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A Study on Relationship Between Causative Factors and Machinery Accidents in Malaysian Construction Project

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Abstract: Construction industry is one of the riskiest industries in Malaysia. This is because the working environment in this industry is quite challenging and unpredictable. The amount of machinery accidents increases annually in construction industry. Thus, it is vital to take serious measures to reduce machinery accidents. For minimizing the machinery accident, it is very important to identify the factors causing machinery accidents and mitigation measures for the factors. The questionnaire survey was used to determine the key factors for machinery accidents. The questionnaire was distributed to all construction professionals who are experienced in the construction field. About 117 questionnaires were received from the construction professionals. Spearman Correlation analysis was used to establish a correlation between the causation factors and machinery accidents. Unsafe work site (r = 0.885), unsafe method (r = 0.811), human error (r = 0.876), and poor management (r = 0.845) are among the factors which have very strong level of correlation with machinery accidents, while unsafe equipment (r = 0.463) and inadequate training (r = 0.577) are factors obtained moderate level of correlation with machinery accidents. The most suitable mitigations to reduce the causation factors is determined using Mean Rank Score method. The three most suitable mitigations determined were inspect wellbeing of equipment at workplace regularly (mean score = 4.84), provide manual guideline on how to use certain equipment (mean score = 4.78) and provide enough lighting during night jobs or enclosed areas (mean score = 4.67). The findings of this study could be a useful guidance for practitioners in controlling machinery accidents at construction sites.

Keywords: Construction, Machinery Accidents, Factors, Correlation, Mitigation

1. Introduction

The building industry in Malaysia plays an important role in the growth of the economy. While the construction sector may not be the main sector contributing to the development of Malaysia's economy, it literally serves as a driver for other economic sectors such as education, banking, manufacturing, and others [1]. Since this industry having high risk of injuries, the construction sector is tend to be one of

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the most dangerous sectors. Statistics of injuries in the construction sector suggest that the injury risk in the Construction industry in Malaysia is already high and show that the construction industry is one of the crucial industries that require a significant and accelerated overhaul of current site safety practices [2]. Machinery is a vital aspect of our daily life. They take different forms and encourage people to work with even less effort and increase production quality [3]. It is a common reality that we see a wide range of construction equipment on any construction site, making construction work simpler, cleaner, and faster.

Workplace accidents relating to machinery are vastly higher than any other form of work injury globally. Three out of the five deaths in worklace are related to construction industry [4]. This is because direct interaction with machinery and powered machines will result in serious occupational injury and death without adequate safety and controls [5]. Construction equipment is an integral aspect of any structural work or infrastructure project. The sudden failure of these devices and systems is grave as it leads to collateral damage, increased expense, disrupted project execution, loss of production, and sometimes even fatality. Heavy building equipment injuries caused by a breakdown are not only physically but also financially severely detrimental to victims. These machines are big, strong and at times difficult and can cause serious injuries or even death if the proper safety equipment is unsuitable. Therefore, studies into the root causes of machine injuries to discourage machine accidents should be found in the construction sector. The aim of this research is to determine the correlation between causation factors and the machinery accidents in Malaysian construction projects. This research carried out to educate parties involved in construction sector about major risks factors causing the machinery accidents at construction projects. This research will create awareness about the severity of factors causing machinery accidents in construction industry that tribute negative impact towards the workers safety. This research will help parties involved in construction industry to be more careful when handling machineries at construction sites and helps to reduce machinery accidents.

1.1 Factors causing machinery accidents

Unsafe equipment is extremely fatal factor of accident. Health and Safety Executive (2013) [6] claimed that moving tools along with machinery will in certain cases cause injury. A research by Kadiri et al. (2014) [7] showed that from 25 reasons, bad safety equipment ranks sixth in Nigeria's construction site, contributing to the highest accident. Improper tool control, such as no testing and repair failure, is primarily troublesome. Unsafe work site has high potential risks on machinery accidents. Many of risks can quickly be identified and reversed whilst others produce incredibly risky conditions, which may endanger the safety of the workers [8]. Usafe work site can be due to chemical hazards, biological hazards, and other hazards, such low lighting, untidy stuff, frequent loud sound, and poor weather on site [8]. These threats will impact running machinery, job efficiency and definitely workers' safety [8].

