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CAUSES OF SCAFFOLD ACCIDENTS IN CONSTRUCTION INDUSTRY

MUIZZ SANNI-ANIBIRE, ABUBAKAR MAHMOUD, and MAJED AL-AYOUNI

Safety Technology Program, Dammam Community College, King Fahd University of Petroleum and Minerals, Dammam, Saudi Arabia

The construction industry is recognized as one of the most hazardous industries globally. Moreover, the rising trend of urbanization in many developing countries has ushered in a new era of high-rise construction, thus increasing the frequency of hazards related to working at height. Accident records in Saudi Arabia reveal that the construction industry accounted for 46.4% of industrial accidents, while fall-related injury accounted for 27% of the recorded injuries. Scaffolding is the most common access equipment used to work at height. Thus, the first stage in controlling the risks of falls from a height may be to identify the causes of scaffold accidents. This study presents 36 causes of scaffold accidents classified into five relevant groups, which have been identified through a thorough review of the extant literature. Additionally, the causes have been arranged in a survey designed based on a Likert scale of importance. Subsequently, 120 copies were administered to construction professionals in the Eastern Province of Saudi Arabia, with a 75% response rate. The Relative Importance Index (RII) was adopted to analyze the feedback. The results revealed that the top three causes of scaffold accidents include: "insufficient bracing/anchorage" (RII of 0.927), "scaffolding erected by incompetent professionals" (RII of 0.926), and "missing/faulty guardrails" (RII of 0.919). This study is of potential benefit to concerned stakeholders in the construction industry.

Keywords: Access equipment, Falls, Work at height, High-rise.

1 INTRODUCTION

Globally, the construction industry is recognized for its hazardous nature. For instance, in Saudi Arabia, the latest statistics show that the construction industry accounted for 46.4% of 53,404 industrial accidents. Fall-related injuries were about 14,475, accounting for 27% of all injuries, and consequently representing the highest category of injuries reported (MLSD 2018). Similarly, it is estimated that more than 9,500 workers are injured and 80 are killed annually in the United States in scaffold mishaps (Halperin and McCann 2004). Moreover, the costs of such accidents range in billions of dollars, in addition to the loss of life, property damage, and permanent disabilities of victims. Thus, safety professionals need to address the threat to the life and health of employees working at height. Though there exists a range of equipment used for work at height, the scaffold is one of the most commonly used access equipment. Therefore, investigating the causes of accidents due to scaffolds is of paramount importance. Experts opine that the first stage in preventing accidents is identifying their causes to facilitate a robust hazard identification and analysis. Though few studies exist in the global research domain, not much emphasis has been placed on stand-alone studies focused on scaffold accidents. Thus, this study

aims at investigating the causes of scaffold accidents in the Saudi Arabian construction industry, with the Eastern Province taken as a regional case study.

2 LITERATURE REVIEW

An accident may be described as an unwanted and unexpected event, which may result from numerous causes. The first step in accident prevention is to understand the root causes of accidents. To this end, models have been developed, such as domino's theory by Heinrich in 1930 and multiple causation theory by Petersen in 1971 (Hamid *et al.* 2008). Falls from height are considered amongst the most common types of construction accidents. A fall can be defined as a downward movement due to a worker's loss of balance. There are numerous causes of fall hazards, including unsafe act, unsafe working condition, communication problems and management's commitment (Liy *et al.* 2016). The scaffold is an essential equipment for work at height in the construction industry. Generally, a scaffold is a temporary structure to facilitate work at height while ensuring its users' safety. The erection of scaffolds is based on codes and guidelines, which may vary across different construction industries. In the UK, the "BS 5973 (1993) Code of Practice for Access and Working Scaffolds and Special Scaffolds in Steel" is applicable, while in the USA, the "Code of Federal Regulations 29 CFR, Part 1926, Subpart L" provided by OSHA is applicable (Reese and Eidson 2006). In Saudi Arabia, local organizations have developed handbooks. This may include Saudi Aramco's "General Instruction (GI): GI 8.001, Safety Requirements for Scaffolds" (Aramco 2016), as well as the "Scaffolding Activities and Responsibilities Requirements" developed by the Saudi Standards, Metrology and Quality Organization (SASO 2017). Despite the existence of standards, accidents reported in work at height vis-à-vis scaffolds are still high, and thus understanding the causes of scaffold accidents may help to ultimately control the risk of scaffold accidents. Few studies exist which discuss the causes of scaffold accidents in various construction climates globally.

