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Causal Factor Analysis of Fatal Accidents in Johor Construction Industries Based on Korean Occupational Safety and Health Agency Classification

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Abstract: Construction work is widely regarded as an accident-prone industry, with hazards and dangers that have the potential to cause numerous injuries or even deaths. Thus, building an accident-free construction environment constitutes one of the core concerns of the industry in achieving sustainable construction. Occupational fatal accidents statistics investigated by Department of Occupational Safety and Health indicate that the construction industry documented the highest number of fatalities from 2015 to 2021. In order to determine the correlation between unsafe acts (UAs) and unsafe conditions (UCs) for accident causes, this study analyses the causes of fatal accidents at Johor construction sites using the categorization developed by the Korean Occupational Safety and Health Agency. The data was analysed using the SPSS software application, with a chi-square and lambda test to determine the significant combinations by determining the relationship between UAs and UCs. Other than that, this study explored and improved the understanding of UAs and UCs of accidents at construction sites. This will be more helpful for preventing accidents at construction sites. A study in a larger scope and using more detailed data would be helpful in future studies.

Keywords: Fatal, accident, causal, construction, KOSHA

1. Introduction

Sustainability in the workplace essentially refers to workplace safety. The Construction industry in Malaysia has rapidly expanded to stay ahead of the curve, as it strives to achieve strong economic growth to become a developed country. However, the construction industry has been well-acknowledged as a major economic force, as well as among the most dangerous in Malaysia [1]. Work in construction projects is widely regarded as an accident-prone industry, with hazards and dangers that have the potential to result in numerous injuries and deaths. Occupational fatal accidents statistics investigated by the Department of Occupational Safety and Health (DOSH) indicates that the construction industry has contributed the highest number of fatalities between 2015 and 2021 [2]. According to the cases reported by DOSH, there were 118 deaths in the construction industry (year 2018), in contrast to only 91 in 2016. These data showed that the construction industry is among the most critical industries, and its site safety needs improvement [3].

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By initially determining the immediate reasons, followed by taking quick remedial action, accidents and serious occurrences may be efficiently avoided. However, as time passes, this piecemeal reactive strategy has shown to be more challenging [4]. Opportunities for prevention, treatment, and improvement should be explicitly linked to a sound theoretical foundation that can be demonstrated to describe what actually occurs, as well as to help define effective preventative measures, classify causal and contributing factors, and understand the mechanisms. Hence, according to a research report by Hudson [5], there is a connection between unsafe actions and unsafe conditions and the occurrence of workplace accidents, and unsafe actions and unsafe conditions were a factor in work accidents.

This study aims to identify the causes of fatal accident at construction sites in Johor, and these causes are identified using the Korean Occupational Safety and Health Agency's (KOSHA) classification. The KOSHA, unsafe acts (UAs) and unsafe conditions (UCs) that were used in Park et al. [6] study to identify the association between UAs and UCs for accident causes are flexible enough to be used in the construction industry to determine the causes of fatal accidents in Johor.

2. Literature Review

2.1 Fatal Accident Causes in Construction

According to information collected from DOSH, there have been a number of accidents in the Johor construction sector. Table 1 provides examples of fatal accident instances.

Table 1 - Examples of fatal construction accidents in Johor [2]

Case Detail	Summary of the Case	Causes of Accident
27/06/2019 Worker died after struck-by falling wooden block	A construction worker was killed after hit by a wooden block fell from 4-meter-high when he was resting at undesignated location.	Employers and employees fail to comply with SOP and HIRARC work. No supervisor while work is in progress. The victim is resting in an inappropriate place.
21/05/2020 Worker dies after falling from height	A foreign worker was killed after being struck by lightning and fell from a 12-foot-high workplace.	Review HIRARC for working in high places. The employer failed to establish a Safe Work Procedure. The employer failed to provide working at height training. The employers failed to provide safe access to the upper floors of buildings.
9/08/2020 2 workers killed by electric shock	Two sub-contractor workers died after being electrocuted while undergoing cable installation work.	Still under investigation with the Energy Commission and Putrajaya DOSH Forensic Engineering Division.
2/09/2020 Mechanic died crushed by roller compactor	A mechanic died after being crushed by a roller compactor machine that fell near the slope while the victim was inspecting the machine.	There is no effect of landslides on the slope near the place where the machinery is placed. There are no procedures related to the repair of damaged machinery during use at this construction site. The roller compactor repair activity is not done in the place provided. There is no monitoring of the repair work activities.

