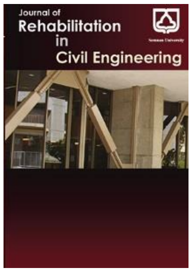
Journal of Rehabilitation in Civil Engineering 10-4 (2022) 01-13



journal homepage: http://civiljournal.semnan.ac.ir/

Risk Assessment and Safety Precautions for Construction Site Scaffolding

Ajibola Ibrahim Quadri[1*], Olaolu George Fadugba[2]

1. Yokohama National University, Japan
2. Federal University of Technology, Akure, Nigeria
Corresponding author: *quadri-ibrahim-rw@ynu.jp*

ARTICLE INFO

Article history:
Received: 24 January 2021
Revised: 08 December 2021
Accepted: 17 December 2021

Keywords:
Scaffolding;
Safety precautions;
JICOSH recommendation;
Fall from height;
Site investigation.

ABSTRACT

Accidents from heights are rampant and are rising day by day, with a higher number of injuries and deaths recorded in the construction industry. Some of the impacts of these incidents are the characteristic nature of the construction sector; unfailing deadlines to be met, environmental conditions during construction, natural and man-made disasters, lack of skilled manpower, undue gain over the provision of the best materials for construction. This paper gives an account of investigations of 100 scaffolding structures erected on-site in South East of Japan in terms of conformity with safety guidelines specified by the Japan International Centre for Occupation safety and health (JICOSH). Different kinds of hazards associated with falls from heights as well as the possible collapse of scaffolding due to human error/negligence and structural problem were also collated randomly from different construction and rehabilitation sites and are presented. Qualitative appraisal of conditions of some scaffolding components such as bracing, guardrails, platforms, struts and dresses, etc., which are categorized into standardized and non-standardized operation were done. According to the investigation, the most significant factor influencing the scaffold accident is structural safety, particularly the improper use of clamps and connectors which are critical elements on site. It is indispensable that trained personnel are hired to carryout scaffolding operation for effective safety.

How to cite this article:
Quadri, A., Fadugba, O. (2022). Risk Assessment and Safety Precautions for Construction Site Scaffolding. Journal of Rehabilitation in Civil Engineering, 10(4), 1-13.
https://doi.org/10.22075/JRCE.2021.22451.1480

1. Introduction

Nowadays construction of buildings and infrastructures has dominated the world, ranging from low rise to high rise structures. This is essential not only for economic activities but also for the betterment of humanity. The construction industry is one of the essential sectors in the development of a nation and the world by extension. Almost fifty percent of the yearly budget is directed to infrastructural built and rehabilitation. Conversely, this industry is also one of the most dangerous owing to the number of structural failures and life of people claimed over years. In the report given by the Social Security Organization (SOCSO) [1], the accident rate is at the rise when compare construction industry to other workplaces, and over fifty thousand (50,000) series of serious frequent accidents and various injuries were recorded annually around the world. The accidents have resulted in the loss of lives, money, properties, and time.

Scaffolding is an organized temporal structure used for supporting materials, workers during the construction process. It is also mostly used as a support during the structural rehabilitation process. Scaffold materials are always standardized for safety and are made off discrete parts of the same material ranging from metal, wooden, bamboo coupled to make a nice and convenient system for users. However, the hazard associated with the usage of this system is rising as construction works are advancing globally.

Accidents by fall from heights are rampant and increasing day by day. About forty percent (40%) of fatal accidents from construction sites are fall from heights, while fall from scaffolding and work platform contributed seventy-five percent (75%) to this accident [2] [3]. In most countries, accidents by construction fall is the leading scenario given rise to injuries and death [4]. U.S. Bureau of Labor and Statistic, [5], reported that scaffold related accident is the second leading accident through collapse or fall from height averaging above 52 death and about 10,000 workers are injured per year. Some of the factor effects of these accidents are the characteristic nature of the building sector; unfaltering deadlines to cover, subcontracting, weather condition during construction, natural and man-made disaster, lack of trained personnel, high employee turnout, accrue of unnecessary gain over the provision of best materials for construction, to mention but a few. Salminen [6], identified some of these factors to have contributed negatively to the occupational safety and workers' health on construction sites. Human errors in construction works have led to the collapse of many buildings more than the error in the planning and design phases as supported by some expert findings [7]. Several kinds of research have been conducted on scaffold safety issues [8,9]. Saurin and Guimaraes [10], conducted an ergonomic survey on the risk associated with working posture when handling heavy loads on the suspended scaffolding and some unsuitable techniques adopted when dismantling scaffolding. Halperin and McCann [11], surveyed about 115 scaffolds erected on-site in the USA and produced some recommendations on the safe handling of scaffolding material on construction sites. However, few of these studies engaged site investigation to ascertain factors related to good scaffolding placement and the real hazard involved.