Whitaker *et al.* (2003) presented a study that developed a decision aid to promote scaffold safety. The authors reviewed 186 paper-based files and 2,910 computer-based files of access-related incidents in the UK. The study suggested that the most frequent causes of scaffold accidents include: "the fitting of defective components", "unauthorized modification of the structure", "omission of barriers", and "errors resulting in simple, readily detectable structural faults"; while common managerial deficiencies included "failure to control risk", "unsafe methods and procedures", and "inadequate training and supervision". Halperin and McCann (2004) developed a 150-point checklist to assess the safety practices at 113 scaffolds in nine areas of eastern United States. The study concluded that thirty-six scaffolds (31.9%) were either in danger of collapse or were missing planking, guardrails, or adequate access. It also suggested a strong correlation between structural flaws and fall protection hazards, as well as between scaffold safety practices and competent/trained scaffold personnel. A more direct study to investigate the causes of scaffold accidents was presented by Enshassi and Shakalaih (2015) in the Gaza Strip. The study identified 33 causes of scaffold accidents categorized into six groups. The results of 35 received questionnaire surveys showed that the top-most causes were: the absence of personal protective equipment (PPE), missing ladders, and wind loads. A study by Błazik-Borowa and Szer (2015) suggested that the most common causes of accidents in scaffolds could be related to violation of regulations, economic factors, and lack of knowledge of issues such as loads, assessment of the technical state and construction-capacity for multiple uses etc. Liy *et al.* (2016) investigated the causes of fall accidents in Kuching, Malaysia. The study showed that falls from roofs and scaffolds are the most significant areas of fall hazards. The main

cause identified in the study was related to communication barriers, workers' negligence, lack of safety devices, poor site management, lack of PPEs.

3 METHODOLOGY

3.1 Stage 1: Review of the Extant Literature

An extensive literature review to identify the causes of scaffold accidents was carried out. An initial list of 52 causes was made, which was further refined into 32 causes based on discussions with three construction professionals. This also involved reviewing a draft questionnaire survey to ensure clarity, inclusiveness, and avoidance of redundancy.

3.2 Stage 2: Questionnaire Administration and Analysis

The questionnaire was administered to construction site supervisors and project managers in the Eastern Province of Saudi Arabia. The questionnaire entailed demographic information of the respondents and contained 36 causes of scaffold accidents in five categories, as shown in Table 1. The respondents were required to rate the importance of each factor on a 5-point Likert scale as follows: 1 "not important", 2 "little importance", 3 "somewhat important", 4 "important" and 5 "very important". Results were analyzed using the RII approach presented by Holt (2014). A total of 120 questionnaires were either distributed in person or sent by emails, with an initial feedback of 93 responses, and usable feedback of 90 responses representing a 75% response rate.

4 RESULTS AND DISCUSSION

The demographic results showed that the highest group of all respondents (26.7%) had 5 to 10 years of experience, 14.2% had less than 5 years of experience, 19.6% had 10 to 15 years of experience, while 19.6% had more than 15 years of experience. The results also showed that 33% of the respondents were experienced in commercial projects, 30% in residential projects, 29% in industrial projects, and 8% in highway projects. The RII values computed from the results are presented in Table 1 according to five categories and are thus systematically discussed.

4.1 Scaffold Erection Components

The results showed that "insufficient bracing/anchorage to prevent the movement of scaffolds" was ranked highest with RII of 0.927. This factor is related to the structural stability of the scaffold (Enshassi and Shakalaih 2015). It can also be inferred that scaffold erection by competent persons, or specially trained crews is crucial to ensuring its stability. "Lack of/or faulty guardrails for each platform to protect workers from falls" was ranked second with RII of 0.919. This result is similar to Heckmann (1995), who concluded that "guardrail requirements" is the most important factor contributing to falling accidents from scaffolds. "Damaged or faulty scaffold tubes" was ranked third with RII of 0.900. "Incompatibility of scaffolding components (due to being manufactured from more than one source)" was ranked last with RII of 0.769.

