.

- (4) Many of the construction companies do not have safety policies, and government regulations are not well formulated and enforced, especially on sites. However, the current measures to address health and safety on Malaysian construction sites are very prescriptive because they depend on regulations.
- (5) Safety and health measures should be a precondition to site construction management and should be included in the method statement.
- (6) Deductively, Figure 4 displays a causation framework of the impacts of unhealthy and safe practices. As the figure demonstrates, addressing the human factors would help reduce scaffolding accidents because errors, faults, oversights, negligence and mistakes are the main contributing factors for scaffolding related to construction sites. Unsafe human behaviour at construction sites is the main cause of the health and safety problems on the construction sites. Hence, influencing the behaviours of site operatives concerning health and safety represents the most systemic approach to reducing accidents and fatalities at construction sites. Regulations, policies, complicated techniques and systems can only play complementary roles, not the main roles.

## 7. Conclusion and recommendations for site operatives

The findings of this study have several conclusions and recommendations. The key findings and recommendations are listed below.

- (1) Scaffolding accidents are rampant on sites, and many have been injured while using scaffolding. All the 24 causes would lead to accidents on the sites. The primary causes are lack of guardrails on scaffoldings, poor inspections of scaffolding, improper assembly of scaffolding, poor safety culture and ignorance of the safety procedures by operatives. The primary causes are related to the safety culture of the construction organizations. There is a need to change the sector's attitudes to health and safety management.
- (2) The effective remedies to reduce or avoid scaffolding accidents include installing a safety net, installing proper guardrails, correctly assembling scaffoldings, quality components and providing proper PPE to site operatives. Inductively, addressing the sites' attitudes and behaviours would help minimize scaffolding-related accidents on sites. Reactive measures are dominant among construction organizations.
- (3) Government agencies should conduct unscheduled inspections to ensure that construction companies adhere to regulations and policies. This will complement the safety culture of the site operatives and the construction organizations.



**Figure 4.**  
Olan's accident causation framework for health and safety practices

- (4) The limitation of this study due to the small sample size may necessitate future research to increase the sample size. In addition, more causes and remedies may be included.
- (5) The causation framework requires verification and validation to measure its suitability for reducing scaffolding accidents on construction sites.
- (6) Future research should differentiate between the causes of accidents and remedies for new construction and maintenance/refurbishment projects.

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