According to Williams et al. [7], fatal accident causes may occur due to many factors. Firstly, failure to use personal protective equipment (PPE), or working without any PPE, can greatly increase the risk of becoming injured. The majority of the operatives lack safety awareness, despite have a zero attitude toward safety, and some are not aware that risks exist, let alone that safety standards exist. Non-use of PPE, on the other hand, can be due to a lack of provision by management (in an attempt to cut costs), or insufficient provision, as well as an absence of regulation in putting it on or complete refusal to comply with the usage, as some workers complain about the disturbances that PPE

causes them. Poor site management is also among the factors of total accidents [8]. The contractor plays the primary role for ensuring that the construction site is in a good condition and safe place. Ineffective enforcement of safety regulations, inadequate supervision, a lack of concern for safety issues, misunderstanding of working plans and detailed drawings, a reluctance to invest in safety, and poor placement of construction materials and equipment are all examples of how contractors contribute to the occurrence of accidents on the job site.

Williams et al. [7] also stated that fatal accidents caused in construction can be come from lack of commitment. Contractors riskily contribute to the workers' safety on site, including the inadequate certified skilled labour, giving jobs to inexperienced individuals, and engaging with incompetent personnel. Furthermore, a lack of worker training, particularly in recognizing and avoiding occupational dangers, has been highlighted as a contributing factor to on-the-job accidents [9].

2.3 Korean Occupational Safety and Health Agency's (KOSHA) UAs and UCs Classification

The health and safety of an individual is important and impacts not only quality of life at work, but also the lives and standards of living of families and communities. Baldissone et al. [10] used Human Factors Analysis and Classification System (HFACS) in their research, which was formerly developed for accident analysis in the aeronautic sector. Baldissone et al. [10] also mention that the method they used is particularly relevant for the identification of preventive actions to be implemented in order to cope with the events observed.

As previously mentioned, this work applies the KOSHA specification. Table 2 and Table 3 show the classification standards that have been defined by KOSHA about UAs and UCs [6]. The causes of the accidents were analysed and categorised using this categorization. Eight (8) types of UCs and eleven (11) types of UAs are defined under the KOSHA categorization.

Table 2 - KOSHA's classification for unsafe act [6]

	Description	Operational Definition
UA 1	Approach to dangerous place	Redefinition of dangerous place (e.g., place where it is meaningless to wear protection)
UA 2	Removal of safety devices	Removing a function or shutdown (adopted from KOSHA)
UA 3	Wrong use of protection	Assumption of all sites where workers are equipped with helmet and safety belt are. In the case of fatal falling under 10m, without using safety helmet
UA 4	Wrong use of equipment	Redefinition of equipment (e.g., except of protection)
UA 5	Repair of equipment in motion	Repair, refueling, welding, cleaning, etc. of the machine in operation (adopted from KOSHA)
UA 6	Failure of speed control of equipment	Speeding or slow operation of a machine (adopted from KOSHA)
UA 7	Careless handling of dangerous substance	Lack of safety measures when handling firearms, explosives, combustibles, and weight (adopted from KOSHA)
UA 8	Neglecting unsafe condition	Load becoming undone while the machine is being operated or poor clearance of the load (adopted from KOSHA)
UA 9	Unsafe movement	Unsafe posture or unnecessary movement (adopted from KOSHA)
UA 10	Defect of supervision	Addition of details (e.g., not following specifications, absence of signaler, etc.)
UA 11	Others	Unable to classify as above (adopted from KOSHA)

Table 3 - KOSHA's classification for unsafe condition [6]

	Description	Operational Definition
Unsafe Condition (UC)		
UC 1	Defect of material	Addition of details (e.g., deterioration of material, poor maintenance, wrong design, faulty assembly, etc.)