Furthermore, unsafe method might be one of the factors of machinery accidents. The methods used in the building industry would impact worker's efficiency, where health and safety are definitely closely connected at work. In a separate incident of unsafe method, Dauly (2011) [9] explained that it would also cause problems to allocate defective machinery or faulty staff to the operating method. Misuse of the machinery can lead to various consequences where unintended accidents can occur. It is also risky to delegate incorrect staff to one job. This can cause failure which will lead to the worst problem, such as bad work standards, property loss or accident [9]. Another set of unsafe methods is job conflicts in one location. Dauly (2011) [9] believed that two or more simultaneous work at one location is extremely dangerous. Moreover, human error can cause machinery accident. Errors might be due to lack of guidance of expertise. Operating out of knowledge and experience could usually result in accident [10]. Human errors might happen when work is carried out in an exhausted state [10].

Poor management can also cause accidents. Tam *et al*. (2004) [11] carried out an analysis in China, which showed that the causes of a work-related accident are due to poor management which caused lack of safety sensitivity among senior generals, lack of safety inputs, lack of strict safety enforcement,

lack of organizational engagement and lack of personal protective equipment (PPE). It also directly means that lack of management facilities may be the root cause of an accident.

Inadequate training can also cause accidents Untrained staff would not be aware of the laws and legislation that can lead to significant injuries. The lack of training will lead to construction accidents which may lead to death (Chen and Wu, 2010). Chen and Wu (2010) [12] stated that the best equipment in the world is worthless without a professional operator. Due to a lack of safety and technical skills training, employees lack the capacity and knowledge to foresee future danger and how to prevent accidents [12].

1.2 Mitigation measure to reduce workplace accidents

There are few solutions for unsafe work site. For the chemical hazard control Zulfadly (2017) [13] states that it is necessary for controlled products to have labeling that clearly define and offer risk information about the product. The second stage is biological hazard control [13]. To prevent this, ensure that the work environment is free from biological hazards by frequent washing [13]. Before the work begins, make sure that all biological threats are detected and fully eliminated [13].

The solutions for human error should be taken serious consideration too. It is incredibly difficult to regulate human behavior. However, safety monitoring tools can help to monitor and evaluating the causes contributing to human error and easily enforce prevention steps. The detection of frequent sources of errors and breaches would lead to better preparation and training for error-making workers. Companies should designate the best person to handle such particular on-site equipment. Make sure that the worker was qualified to handle such equipment. Employers must ensure that an employee does not work longer than the specified time to avoid them getting tired and tend to make errors.

Moreover, solutions on poor management are also important because weak management can contribute to several machinery accidents and also have an effect on contractors' financial expenses and even funding costs. The safety improvements will minimize machinery injuries. Several publications demonstrate different methodologies for upgrading safety standards [14]. The management should recommend changes in the safety of the project at the design stage unless the planners have an understanding of risk detection at the design stage [14]. The creation of a mentally healthy human community has a positive effect on improvements in safety [14]. In addition, all workers must be equipped with necessary PPE for every work. Employees should under no conditions execute tasks without the tools required [14]. For employers who supply employees with machines for daily tasks, it is essential that machines are routinely maintained and repaired [14].

Inadequate training factor can be solved by making sure that the employees following the Safety, Health and Welfare at Work Act (2005) [14] guidelines. Employers shall ensure that its workers undergo the following training evidence. Any employer who intends to fulfill any of these standards may be responsible for any accidents due to insufficient practice. Staff themselves should be responsible for receiving training and information. They should make an attempt to enroll in short-term classes or online programs to improve their skills. Employees do not always rely on their bosses to have anything [14].

2. Research Methods

The research methodology for this project highlights the steps required to achieve the aim of study.

2.1 Questionnaire development

In this research, the questionnaire survey consists of 3 sections. The first section contains questions related to the respondent, job roles, working experience, academic qualification, and working location. The second section is conducted to determine the correlation of causation factor and machinery accident at construction site. It is achieved by assessing the agreeability of respondents on the factors leading to

machinery accidents. The respondents have been requested to state the agreeability of each causation factors of machinery accident by using five Likert scales.