This research was conducted to show the level of risk associated with the use of scaffolding in the Southeastern part of Japan, and to correlate the safety in scaffold practice and some other uncertainties variable hazard on construction sites. This kind of survey has been conducted in the United State (Halperin and McCann) [11], in Spain (Rubio Romeo *et* *al.* 2013) [12], in Poland (Pienko *et al.*) [13], Malaysia (Hamdan and Wang) [14], New Zealand (Buckley et al.,) [15]. The regulation practice is always different in many countries based on the safety as well as the method of preventing disaster on construction sites, these are some of the increasing challenges in the construction industry and frequent scientific research [16,17]. Individual characteristics, site conditions, organizational characteristics, agents (scaffolds/ladders), and weather conditions are some of the risks associated with falls from heights globally, according to Nadim et al., [18]. There is a high risk of erecting scaffolding for a high-rise building without using protective cover during a windstorm. Because the wind actions effect is not included in the scaffolding codes [19], it is critical to follow expert instructions. Camino López et al., [20], concluded that comprehensive training was required depending on the asperity of work, time of work, and work organization in their investigation of the scaffolding risk in Spain for a decade between 1990 and 2000, which claimed over one million workers. Dabrowski [21], concluded that subcontractors (small construction firms) that dominated the Polish market posed a high risk of failure because safety on construction sites is compromised, necessitating attention to the specificity of operation.

On like some other countries where there are no prescribed regulatory safety conditions for design, support, and putting scaffold in place for construction/rehabilitation, Japan International Centre for Occupation safety and health (JICOSH) [22], clearly states out the guidelines and regulations concerning the prevention of industrial accidents occasion from the use of scaffolds and the possible fall from construction sites. However, many scaffolding and construction companies are defaulters of the regulations. Some of the recommended guidelines for ensuring zero accidents during scaffolding set up where a height of 2 meters or more is involved, extracted from the JICOSH [22], handbook are summarized below.

- The employer shall instruct workers to use safety helmets to prevent danger from falling objects or falling from heights.
- The working floor is difficult to set up in some cases due to the circumstances of operations, in this scenario, safety nets shall be installed, and safety belts shall be provided for workers.
- Insulator shall be provided where the scaffolding set up is close to the power line to avoid electrocution of workers.
- Handrails having a height of more than 75 cm shall be provided on the outside of the scaffolding.
- The working floor shall have a width of not less than 40 cm and the clearance distance between the floor shall not be more than 3 cm. The floorboard shall be fastened to two support with adequate strength to prevent movement.
- During strong winds, heavy rain, and heavy snow, the employer shall not allow workers to carry out any operation if danger is involved. Furthermore, workers shall not be allowed access to places where the danger of falling is anticipated.
- Ascending and descending facilities shall be provided when performing operations at a height above 1.5m.

As far as the regulation ethics are concerned, at present both conformed and non-conformed scaffolding can be seen on Japanese construction sites. When it comes to hiring scaffolding for the building or rehabilitation process, contractors in charge are sensitive to the cost acquisition. The price of acquiring scaffolds is expressed per square meter according to some international standards EN 12810 [23], EN12811 [24], which is adapted by the Japanese regulatory body. The cost of acquiring standardized scaffolding can be as much as ten thousand yen (10000 yen) per square meter, whereas, unstandardized ones can be hired as low as three thousand yen (3000 yen) per square meter. Thus, the difference in the acquisition cost is always justified in terms of safety conformity. Although there are some existing literatures on the safety standards in relation to falls from height and sufficiently dealt with injuries caused as a result of accidental fall [9,15]. Some researchers have also examined the risk of falls from height in relation to different types of equipment used through the means of questionnaires distributed to workers as feedback [14,17,25]. Many of the reviews did not consider the hazard involved in the real site situation during the scaffolding erection.

