Construction Workers Fall Accidents from Scaffolding in Gaza Strip

Adnan Enshassi [1]* and Sobhi Shakalaih [2]

***Abstract:** The aim of this paper is to identify and rank the main causes of fall accidents from scaffolding according to their relative importance as perceived by project managers and site engineers in construction projects in the Gaza Strip. A total of 50 questionnaires were distributed to project managers and site engineers, 35 questionnaires were received yielding 70% response rate. A total of 33 factors that cause fall accidents in scaffolding were identified through a literature review and consolidated by a pilot study. These factors were categorized into six groups: factors related to erection, factors related to the staff (Scaffolders), factors related to loads, factors related to the personal safety, factors related to the workers behavior, factors related to the personal competencies. The results indicated that factors related to the workers behavior are the major factors that caused fall accidents from scaffolds. The results revealed that the top ranked factors which caused falls accidents from scaffolding were: absence of personal protective equipment (PPE), missing ladders, wind loads, disguised the design code, lack of proper assembly or inspection, overhead tools and materials, climbing and neglect using ladders, lack of guardrails, missing bracing and working during fatigue. These findings would help contractors to understand the top factors that caused fall accidents so that they can take them into consideration in safety planning in order to minimize the possibility of their occurrences.*

***Keywords:** safety, construction, workers, fall accidents, scaffolding*

I. INTRODUCTION

Scaffold erection has been defined as a variable that combines all components related to scaffolding safety. Scaffolding is a dynamic process, during the design phase through the construction [1]. Some studies have dealt with the bodily injuries caused as a result of non-occupational accident such as falls from ladders and scaffolding [2]. Chi et al [3] stated that the falls through roof surfaces were linked with lack of complying scaffolds.

In Hong Kong, Wong et al [4] reported that most of the fall accidents were caused by falling from ladders, scaffold, working platforms and opening roofs. The most common accidents types in Kuwait were tools accident, falls from ladders and falls from scaffolding which happened during normal working hours in the summer season [5]. In Pakistan, Farooqui et al [6] stated that workers fall from heights were due to weak scaffolding and the lack of safety. Paul [7] mentioned that scaffolding accidents have many causes, falling objects, electrocution, falls during assembly or disassembly, falls while working, overturns, falls while climbing, and construction deficiencies. According to the Occupational Safety and Health Administration (OSHA), construction deficiencies were responsible for 30% of all scaffolding accidents [7].

The construction industry became a major industry in Palestine during the past few years. Although it contributes around 19% to GDP, it still lacks the consideration for safety of workers. Safety in construction industry is one of the major factors that affects the field and should be studied and integrated as an inherent culture of each member of the project. Behavior of workers on job site is a reflection of the safety culture they gained. The aim of this paper is to identify and rank the main causes of fall accidents from scaffolding according to their relative importance as perceived by project managers and site engineers in construction projects in the Gaza Strip.

II. LITERATURE REVIEW

The safe scaffolding should be of adequate strength to support the weight and stress which the processes and workers will place upon it, and should be designed to prevent the fall of workers and materials [8]. Many construction accidents are caused by deficiencies in the project design phase [9]. Heavy moving equipment, overhead tools and materials, lack of proper assembly or inspection, wind, heights, and worker fatigue causes scaffolding accident [7].

OSH Academy Course 714 Study Guide [10] reported that workers fall from scaffolds when components fail, handrails give way, planks break, and scaffold supports collapse, while most scaffold accidents can be traced to untrained or inappropriately trained workers. The main factors causing the scaffolds accidents are inappropriate work practices; inappropriate construction of scaffolding including planking; safety equipment not used and unexpected force shifted scaffolding [11,12]. Heckmann [13] concluded that scaffold accidents generally concerned the tubular welded frame type associated with masonry construction. Halperin [14] reported that scaffold injury incidents occur in two ways, falls from scaffolds, or scaffold collapses.

[1] Distiguished Professor, Gaza Palestine, aenshassi@gmail.com (*Corresponding Author)
[2] Project Manager, PRCS, Gaza Palestine, sshakalih@palestinercs.org

The failure chain of the component can be explained by three different phases or events: initial crack formation, brittle propagation, final failure [15]. The accidents happened as a reason when ladder used in all construction sites doesn't match to standards. Inadequate provision of PPE or their absence in addition to inappropriate training of workers, are frequent causes of fall accidents [16]. It was revealed that personal factors particularly worker behavior are main factors leading to fall accident causation in high rise building projects occurring in the scaffolding area [17,18]. Romero et al., [19] demonstrated that the standardization of scaffolding equipment had a direct and positive impact on work safety conditions at construction sites.