UC 2	Defect of safety devices	Regulation of examples of safety devices (e.g., safety net, guard net, etc.)
UC 3	Defect of protection	Regulation of examples of safety devices (e.g., safety helmet, safety belt, isolative tool, etc.)
UC 4	Defect of work place	Addition of details (e.g., place where there is a possibility of falling, collapse, being caught between items, stumbling, electric shock)
UC 5	Defect of working environment	Regulation of unsuitable temperature and humidity
UC 6	Defect of production process	Addition of details (e.g., flammable work, explosion work, weight work, etc.)
UC 7	Defect of warning sign	Boundary area unknown or missing (adopted from KOSHA)
UC 8	Others	Unable to classify as above (adopted from KOSHA)

3. Methods

Firstly, data from the DOSH website was used to learn more about fatal incidents and their causes in the construction sector, especially in Johor. The author used keywords such as “construction” and “Johor” for data screening, to ensure the cases displayed by the website were related to fatal accidents in construction sites in only Johor.

Next, the cases collected were analysed and tabulated to identify the frequency of UAs and UCs for each case. The KOSHA classification (Table 2) was used to determine the UAs and UCs for fatal accidents in Johor. Subsequently, a correlation coefficient test was performed to determine the effect of UAs and UCs on accidents in order to better understand how accidents occur. Hence, only one-to-one combinations of UAs and UCs were properly considered. As a result, the main combinations of UAs and UCs were identified by using a Chi-square test and a lambda analysis to determine a correlation between UAs and UCs.

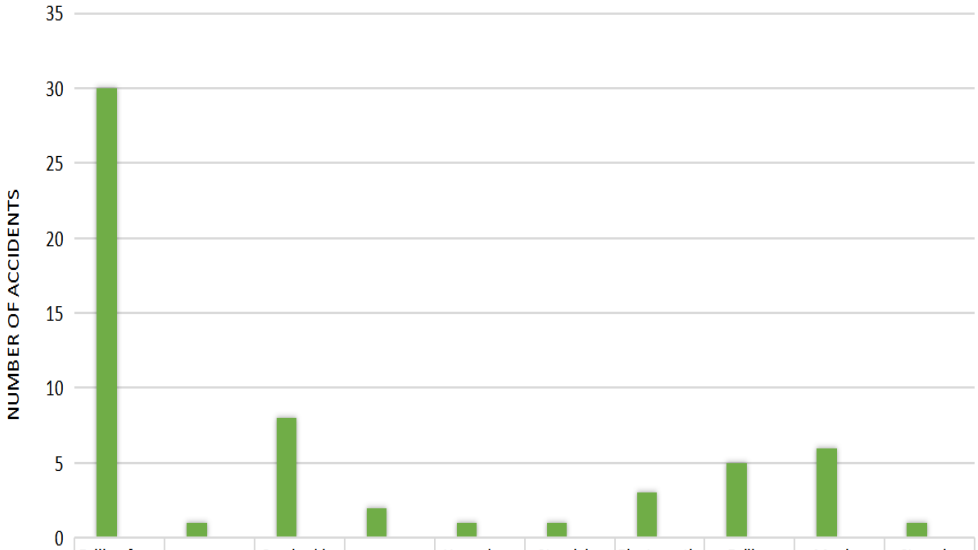
A Chi-square test was applied to determine the significant combinations by identifying the relationship between UAs and UCs. The degree of lambda is a criterion for determining how strong a correlation of nominal variables is by estimating the value of two variables. The lambda test was also used in this study to determine the combining degrees of the variables. Lambda's value typically ranges from 0 to 1, with the closer it is to 1 the more cohesive the variables are considered to be.

This study used a chi-square test analysis with a 0.01 level of significance. Because a result with an anticipated frequency of less than five equals 20% of the total when running a chi-square test, the combinations that did not satisfy the requirement were discarded. Therefore, only combinations that met the chi-square test's significance threshold were subjected to the lambda analysis.