2.2 Data collection

This study was focused on random construction professionals, safety officers and construction workers at several construction projects in Malaysia. This is because among of them already knows and familiar about the machinery accidents precaution practices in a construction site in order to minimize the amount of machinery accidents. The online questionnaires were distributed using three ways: forwarding email to organizations, through various construction pages on Facebook media and sharing the questionnaire to the seniors. There were about 117 questionnaires were obtained from respondents who are working in construction-based companies in all over Malaysia.

2.3 Data Analysis

After all the required data were gathered from the surveys and were analyzed using Statistical Package for Social Science (SPSS). The Spearman Correlation analysis were used to establish the correlation between the causation factors and the machinery accidents. While Mean Rank Score method were used to identify the most suitable mitigation to reduce the factors causing machinery accidents.

2.3.1 Spearman Correlation Analysis

Correlation between quantitative variables is typically measured using a statistic called Spearman's Correlation Coefficient or Spearman's r [15]. This analysis fulfills the objective to establish correlation between the causative factors and the machinery accidents. The SPSS software was used for the data processing. A non-parametric procedure used to calculate the level of interaction between two variables is the spearman rank correlation. In order to be calculated on an ordinary scale at least, the Spearman Rank Correlation Test has no assumptions of the distribution of the data and is an effective correlation analysis. Positive relationship means higher scores on one variable tend to be associated with higher scores on the other. Spearman's r ranges from −1.00 (the strongest possible negative relationship) to +1.00 (the strongest possible positive relationship). A value of 0 means there is no relationship between the two variables.

2.3.2 Mean Rank Score

Data gathered from the survey have been analyzed by using Mean Rank Score method to obtain most suitable approach to minimize machinery accidents. The rating of the respondents was converted into scores. This can be illustrated mathematically as below:

$$\text{Mean Score (ms)} = \frac{\sum nW}{N} \quad (2.1)$$

Where;
$\sum$ = summation
n = the highest attainable rating
W = corresponding weight of rank category
N = total number of respondents

Once the mean score obtained from Mean Score method, the most suitable approach to minimize machinery accidents was ranked. The decision rule is that any approach whose mean falls between 0.5 – 1.49 is regarded as "not suitable", 1.5 – 2.49 is slightly suitable, 2.5 – 3.49 is moderately suitable, 3.5 – 4.49 is very suitable and 4.5 – 5.0 is regarded as most suitable [16].

3. Results and Discussion

3.1 Respondents demographic

According to Table 1, statistics analysis of the respondents' profile, about 58 respondents which is 49.6% were engineers. There were about 26 respondents which is 22.2% working as site supervisors in their firms. About 19 safety officers which is 16.2% and 12 project managers which is 10.3% responded the survey. Moreover, 2 of them which is 1.7% belong to others, which consist of technician and operator. Furthermore, the working site location was required to be filled out in this questionnaire to justify all the states in Malaysia were covered in this survey as per the title. As per expected, Selangor, Kuala Lumpur, Johor, and Penang were the top 4 states with the highest number of respondents.

Table 1: Respondent's Demographic

Item		Frequency	Percentage (%)
Job Role	Project Manager	12	10.3
	Site Supervisor	26	22.2
	Engineer	58	49.6
	Safety Officer	19	16.2
	Others	2	1.7
Working Experience	< 5 years	20	17.1
	5-10 years	34	29.1
	11-15 years	27	23.1
	16-20 years	23	19.7
	21-25 years	7	6.0
	26-30 years	6	5.1
	31-35 years	0	0
	> 35 years	0	0
Academic Qualification	Diploma	9	7.7
	Degree	84	71.8
	Masters	17	14.5
	PHD	7	6.0
	Others	0	0
Site Location	Perlis	6	5.1
	Kedah	4	3.4
	Penang	9	7.7
	Kelantan	5	4.3
	Terengganu	4	3.4
	Pahang	4	3.4
	Selangor	28	23.9