To understand the engineering perspective on the hazards involved in scaffolding on-site, the author visited 100 sites located in Southeast of Japan between January and December 2019. The sites visited included both small scale building construction and rehabilitation and largescale level. Real scenarios of hazard due to human error/negligence and structural hazard were taken, the scaffold components are examined and scored using modified criteria in the past and then statistically analyzed for appropriate measures. The complexity of setting scaffold increases with height; it is essential to comprehend the load capacity of the individual elements and the condition of some joint's components. Constant use of the same components leads to fatigue behavior that promotes quick deformation and local damage to the component. Furthermore, improper storage exposed the scaffold components to an environmental hazard and insect attacks such as corrosion of steel, termite attack in case of wood, and bamboo.

2. Japan geographical location

The Japanese archipelago is situated in an area where several continental drift and oceanic plates meet around the east region. This is the cause of several natural disasters such as earthquakes, tsunami, typhoons, and others [26]. Many parts of the country have experienced and still experiencing devastating earthquakes as high as magnitude ranging between 3 and 9 and tidal waves. The ground motion can sometimes be large which damaged some important buildings and highway bridges. Scenarios experienced in the year 2005 and 2011, [27,28]. Thus, serious attention should be paid to seismic issues when erecting scaffold with trained personnel and the experience of disasters in the area so that serious damage of properties and loss of lives can be avoided. The research covers four out of the seven prefectures (Chiba, Kanagawa, Saitama, and Tokyo) in the Kanto region located between 36.4599^{0}N and 139.6911^{0}E of Japan, Figure 1. Kanto region is the largest island of Japan that housed one-third of the total population of the country, this region also stands as the largest center for the socio-economic activity of the country. Thus, heavy demands are on buildings and other related infrastructures. Retrofitting of the infrastructures is constantly done to strengthen them against seismic actions which required some access to the area above the reach without using scaffolding.

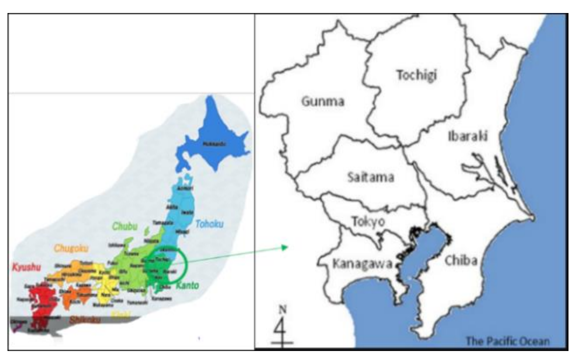


Fig. 1. Map of Japan Showing the Seven Prefecture in the Kanto Region http://goinjapanesque.com/map-of-japan-en/)[29].

3. Methodology

3.1 Various hazard in scaffold erection

The authors presented different kinds of hazards associated with falls from heights as well as the collapse of scaffolding due to human error/negligence, and structural problem collated randomly from different construction and rehabilitation sites. Figure 2 (left side) shows a 25 cm compression-tension support clamp lopsidedly placed longitudinally on a half-width size mesh to support a full-width size mesh along the transverse direction, this was done to complete a lift of the scaffold section in an ongoing construction of a 3-story wooden building. A half-width size mesh was adopted due to the limited space available for work, however, the connector seat for the half-width mesh could not agree with the full width one. The personnel thus improvised by using the clamp. This and others are some of the human errors that led to fall from heights on-site when inexperienced people handle the scaffold erection. Figure 2 (right side) is the rehabilitation of two adjacent 4-story buildings. Here, some of the clamps and scaffold elements used are corroded due to the long-term exposure to the environment and constant usage without proper care. The corroded elements are vulnerable under constant loading, and strong ground motion can increase the stress action beyond their carrying capacity. In this case, the global stability of the entire system is affected, corrosion-fatigue crack propagation could be triggered while the structure failed without prior warning.

In Figure 3, the modular assemblage of scaffolding for the construction of a 3-story building (left) and 2-story building (right) are shown. The guard rails in both cases are absent in the module. The landing platform to support heavy materials and workers at some section is absent in the case of the 2-story building scaffolding, the reason for this is not clear to the author. However, double longitudinal 4 meters pipes are clamped together to complete the floor lift in this section. This practice is common when there is a shortage of scaffolding components.

Fig. 2. Improper placement of support clamp (left) and corroded scaffold elements.

Fig. 3. Absence of scaffold insulator (left) and guard rails (right).