III. Methodology

A questionnaire was developed to elicit the perception of site engineers and project managers regarding the factors causing fall accidents from scaffolding in construction projects in Gaza Strip. The initial intent was to utilize the data already available in literature review as identified by [7,9,10,11,12,13,14,16,20,21,22,23,24,25,26,27]. A total of 50 factors were identified from literature but 33 factors were used in this study according to the result of the pilot study.

The respondents were asked to indicate their response on 33 well recognized causes of scaffolding fall accidents. The questionnaire was divided into two parts. The first part requested general information about the respondent. The second part of questionnaire focused on the causes of scaffolding fall accidents in construction projects in Gaza Strip. A total of 50 questionnaires were distributed to construction managers and site engineers in contracting companies, 35 questionnaires were returned with 70% response rate.

The respondents were required to rate the importance of each factor on a 5-point Likert scale using 1 for not important, 2 for of little importance, 3 for somewhat important, 4 for important and 5 for very important. Then, the relative importance index was computed using the following equation [28,29]:

$$\text{Relative importance Index} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Where W is the weighting given to each factor by the respondent, ranging from 1 to 5, (n1 = number of respondents for strongly disagree, n2 = number of respondents for disagree, n3 = number of respondents for do not know, and n4 = number of respondents for agree, and n5 = number of respondents for strongly agree. A is the highest weight (i.e 5 in the study) and N is the total number of samples. The relative importance index ranges from 0 to 1 [30].

IV. Results and Discussion of Factors Causing Fall Accidents from Scaffolds

A. Group 1: Factors Related to Erection

As illustrated in Table (1) the erection group consists of 11 factors that may cause fall accidents from scaffoldings. Ladders are not used or installed for movement between the platforms was ranked the first position with RII of 0.893. There is a high possibility for fall accidents if ladder are not used. This result matched with [13] finding. Guardrails are not erected for each platform to protect workers from falls was ranked the second with RII of 0.862. This result is considered important because it is necessary in the erection of scaffolding to erect handrails in order to avoid falls. This result is in agreement with Heckmann [13] who concluded that guardrail requirements is the first important factor from the top six factors of fall accidents from scaffolding. Braces will not be erected to prevent the movement of scaffolds body was ranked third factor with RII of 0.842. The importance of this factor is related to collapse of scaffolds as results of missing braces, the braces are considered essential component of scaffolding structure. Scaffold is not tied to the building was ranked the last with RII of 0.537. The majority of contractors in the Gaza Strip tied normally the scaffolds to the buildings.

TABLE 1
RII and Ranks of Factors Related to Erection Group

Factor	RII	Rank
Ladders are not used or installed to movement between the platforms.	0.893	1
Guardrails are not erected for each platform to protect workers from falls.	0.862	2
Braces will not be erected to prevent the movement of scaffolds body.	0.842	3
Metal plates are not erected in the bottom of the legs of the scaffold.	0.831	4
Soil is not examined or where scaffolding will be erected.	0.812	5
Scaffolding components are not inspected prior to erection.	0.800	6
Wood planks erected in the platforms are inadequate, or do not close all the holes.	0.721	7
Scaffolding platforms are erected with width unsuitable for the movement of workers.	0.713	8
Use inadequate number of ties in the erection of planks.	0.663	9
Scaffolding components manufactured from several factories and more than one source.	0.582	10
Scaffold is not tied to the building.	0.537	11
All factors	**0.751**	

B. Group 2: Factors Related to the (Scaffolders)

Table (2) shows the RII and ranks of 3 factors related to staff (scaffolders) group. Scaffolding is erected without the presence of a competent engineer factor was ranked first with RII of 0.827. This result reflected the importance of the presence of the competent engineer in the site to reduce fall accidents. This result is in line with [14] findings who stressed the significant of the scaffolding safety training of the competent person

present on the site. Workers experience certificates are not examined in the pattern of scaffolding before implementation was ranked second with RII of 0.80. The inappropriate number of employment is choosing by each project was ranked the last factor with RII of 0.593. Halperin [14] found that there was no statistically significant difference between scaffolds being used by one or by many workers.

TABLE 2
RII AND RANKS OF FACTORS RELATED TO THE STAFF (SCAFFOLDERS) GROUP

Factor	RII	Rank
Scaffolding is erected without the presence of a competent engineer.	0.827	1
Workers experience certificates are not examined in the pattern of scaffolding before implementation.	0.800	2
The inappropriate number of employment is choosing by each project.	0.593	3
All factors	0.740	

C. Group 3: Factors Related to Loads

The RII and ranks of the 3 factors included in this group are illustrated in Table (3). The results revealed that does not take into account the wind loads effects on the scaffolding, was ranked first with RII of 0.882. In Gaza Strip scaffolding erection procedure did not take into consideration wind loads especially in high building which increase the probability of scaffolding collapse. Actually, there is no design for scaffolding to any building in the Gaza Strip due to non-existence of regulation. It was of the scaffolds, even if the safety of the scaffolds was implied by the design code [22]. Does not take into account the live loads was ranked second with 0.791. This emphasized the importance of this factor in this group.