K. Lumpur	20	17.1
Malacca	4	3.4
N. Sembilan	8	6.8
Johor	15	12.8
Sabah	5	4.3
Sarawak	3	2.6
Perak	2	1.7

3.2Correlation between the causative factors and the machinery accidents

Based on Table 2, overall, significant positive correlation was found between all the reviewed six causation factors with machinery accidents. Unsafe work site, unsafe method, human error, and poor management are among the factors with very strong level of correlation with machinery accidents, while unsafe equipment and inadequate training are factors with moderate level of correlation. There were not any factors with weak correlation and very weak correlation. Unsafe work site factor is recorded the strongest correlation compared to other factors. This main factor was consisting of several sub factors or supporting incidents such as exposed to flammable chemicals, workers sickness, poor lighting, communication lacking, poor weather, poor housekeeping, and insufficient site space. Next highest factor is, human error which consist of sub factors such as workers laziness, performing job without expertise, lack of experience, restless, angriness, and alcohol or drug consumptions. Poor management was ranked the third most strongest correlation. This factor was strongly supported with incidents such as bad safety facilities, poor safety surveillance, lack of enforcement and many more. Comparatively, the factor with least strong level of correlation is unsafe method. Unsafe method is basically the mistakes or wrong methods used to complete a job or handle the machineries.

Unsafe equipment and inadequate training are factors with moderate level of correlation. Inadequate training factor is more higher compared to unsafe equipment factor. Worker's poor knowledge, lack of skills, outdated of current technology and many others are the main proof that workers need loads of training.

Table *2*: Correlation between the causative factors and machinery accidents

MACHINERY ACCIDENTS			
Variables	**rho value (r value)**	**p-value**	**Level of correlation**
Unsafe equipment	0.463**	<0.001	Moderate
Unsafe work site	0.885**	<0.001	Very strong
Unsafe method	0.811**	<0.001	Very strong
Human error	0.876**	<0.001	Very strong
Poor management	0.845**	<0.001	Very strong
Inadequate training	0.577**	<0.001	Moderate

3.3 Propose mitigation to reduce factors contribute to machinery accidents at construction sites.

Based on Table 3, can conclude that respondents considered 4 out of 17 mitigations as most suitable and other 13 as very suitable mitigations. Therefore automatically, the 4 most suitable will be the top four mitigations to reduce the causation factors of machinery accidents in Malaysian construction sites.

The first top mitigation is to inspect wellbeing of equipment at workplace regularly. Well maintained equipment would be safe to use for longer time period without any worries. The next mitigation is to provide manual guideline on how to use certain equipment. Most of the workers are not capable to use high tech equipment or new equipment. So, they tend to make mistake and injured themselves. So, by providing the user manual they could be careful in handling those machines safely. The third mitigation is to provide enough lighting during night jobs or enclosed area. Working in limited light source could block the eyesight of workers during handling machineries. Moreover, unclear visionary always leads to many mistakes and injuries. Final mitigation is workers should frequently improve their knowledge of machineries by joining courses. This could help them in gaining some experience and capability to use different type of machineries safely and protect themselves from accidents.

Table 3: Ranking of mitigations to reduce factors causing machinery accidents.

No	Mitigations to reduce causation factors	Mean Score	Ranking
1	All equipment is inspected regularly at workplace.	4.8462	1
2	Should provide manual guideline on how to use the equipment.	4.7863	2
3	Provide sufficient lighting when working at night (example: closed area and confined space)	4.6752	3
4	Workers should join short term courses or online courses to develop their knowledge on each machinery they use at site.	4.5983	4
5	Companies should make sure an individual not to work more than the fixed time.	4.0256	5
6	Machinery operation should be assisted by procedure manual.	3.9829	6
7	Stop working when bad weather condition.	3.9744	7
8	Safety enhancements should be proposed by the management at the design stage of the project.	3.9316	8
9	Organize awareness briefing/talk to all workers about dangerous consumption of alcohol/drug during working period.	3.9231	9
10	Relocate all chemical products to safer place before starting the work.	3.8974	10
11	Create special working area for high noise work.	3.8889	11
12	Employers should appoint well trained employee in handling some specific machineries.	3.8547	12
13	Workers must be equipped with ear protection.	3.8547	12
14	Employees should create a friendly environment in workplace.	3.8547	12
15	Sort out unimportant material to other location.	3.8034	13

16	Use fixed guards from best material to cover the dangerous parts.	3.7778	14
17	Carry out periodic cleaning at work site.	3.7350	15