Furthermore, the 3-story scaffolding is close to the electricity distribution high tension cable. Japan international Centre for occupational safety and health (JICOSH) guidelines recommended the use of insulators to avoid electrocution during high wind. The insulator is overlooked by many scaffolding companies when there are favorable seasonal climate conditions. Several traditional designs of scaffolds in Japan have been on how to make it stronger because of the prevalent natural disaster (earthquake, storm, and hurricane, etc.), safety, however, efficiency of scaffolding erection are sometimes jeopardized because it is a temporal structure. Figure 4 is a 27 meters building mainly used for offices, is situated in Tokyo prefecture about 1 kilometer from the Pacific Ocean. The top surface is to be worked on but due to the limited access to the top, scaffolding was erected as quick access to transport some materials to be used. The distance between the erected ground poles connected by the lower transform to make the scaffold is 1.8 meters, anchored screws are used at every 3 meters to fasten the scaffold setup with the wall for more strength. However, two of the scaffold legs are erected on the fence, making the base plate structurally unstable. During strong wind or ground motion occasion by an earthquake, there is the possibility of a pullout of the anchored screws from the concrete wall, coupled with the overturning moment due to the improper placement of the base plates. Furthermore, the major highway around the Tokyo metropolitan is just 15 meters beside the 27 meters scaffold, hence, the chances of an accident occurring due to no safety erection are high.

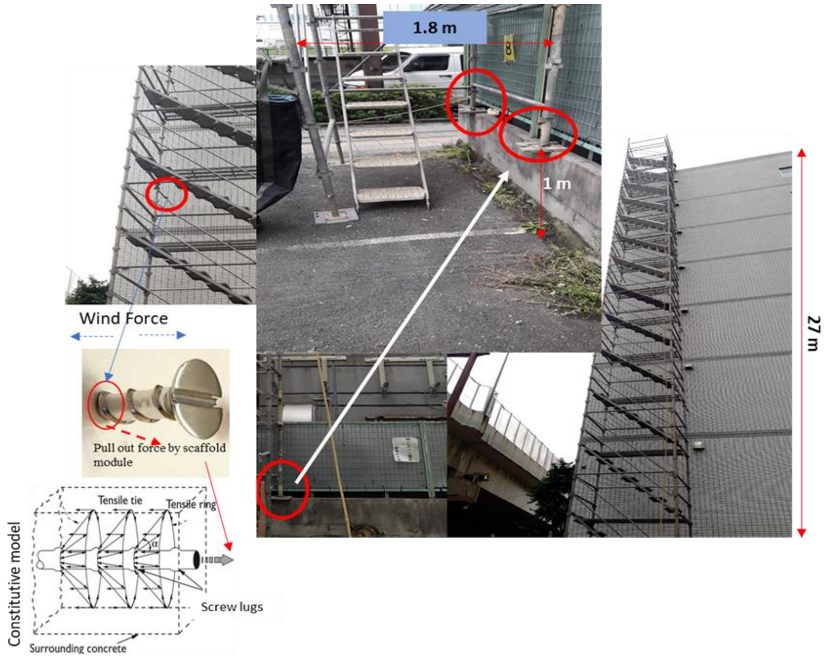


Fig. 4. Renovation of the roof of 27 meters high building in Tokyo.

3.2, Analysis of modules

Having understood the special features of some of the elements, it is important to delineate the necessary criteria precisely for the elements taking the JICOSH recommendations as a reference. The 100 visited sites were evaluated statistically, the general review involves the mop-up of the checklist given in Table 1 which is segmented into four classes in particular; recommended dress, support safety, structural safety, and general safety. For the overall evaluation, a 5-point scale, Table 2, were applied to decisively characterize the extraordinary standards of a portion of the components. After the field research, the information was organized for resulting measurable handling by methods of product software package, surfer form 8, for the investigation of the acquired data. For every one of the organized checklists, the average and the standard deviation of the examination were worked out for the two types of the considered scaffolding: standardized and non-standardized.

4. Results and discussion

All the investigated sites adopted standard helmet for all workers and inspectors, thus, we considered that they are present and worn appropriately. As for the safety belt, nearly a few among the workers used the safety belt, because of work division, workers who participated in the scaffolding erection above the ground adopted the safety belt. Generally, the safety boot is adopted on every site, but the standard safety boot and its conditions are taken into consideration during the assessment. As far as clothes are concerned, several scaffolding companies adopted their clothes based on seasonal effect, good appraisal was necessary by taking into consideration the seasonal effect. Thus, interviews were conducted to adjudge the grading criteria.