4.2 Unsafe Act

This group comprised of eight causes. The findings revealed that "overloading of the scaffolding (workers and materials)" was ranked first with RII of 0.918. "Failure to use personal protective equipment (PPE) (e.g., hard hats, fall protection system)" was ranked second with RII of 0.913. Similarly, Enshassi and Shakalaih (2015) concluded that failure to use PPE by workers is the most important cause of scaffold accidents. "Borrowing (removal of scaffold components while

in use)" was ranked third with RII of 0.902. This emphasizes the need to ensure that such crucial elements such as braces, standards, or ladders remain in place while the scaffold is in use.

Table 1. RII values for the causes of scaffold accident according to various categories.

	Causes related to Scaffold Erection Components	**RII**	**In-Group Ranking**
1	Insufficient bracing/anchorage to prevent the movement of scaffolds.	0.927	1
2	Lack of/or faulty guardrails for each platform to protect workers from falls.	0.919	2
3	Damaged or faulty scaffold tubes.	0.900	3
4	Ladders are not used or installed for movement between the platforms.	0.870	4
5	Scaffolding components are not inspected prior to erection.	0.841	5
6	Scaffolding is not tied to the building (independent tied or putlog).	0.829	6
7	Inadequate number of ties in the erection of planks.	0.825	7
8	Insufficient width of scaffolding platforms for the movement of workers.	0.822	8
9	Lack of/inadequate toe boards.	0.816	9
10	Incompatibility of scaffolding components (due to being manufactured from more than one source).	0.769	10
	Average	**0.852**	
	Causes related to Unsafe Act		
11	Overloading of the scaffolding (workers and materials).	0.918	1
12	Failure to use personal protective equipment (e.g. hard hats, fall protection system).	0.913	2
13	Borrowing (removal of scaffold components while in use)	0.902	3
14	Workers moving between the platforms by jumping and they do not use access equipment (e.g. ladders).	0.901	4
15	Fatigue, stress and illness of workers on the scaffolding.	0.867	5
16	Improper use of tools/safety equipment.	0.833	6
17	Not using appropriate jacks to lift up materials and tools.	0.824	7
18	Improper positioning and posture during working.	0.807	8
	Average	**0.871**	
	Causes related to Unsafe Condition		
19	Poor ground conditions (weak and uneven base).	0.915	1
20	Potential contact with electrical wire/cables/connections.	0.891	2
21	Vehicle collision with the scaffolding.	0.881	3
22	Bad weather (rainy/windy/severe heat).	0.856	4
23	Lack of safety net/shrouds not properly installed to prevent the fall of objects.	0.841	5
24	Inadequate passages and paths due to working in crowded spaces.	0.791	6
25	Poor site housekeeping.	0.759	7
	Average	**0.848**	
	Causes related to Communication Barriers		
26	Language barrier	0.849	1
27	Poor communication lines among safety officers and employees	0.831	2
28	Lack of/unclear signage and warning signs	0.800	3
29	Unclear instructions/poor information	0.760	4
	Average	**0.810**	
	Causes related to Management and Organization		
30	Scaffolding is erected by incompetent/untrained/uncertified contractors.	0.927	1
31	Failure to provide appropriate/sufficient PPE.	0.899	2
32	Lack of workers training.	0.891	3
33	Lack of frequent inspection by competent persons.	0.890	4
34	Lack of safety policies.	0.876	5
35	Lack of compliance to code requirements.	0.868	6
36	Inadequate planning during the preconstruction phase.	0.838	7
	Average	**0.884**	

4.3 Unsafe Condition

The results revealed that "poor ground conditions (weak and uneven base)" was ranked first with RII of 0.915. This factor shows the importance of the scaffold's foundation as suggested by Whitaker *et al.* (2003). "Potential contact with electrical wire/cables/connections" was ranked second with RII of 0.891. "Vehicle collision with the scaffolding" was ranked third with RII of 0.881, highlighting the need for adequate barriers between scaffolds and the movement of people and equipment in construction sites.