4.0 Conclusion

The study has been achieved and explained the three objectives which has been drawn out. Literature review was performed to obtain the main six factors which are unsafe equipment, unsafe worksite, unsafe method, human error, poor management, and inadequate training. Correlation analysis method was used to establish correlation between the main six causative factors and the machinery accidents. All the factors were having significant positive correlation to machinery accidents. Factors such as human error, unsafe work site, poor management and unsafe method was among the very strongly correlated factors with machinery accidents. On the other hand, inadequate training and unsafe equipment are factors with moderate level of correlation with machinery accidents. This study had also suggested about 17 suitable mitigations to reduce factors causes machinery accidents in construction site. About 4 mitigation was chosen as most suitable ways to overcome this problem. The four most suitable mitigations determined from the analysed are inspect wellbeing of equipment at workplace regularly, provide manual guideline on how to use certain equipment, provide enough lighting during night jobs or enclosed area and workers should join short term courses or online courses to develop their knowledge on each machinery they use at site.

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References

[1] Othman, I., Majid, R., Mohamad, H., Shafiq, N., & Napiah, M. (2018). Variety of Accident Causes in Construction Industry. In MATEC Web of Conferences (Vol. 203, p. 02006). EDP Sciences.

[2] Kadiri, Z. O., Nden, T., Avre, G. K., Oladipo, T. O., Edom, A., Samuel, P. O., & Ananso, G. N. (2014). Causes and effects of accidents on construction sites (a case study of some selected construction firms in Abuja FCT Nigeria). *IOSR Journal of Mechanical and Civil Engineering*, *11*(5), 66-72.

[3] Hamid, A. R. A., Abd Majid, M. Z., & Singh, B. (2008). Causes of accidents at construction sites. Malaysian journal of civil engineering, 20(2).

[4] Bilim, N., Kekec, B., & Bilim, A. (2018). Analyses of Heavy Construction Equipment Accidents and Safety Prevention. Academic Perspective Procedia, 1(1), 1136-1139.

[5] OSHA (2018). Safeguarding Equipment and Protecting Workers from Amputations. Retrived on March 19,2020, from https://www.osha.gov/Publications/OSHA3170/osha3170.html

[6] Marsh, S. M., & Fosbroke, D. E. (2015). Trends of occupational fatalities involving machines, United States, 1992–2010. American journal of industrial medicine, 58(11), 1160-1173

[7] Health and Safety Executive (2013). Providing and using work equipment safely. United Kingdom: HSE Books.

[8] Rahim. A., Hamid, A., Majid, M. Z. A., & Singh, B. (2008). Causes of accidents at construction sites. Malaysian journal of civil engineering, 20(2), 242-259.

[9] Dauly, F. A. (2011). Faktor-faktor yang Berhubungan dengan Kecelakaan Kerja pada Buruh Konstruksi di PT. PP (Persero) Proyek Tiffani Apartemen Kemang Jakarta Selatan.

[10] Aksorn, T., & Hadikusumo, B. H. W. (2007). The unsafe acts and the decision-to-err factors of Thai construction workers. Journal of Construction in Developing Countries, 12(1), 1-25.

[11] Tam, C. M., Zeng, S. X., & Deng, Z. M. (2004). Identifying elements of poor construction safety management in China. Safety science, 42(7), 569-586.

[12] Chen, Z., & Wu, Y. (2010, August). Explaining the causes of construction accidents and recommended solutions. In 2010 International Conference on Management and Service Science (pp. 1-5). IEEE.

[13] Zulfadly, T. M. (2017). Factor of work accident in Indonesian construction site: Medan, Indonesia (Doctoral dissertation, Universiti Tun Hussein Onn Malaysia)

[14] Hardison, D., Behm, M., Hallowell, M. R., & Fonooni, H. (2014). Identifying construction supervisor competencies for effective site safety. Safety science, 65, 45-53.

[15] Bruffaerts, R., Mortier, P., Kiekens, G., Auerbach, R. P., Cuijpers, P., Demyttenaere, K., ... & Kessler, R. C. (2018). Mental health problems in college freshmen: Prevalence and academic functioning. Journal of affective disorders, 225, 97-103.

[16] Govan, A. Y. (2008). Ranking Theory with Application to Popular Sports.