As can be seen in Figure 5, the standardized recommended dress scored over 4.5 points except for the safety belts with 4.5 points. Non-standardized scored below 4.5 except for the helmet which scores exactly 5 points together with that of standardized. This points to the importance of protecting the head from unforeseen incidence such as falling objects or colliding with scaffold setup. And as can be seen in Table 3, the standard deviation, SD, of the standardized type of scaffolding for the dress considered are closed to the average values compare with the non-standardized ones except for the SD of the safety belt for the standardized which is more dispersed than the non-standardized. However, there is the same spread between both types of scaffolding for the helmet used.

Table 1. Statistical Analysis of JICOSH Recommended Guidelines for Scaffold Safety.

Items Considered
Recommended Dress
• Clothes
• Safety boot
• Helmet
• Safety Belt
Support safety
• Structs element correctly positioned for support
• Base Plates are correctly placed and aligned to resist overturning.
• Support rest on sleepers
• Guard rails are well placed
Structural Safety
• Clamps well tightened
• Horizontal, vertical, and inclined bracing are correctly joined and positioned
• Multipurpose clamps (swivel Coupler) are used in case of inclined bracing for moments balancing
• Vertical poles are aligned by connectors to avoid instability
• Anchor ties in good position
• Platforms
General Safety
• Landing Platform is well positioned
• Ladder is well positioned
• Handrails are well positioned
• Standard net is used during work
• Toe-boards correctly positioned

Table 2. Criteria for assessing the checklist Items During the inspection of the scaffold

Assigned Value	Assessment Criterion
1	Between 0% to 20 % scaffold system has the relevant elements in good condition
2	Between 21% and 40% scaffold system have the relevant elements in good condition
3	Between 41% and 60% scaffold system have the relevant elements in good condition
4	Between 61% and 80% scaffold system have the relevant elements in good condition
5	Between 81% and 100% scaffold system have the relevant elements in good condition

Fig. 5. Position of the Dress code.

Table 3. Mean and Standard deviation of Dress code.

Scaffolding Types		Safety Belt	Helmet	Safety Boot	Clothes
Standardized	Mean	4.50	5.0	4.92	4.86
	SD	0.54	0.0	0.07	0.14
Non-Standardized	Mean	3.67	5.0	3.77	4.0
	SD	0.38	0.0	0.3	0.23

As regards support safety, when the sleepers are necessary, it was ensured that they are not in a bad state. The guard rail is one of the important elements of the scaffold components, we took into consideration their presence in every scaffold lift and in the right position. We also checked the placement of the base plates appropriately and took the assessment in the right manner by ensuring their proper position. As for the support struts, we ensured they are used for their intended purpose before taken the assessment and they are positioned correctly. Figure 6 is presented to show the safety support level of the scaffold module. The standardized scaffolding score averagely below 4.5 points while the non-standardized scaffolding score below 3.5 points with struts support having an average of 2.12 points, this is because most of the work examined under non-standardized scaffolding did not make use of the support struts. Table 4 shows the measure of dispersion under the support safety category, the non-standardized scaffolding is more disperse away from the average value compare with the standardized type as indicated by the standard deviation, SD, of the considered items.

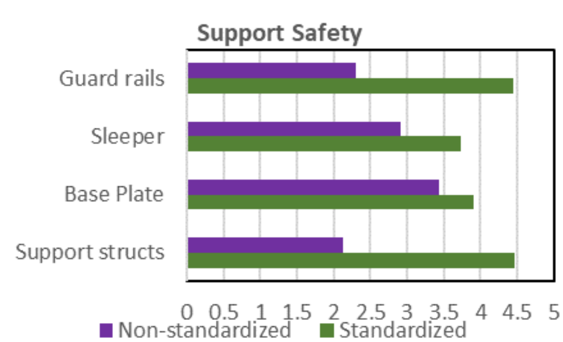


Fig. 6. Position of support safety.

Table 4. Mean and Standard deviation of Support Safety.