4.4 Communication Barriers

The causes related to communication barriers were perceived in decreasing order by the respondents as follows: "language barrier" with RII of 0.849; "poor communication lines among safety officers and employees" with RII of 0.831; and "lack of/unclear signage and warning signs" with RII of 0.800. Communication barriers may be attributed to the different languages of foreign workers commonplace in the Middle East. Thus, there is a potential problem due to poor line of communication between the management and workers, as well as between workers.

4.5 Management and Organization

The results showed that "scaffold is erected by incompetent/untrained/uncertified contractors" was ranked first with RII of 0.927. Trained scaffold erection crews are likely to erect safer scaffolds (Halperin and McCann 2004). "Failure to provide appropriate/sufficient PPE" was ranked second with RII of 0.899. Previous studies have shown that lack of safety training as well as inadequate provision of PPE had increased the risk of falls. Furthermore, loose traditional clothing common amongst construction workers in Middle Eastern countries may contribute to the risk of falls. The average RII results summarized in Figure 1 also show that the most important cause is the Management and Organization group with RII of 0.884. It is thus critical that management's commitment to safety be emphasized due to its being crucial to preventing accidents.

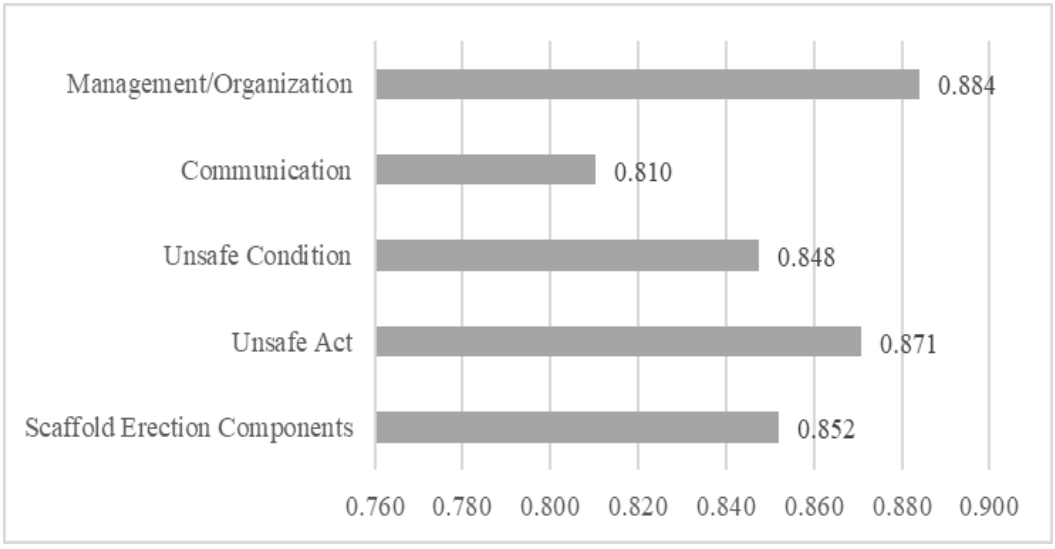

Figure 1. Plot of averaged RII values for grouped causes of scaffold accidents.

5 CONCLUSIONS

This study has presented an investigation of the causes of scaffold accidents in the Saudi Arabian construction industry. Its significance is based on historical reports, which suggest that scaffold accidents constitute the majority of workplace accidents in Saudi Arabia. Based on the results presented in previous sections, it can be concluded that poor design, erection, and maintenance of scaffolds, as well as inadequately trained/incompetent professionals, were the root causes of scaffold accidents in Saudi Arabia. Hence, safer scaffolds could be achieved through ensuring:

- The implementation of scaffold safety practices through inspecting and monitoring of construction sites.
- Competent persons are responsible for scaffold erection, dismantling through training or outsourcing to qualified and certified contractors.
- Adequate provision and correct use of PPEs and fall arrest systems.
- Competent persons are available for supervision and monitoring during work at height with the scaffold.

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