TABLE 3
RII AND RANKS OF FACTORS RELATED TO LOADS GROUP

Factor	RII	Rank
Does not take into account the wind loads effects on the scaffolding.	0.882	1
Does not take into account the live loads such as movement of staff and materials on the scaffolding.	0.791	2
Does not take into account the dead loads that are performed on the scaffolding.	0.477	3
All factors	0.717	

D. Group 4: Factors Related to the Personal Safety

The ranks and the RIIs of four factors related to personal safety are presented in Table (4). 'Do not be disposed of material accumulated at the end of each working day' factor was ranked in the first position with RII of 0.866. This result revealed that the accumulated materials hinder the movement of workers and increase slips from platforms.. The workers lift heavy materials with their hands up between platforms was ranked second factor with RII of 0.793. This result indicated that workers using their hands to lift heavy materials caused falls by slip or wrong overturn.

TABLE 4
RII AND RANKS OF FACTORS RELATED TO THE PERSONAL SAFETY GROUP

Factor	RII	Rank
Do not be disposed of material accumulated at the end of each working day.	0.866	1
The workers lift heavy materials with their hands up between platforms.	0.793	2
Shrouds are not installed to prevent the fall of objects from highest.	0.742	3
Does not use the appropriate jacks to lift up tools.	0.661	4
All factors	0.765	

E. Group 5: Factors Related to the Workers Behavior

As shown in Table (5), this group comprised 6 factors that are related to the workers behavior. Workers do not take personal protective equipment (PPE) that prevent slipping was ranked in the first position with RII of 0.897. This result revealed inadequate provision of PPE. Workers moving between the platforms by jumping and they do not use ladders was ranked second with RII of 0.897. This result is agreed with Saurin and Guimares [20] who indicated that unsafe acts were a commonplace. Workers working on the scaffolding during fatigue, stress and illness, was ranked third with RII of 0.837. This result elucidate that there is no chick list for the workers before working in scaffolding and inadequate rest breaks for the workers to reduce fatigue.

TABLE 5
RII AND RANKS OF FACTORS RELATED TO THE WORKERS BEHAVIOR GROUP

Factor	RII	Rank
Workers do not take personal protective equipment (PPE) that prevents slipping.	0.897	1
Workers moving between the platforms by jumping and they do not use ladders.	0.863	2
Workers working on the scaffolding during fatigue, stress and illness.	0.837	3
The work is continued during bad weather like rain and severe heat.	0.792	4
The work is continued during the movement of suspended scaffolding.	0.696	5
Are not taking into account the electrical connections and prevention while working.	0.627	6
All factors	0.785	

G. Group 6: Factors related to the personal competencies

Table (6) illustrates that 'Did not work in according to the code used in the erection of scaffolding' factor was ranked in the first position with RII of 0.873. There is no testing, inspection and visit work sites are done by the competent authorities was ranked also first with RII of 0.873 as the same importance with previous factor. Warning and safety signs are not placed for the workers at the work site was ranked last with RII of 0.624. This result indicated that this factor has a little effect in causing scaffolding accidents in Gaza Strip.

TABLE 6
RII AND RANKS OF FACTORS RELATED TO THE PERSONAL COMPETENCIES GROUP

Factor	RII	Rank
Are not working in according to the code used in the erection of scaffolding.	0.873	1
There is no testing, inspection and visit work sites are done by the competent authorities.	0.873	1
No training is given to workers in the field of scaffolding.	0.727	3
No training is given to workers in the field of first aid and safety.	0.727	3
Incentives are not given to workers.	0.691	5
Warning and safety signs are not placed for the workers at the work site.	0.624	6
All factors	0.752	

VI. CONCLUSION

The results revealed that factors related to the workers behavior are the major factors caused fall accidents from scaffolds in the Gaza Strip. The results indicated that the top ten factors influencing the occurrence of falls from scaffolds are:

- Absence of personal protective equipment (PPE)
- Missing ladders.
- Wind loads.
- Disguised the design code.
- Lack of proper assembly or inspection.
- Overhead tools and materials.
- Climbing and neglect using ladders.
- Lack of guardrails.
- Missing bracing.
- Working during fatigue.

It is recommended that contractors should follow up their workers regarding the use of the personal protective equipment (PPE). Contractors should hire competent person because scaffolds must be erected, dismantled, or moved only under the supervision of a competent person. The competent person must be on site to direct and supervise the work. To enhance the degree of confidence of the current study results, it is recommended to collect data repetitively over an extended period, like repetitive interviews and surveying over month's interval. Small sample size could result in reduced accuracy of parameter estimates and reduced power for testing. To minimize the limitations of the research results, survey study with larger sample size is recommended.

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