Scaffolding Types		Guard rail	Sleeper	Base Plate	Support struts
Standardized	Mean	4.45	3.74	3.9	4.46
	SD	0.45	0.29	0.30	0.48
Non-Standardized	Mean	2.31	2.91	3.44	2.12
	SD	0.38	0.56	0.39	0.68

As far as the structural safety is concerned, we took into account the best possible way when at least each of the scaffold modules at the same or different height have diagonal or frame brace installed, and when the scaffold lift had guardrail in the appropriate position. As for the connectors, we checked that they are well connected with poles and well fastened together. Multipurpose clamps (swivel coupler) and ordinary clamps serve different purpose. The multipurpose clamps can connect horizontal guard rails and diagonal bracing together while the ordinary clamps connect the vertical poles with the guard rails. We examined the correct positioning. We further carefully examined the best position when all the scaffold modules had platforms not less than the minimum width recommended and appropriately secured to the framework. On the level of structural safety, the platforms and multipurpose clamps scored averagely below 4.5 points under the standardized scaffolding type, while the rest of the items scored above 4.5 points as presented in Figure 7. Ties have the highest points under the non-standardized scaffolding with an average value of 4.45. It can be seen in Table 5 that the dispersion from the average values of all the items for the category of both the standardized and non-standardized are almost equivalent except for the ties which have SD of 0.21 for the standardized and 0.45 for non-standardized scaffolding.

The general safety of some of the scaffold modules was also investigated, ladder existence at each landing flight was ensured for evaluation and its presence on every scaffolding story up to the top was ascertained. The presence of the handrails was examined both along the ladder and at the necessary section on the setup and are well-positioned. The presence of the toe-board was also considered on every scaffold story up to the final height and in the correct position laterally placed on the scaffold. As for the standard net, it was examined that it serves its purpose by ensuring protection and are well tightened to the poles in the correct position. Ladder occupied the highest average point among the standardized types of scaffolding component with the lowest dispersion from the average, as presented in Figure 8, whereas the toe-boards with the lowest average point has the highest spread away from the mean. The same deviation is observed under the non-standardized type of scaffolding as shown in Table 6.

6

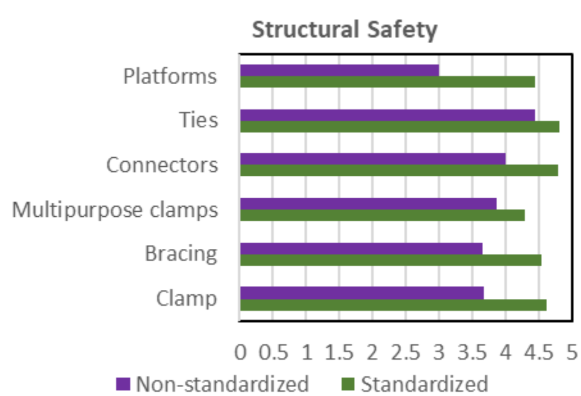


Fig. 7. Position of structural safety.

Table 5. Mean and Standard deviation of Structural Safety.

Scaffolding Types		Platforms	Ties	Connectors	Multipurpose Clamps	Bracing	Clamps
Standardized	Mean	4.45	4.82	4.80	4.30	4.54	4.62
	SD	0.45	0.21	0.23	0.3	0.33	0.31
Non-Standardized	Mean	3.00	4.45	4.01	3.86	3.66	3.67
	SD	0.46	0.45	0.24	0.29	0.37	0.37

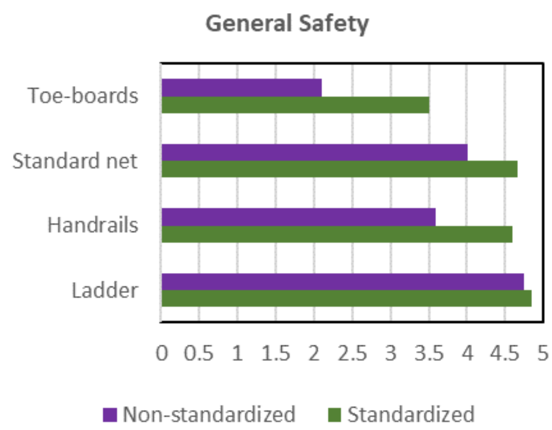


Fig. 8. Position of general safety.

Table 6. Mean and Standard deviation of General Safety.