4. Results

4.1 Frequency of Fatal Accidents Based on Accident Types in Johor

Fifty-eight (58) of the 582 total accident cases were found on the DOSH website involved fatal accidents in the construction sector, specifically in Johor. The frequency for the different types of fatal accidents that occurred in the 58 cases included in the analysis are shown in Fig. 1. Thirty cases (51.7%) of fatal accidents were due to falls of persons that involved the victim falling from a high location. Eight fatal accidents were due to being crushed by an object (13.8%). Next, six cases (10.3%) from the 58 cases involved a moving truck/lorry, while five cases involved falling objects (8.6%). Three cases involved electrocution (5.2%) and two cases involved being buried (3.4%). However, other cases such as suffocation, hazardous chemical and being stung by hornets have only one case each (1.7%). This statistic shows that accidents that occur in the construction industry vary. However, the most common accident that always occurs at construction sites is falling from a high location, which may be caused by unsafe acts or conditions.



	Falling from height	Suffocation	Crushed by object	Buried	Hazardous chemical	Struck by lightning	Electrocution	Falling object	Moving truck / lorry	Stung by hornet
NUMBER OF ACCIDENTS	30	1	8	2	1	1	3	5	6	1
PERCENTAGE	51.7%	1.7%	13.8%	3.4%	1.7%	1.7%	5.2%	8.6%	10.3%	1.7%

Fig. 1 - The frequency of different types of fatal accidents

4.2 Frequency of Fatal Accidents According to The Combination of UAs and UCs

The data were identified using KOSHA's classification of UAs and UCs, as depicted in Table 2 and Table3. Fifty-eight (58) cases related to fatal accidents in Johor construction sites were carefully investigated using this type of classification.

It is clear that there could possibly be multiple UAs and UCs involved in fatal accidents. However, since the primary aim of this work is to determine the relevant combination of UAs and UCs, only one-to-one combinations of UAs and UCs were properly considered. Furthermore, investigating all inconsequential combinations for determining the cause of construction accidents is practically ineffective, because of some data from the website were unavailable. Table 4 shows the frequency of fatal accidents brought on by various UAs and UCs.

Table 4 - The frequency of the cases related to UAs and UCs

	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	Total
UA1	1	1	0	2	0	0	0	2	6
UA2	0	2	1	2	0	0	0	0	5
UA3	1	3	0	11	0	0	0	0	15
UA4	0	0	0	0	0	0	0	0	0
UA5	0	0	0	0	0	0	0	0	0
UA6	1	0	0	0	1	0	2	0	4
UA7	1	0	0	7	0	1	0	0	9
UA8	2	0	0	3	0	0	0	0	5
UA9	0	0	0	1	0	0	0	0	1
UA10	2	0	1	1	0	0	2	2	8
UA11	0	0	1	2	1	0	0	1	5
Total	8	6	3	29	2	1	4	5	58

From the table, it could be seen that the UA3 (wrong use of protection, e.g. "not wearing safety helmet in the case of fatal falling under 10m") was the highest cause of fatal accident, followed by UA7 ("careless handling of dangerous substance") and UA10 (defect of supervision). All of the above factors can be linked to deficiencies in human factors such as attitude of workers [11]- [13]. Kerry et al. [9] in their study also found that construction stakeholders had strong

agreement on human factors as the most contributing factor for accident. Meanwhile, UC4 (defect of workplace, for example "place where there is a chance of falling, collapsing, being caught between items, tripping, or getting shocked by electricity") is the most contributing factor of UC that cause fatal accident in construction site in Johor.

4.3 Relationship Between UAs and UCs

This study implies that it is crucial to find the relevant combinations that exhibited a strong correlation between the 8 UCs nd 11 UAs, in line with Park et al. [6] findings. Using the Chi-Square and Lambda tests, this study attempted to investigate the association between the UAs and UCs. Table 5 shows the summary of the analysis.

Table 5 - Chi-square and lambda test of Unsafe Acts (UAs) and Unsafe Conditions (UCs)

	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8
UA1	0	0	--	0.057*	--	--	--	0
UA2	--	0	0	0.029*	--	--	--	--
UA3	0	0	--	0.159*	--	--	--	--
UA4	--	--	--	--	--	--	--	--
UA5	--	--	--	--	--	--	--	--
UA6	0	--	--	--	0	--	0	--
UA7	0	--	--	0.132*	--	--	--	--
UA8	0	--	--	0.029*	--	--	--	--
UA9	--	--	--	0.033*	--	--	--	--
UA10	0	--	0	0	--	--	0	0
UA11	--	--	0	0.029*	0	--	--	0

Note: *p < 0.01, --: Not available for lambda analysis due to expected frequency.