Scaffolding Types		Toe-boards	Standard Net	Handrails	Ladder
Standardized	Mean	3.49	4.67	4.60	4.85
	SD	0.38	0.35	0.35	0.18
Non-Standardized	Mean	2.10	4.01	3.60	4.75
	SD	0.68	0.24	0.39	0.27

Through the categories of four recommended factors identified from the JICOSH guidelines such as the recommended dress, structural safety, support safety and general safety, although some non-standardized scaffolds were effective during the inspection, the individual component in the scaffold with regards to the general safety seems to vary from site to site, most of them often shown a total lack of essential safety element for appropriate working on the erected scaffold.

As for support safety in non-standardized scaffolding, the support strut had an average low score of 2.12. This is because it is possible to reach enough stability without considering the adoption of struts element, moreover, different kinds of components are also used for more stability such as bracing.

The highest factor influencing the scaffold accident from the investigation is the structural safety most especially the inappropriate usage of clamps and connectors which are one of the critical elements on site. The intricacies in scaffolding structures call for coaction among the designers, scaffold personnel and the users. Only in this case the basic quality such as capacity, safety and comfort in using scaffold can be achieved.

5. Conclusion

Scaffolding as work equipment for the performance of temporary work at height is a prime factor in workers' safety conditions. The presence of scaffolding at construction sites, the type of scaffolding adopted, its methodology of assembly in relation to its operating condition, all contributed to the level of workers' safety.

References

[1]. Social Security Organization (SOSCO). (2000). Annual Report on Building Sites. Kuala Lumpur.https://presspage-

production-content.s3.amazonaws.com/uploads/2731/annualreport2000.pdf?10000

[2]. Chong H.Y. & Low T.S. (2014). – Accidents in Malaysian Construction Industry: Statistical Data and Court Cases. *Int. J. Occup. Saf. Ergon.*, **20** (3), 503–513. doi:10.1080/10803548.2014.11077064.

[3]. *Worker deaths by falls: a summary of surveillance findings and investigative case reports.* (2000). U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. doi:10.26616/NIOSHPUB2000116.

[4]. Hinze J. & Russell D.B. (1995). – Analysis of Fatalities Recorded by OSHA. *J. Constr. Eng. Manag.*, **121** (2), 209–214. doi:10.1061/(ASCE)0733-9364(1995)121:2(209).

[5]. Joint CIB W099 & TG59 International Safety H. and People in Construction Conference, Emuze, Fidelis, Behm M., Central University of Technology F.S., & Dept. of Built Environment, eds. (2017). – *Joint CIB W099 & TG59 International Safety, Health, and People in Construction Conference*.

[6]. Salminen S. (2004). – Have young workers more injuries than older ones? An international literature review. *J. Safety Res.*, **35** (5), 513–521. doi:https://doi.org/10.1016/j.jsr.2004.08.005.

[7]. Lateef H.T. & Quadri A.I. (2018). – Human Error Uncertainties for Structural Detailing in Reinforced Concrete Buildings. *Proc. Eng. Eng. Technol. Technol.*, **2** (3), 1–15. doi:file:///C:/Users/User/Downloads/HumanErrorProbability.pdf.

[8]. Lipecki T., Jamińska-Gadomska P., Bęc J. & Błazik-Borowa E. (2020). – Façade scaffolding behaviour under wind action. *Arch. Civ. Mech. Eng.*, **20** (1), 27. doi:10.1007/s43452-020-00034-0.

[9]. Faergemann C. & Larsen L.B. (2000). – Non-occupational ladder and scaffold fall injuries. *Accid. Anal. Prev.*, **32** (6), 745–750. doi:10.1016/S0001-4575(99)00124-4.

[10]. Saurin T.A. & Guimarães L.B. de M. (2008). – Ergonomic assessment of suspended scaffolds. *Int. J. Ind. Ergon.*, **38** (2), 238–246. doi:https://doi.org/10.1016/j.ergon.2005.11.010.

[11]. Halperin K.M. & McCann M. (2004). – An evaluation of scaffold safety at construction sites. *J. Safety Res.*, **35** (2), 141–150. doi:https://doi.org/10.1016/j.jsr.2003.11.004.

12. Rubio-Romero J.C., Gámez M.C.R. & Carrillo-Castrillo J.A. (2013). – Analysis of the safety conditions of scaffolding on construction sites. *Saf. Sci.*, **55**, 160–164. doi:https://doi.org/10.1016/j.ssci.2013.01.006.

[13]. Pieńko M., Robak A., Błazik-Borowa E. & Szer J. (2018). – Safety Conditions Analysis of Scaffolding on Construction Sites. *Int. J. Civ. Environ. Eng.*, **12** (2), 7.

[14]. Hamdan N. & Awang H. (2015). – SAFETY SCAFFOLDING IN THE CONSTRUCTION SITE. *J. Teknol.*, **75** (5). doi:10.11113/jt.v75.4956.

[15]. Buckley S.M., Chalmers D.J. & Langley J.D. (1996). – Falls from buildings and other fixed structures in New Zealand. *Saf. Sci.*, **21** (3),247–254. doi:https://doi.org/10.1016/09257535(95)00068-2.

[16]. Błazik-Borowa E. & Szer J. (2015). – The analysis of the stages of scaffolding “life” with regard to the decrease in the hazard at building works. *Arch. Civ. Mech. Eng.*, **15** (2), 516–524. doi:https://doi.org/10.1016/j.acme.2014.09.009.

[17]. Whitaker S.M., Graves R.J., James M. & McCann P. (2003). – Safety with access scaffolds: Development of a prototype decision aid based on accident analysis. *J. Safety Res.*, **34** (3), 249–261.

doi:https://doi.org/10.1016/S0022-4375(03)00025-2.

[18].Nadhim E., Hon C., Xia B., Stewart I. & Fang D. (2016). – Falls from Height in the Construction Industry: A Critical Review of the Scientific Literature. *Int. J. Environ. Res. Public. Health*, **13** (7), 638. doi:10.3390/ijerph13070638.

[19].Camino López M.A., Ritzel D.O., Fontaneda I. & González Alcantara O.J. (2008). – Construction industry accidents in Spain. *J. Safety Res.*, **39** (5), 497–507. doi:10.1016/j.jsr.2008.07.006.

[20].Lipecki T., Jamińska-Gadomska P., Bęc J. & Błazik-Borowa E. (2020). – Façade scaffolding behaviour under wind action. *Arch. Civ. Mech. Eng.*, **20** (1), 27. doi:10.1007/s43452-020-00034-0.

[21].Dąbrowski A. (2015). – An investigation and analysis of safety issues in Polish small construction plants. *Int. J. Occup. Saf. Ergon.*, **21** (4), 498–511. doi:10.1080/10803548.2015.1085206.

[22].Japan International Centre for Occupation safety and health (2008). Regulation Concerning the Prevention of Industrial Accidents due to Falls from Heights. JICOSH, Japan; https://www.jniosh.johas.go.jp/icpro/jicosh-old/english/osh/outline/16.html

[23].EN12810-1. (2002) Façade scaffolds made of prefabricated components—Part 1: Product specifcations, European Committee for Standardization, Brussels, Belgium,: file:///C:/Users/User/Downloads/EN_12810-1%7B2003%7D_(E).pdf

[24].British Standards Institution & National Standards Authority of Ireland (2004). – *Temporary works equipment. performance requirement and general design. Part 1, Part 1,.*

[25].Kines P. (2003). – Case studies of occupational falls from heights: Cognition and behavior in context. *J. Safety Res.*, **34** (3), 263–271. doi:https://doi.org/10.1016/S0022-4375(03)00023-9.

[26].TANAKA K., WASHIDA M., NISHIUKE Y. & HIRAISHI T. (2020). – Numerical Simulation of Storm Surges and Waves Caused by Typhoon Jebi in Osaka Bay with Consideration of Sudden Change of Wind Field. *J. Nat. Disaster Sci.*, **40** (2), 44–68. doi:10.2328/jnds.40.44.

[27].Motosaka M. & Mitsuji K. (2012). – Building damage during the 2011 off the Pacific coast of Tohoku Earthquake. *Soils Found.*, **52** (5), 929–944. doi:https://doi.org/10.1016/j.sandf.2012.11.012.

[28].TAKAHASHI Y. & HOSHIKUMA J. ichi (2013). – DAMAGE TO ROAD BRIDGES INDUCED BY GROUND MOTION IN THE 2011 GREAT EAST JAPAN EARTHQUAKE. *J. JSCE*, **1** (1), 398–410. doi:10.2208/journalofjsce.1.1_398.

[29].http://goinjapanesque.com/map-of-japan-en/ 17th August, 2020.