According to Park et al. [6], in order to find an association between UAs and UCs, investigating combinations that have high correlation among them was more effective than simply looking at how frequently each UA and UC occur. The variance between the findings of a frequency analysis (Table 3) and a correlation analysis served as evidence of this (Table 5). The findings of this work show that UC4-UA3, with a lambda value of 0.159, was the combination with the highest correlation, followed by UC4-UA7 and UC4-UA1. However, the results of lambda test showed that the combinations of the UAs and UCs had a relatively low coherence (near to 0). Due to the small sample size, it is presumed that two variables had a meaningful correlation if lambda for the combinations was greater than 0.1, which is thought to be a threshold for substantial correlation. Consequently, this study found that there were two (2) major combinations that accounted for 31% of all accidents (Table 6).

Table 6 - Combinations of Unsafe Acts (UAs) and Unsafe Condition (UCs) with the correlation value

Combination of UAs and UCs	Number of Accidents
UA3 (Wrong use of protection) & UC4 (Defect of workplace)	11 (19.0%)
UA7 (Careless handling of dangerous substance) & UC4 (Defect of workplace)	7 (12.1%)
Total	18 (31.1%)

An example of a fatal accident case for 'wrong use of protection' is 'the victim fell from the roof as the roof installation works are being carried out'. Working at a height (above 10 ft) is dangerous where there is a possibility of falling and requires the worker to wear a safety harness. As noted by Goh et al. [14], the likelihood of an accident occurring may be increased when working without wearing PPE. The main reasons why employees choose not to wear PPE while they are working are the fact that they find the gear uncomfortable to wear while doing their duties on the job site and that they view it as a distraction from their ability to produce quality work. This finding is in line with Ali et al. [15] that some employees experienced discomfort when using any sort of PPE, which negatively impacted their ability to execute their jobs. Even though the use of PPE is the last resort based on the hierarchy of risk controls, notably it may reduce the impact on the worker's body when the accident occurs [16].

Meanwhile, for 'careless handling of dangerous substance', an example of a fatal accident case is a construction worker who was killed after being hit by a wooden block fell from 4-meter-high when he was resting at an undesignated location'. The undesignated location mentioned in the case above is considered a dangerous place,

whereby lack of safety measures at the site which could prevent any object to fall and striking the person below indicated the careless handling of a dangerous substance. Struck-by object accidents are among the highest contributors to fatality in the Malaysian construction industry, particularly in Johor [17], [18]. A detailed analysis of the causes of struck-by accidents revealed that the most contributing factors to this type of accident are related to 'unsafe working conditions' and 'no safe operation' [19]. Regular training related to struck-by accidents and the use of warning signs or barricades are perceived as significant measures to prevent this type of accident [18].

5. Conclusion

This work investigated the cases of fatal accident in the Johor construction industry. The data was analyzed to obtain the frequency of different types of fatal accident cases. It can be concluded that the most frequent types of incidents are falling from a high location, being crushed by an object, a moving truck or lorry, a falling object, electrocution, being buried, suffocation, hazardous chemical, being struck by lightning, and lastly, being stung by hornets.

Meanwhile, the main result of the accident towards unsafe acts and unsafe conditions was found by using the Korean Occupational Safety and Health Agency's KOSHA's classification, with eleven (11) conditions of UAs and eight (8) conditions of UCs. All 58 cases were analysed with each UA and UC.

This work's objective was achieved by using correlation analysis with the lambda test. The highest frequency with 11 cases was a combination of UA3 and UC4. The chi-square and lambda test results show that all UA and UC combinations possessed a weak relationship, though 2 combinations (UA&UC) and (UA7&UC4) possessed meaningful correlation. This study only focused on fatal accident cases at construction sites in Johor. It is recommended that for future work, the data can be extended to all states in Malaysia. Further work is sought to investigate the relationship between UAs and UCs, and the root cause of the fatal accident.

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