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The Analysis of Struck-By Accidents at Construction Sites in Johor

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Abstract: Malaysia's construction industry has been categorized as the most hazardous industry due to its high risk in causing construction accidents compared to the other industry. Among the various reported accident fatality cases to the Department of Occupational Safety and Health (DOSH) from the year 2010 to 2018, 'struck-by object' is among the most accounted fatal accident types. This study aims to analyse the struck-by accidents at construction sites in Johor and investigate the significant contributing factors of this type of accident. It was carried out by computing the contributing factors of struck-by accidents from the DOSH website, which was later designed as questionnaire questions. The questionnaire was distributed to 150 respondents that comprise of safety personnel who are working at construction sites, and about 116 answered questionnaires were received. From the questionnaire survey, the most significant contributing factor to struck-by object accidents is due to lack of training. Whereas for the analysis of the real cases, the significant contributing factor to struck-by object accidents is due to inadequate safe operating procedures. Using Spearman's rank correlation, it was found that there is a variation in the respondents' perceptions with the real fatal cases reported in the DOSH website. This results from this study create major eye-opening on the weak correlational relationship between the safety personnel's perceptions and what actually the cause is. This study provides awareness on the issue and further actions should be taken to ensure the fatality rate of struck-by object accidents could be reduced.

Keywords: Struck-by accident, construction safety, accident prevention at construction site

1. Introduction

The construction sector plays a vital role as it is the sector that provides the socio-economic infrastructure for industrial growth, and production and basic amenities. According to the statistics reported by the Department of Statistics Malaysia, the value of the construction work had contributed a moderate growth of 5.3 percent year-on-year to record RM 35.6 billion in the second quarter of 2018 which acted as the bolster in the gross domestic product (GDP) of Malaysia [1]. The importance of the construction sector is therefore cannot be neglected. However, the construction sector was considered the most hazardous industries in the world [2]. The nature of this sector is a high risk in causing construction accidents, which could further cause injuries or fatalities to the employees.

Among the various types of accidents, struck-by objects accidents were investigated in great detail as there are less studies conducted compared with fall from height accidents. In addition, one must know that the victims of the struck by

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objects accidents not only the construction practitioners but also can be involving the public. According to The Star news dated on 26 August 2016, a woman was killed instantly as a crane fell onto her car along the road. This tragic accident that took place near Bukit Bintang, Kuala Lumpur was spread all over Malaysia and one cannot neglect the serious impact of struck by object accidents that can risk the safety of the public [3].

Therefore, this study seeks to determine the causation factors of struck-by objects fatalities. The nature of struck by objects accidents from the reported cases to DOSH was analyzed to identify the significant contributing factors due to struck by objects accidents at the construction site. Moreover, the relationship between the perceptions of the construction practitioners on the factors due to struck-by objects accidents with the real cases was investigated. This study is limited to the analysis of the fatal case that has already happened in Johor construction site and the selected respondents are working in Johor.

2. Literature Review

2.1 Statistical Data of the Types of Construction Accidents in Malaysia

According to Mohan and Zech [4], it is important to examine the real accident data to identify the major contributors for the most frequent occurrence of accidents. At the same time, effective solutions for accidents can be proposed and may help in reducing the rates of accidents. Chong & Low [5] summarized the data on causes of accidents based on SOSCO data from the year 2005 to 2009 (see Fig. 1). It can be found that stepping on, striking or being struck by objects is the most common accident as it contributed to 8997 cases of accidents in the year 2005 to 2009. It was then followed by a fall accident which contributes to an annual average of 1042 cases.

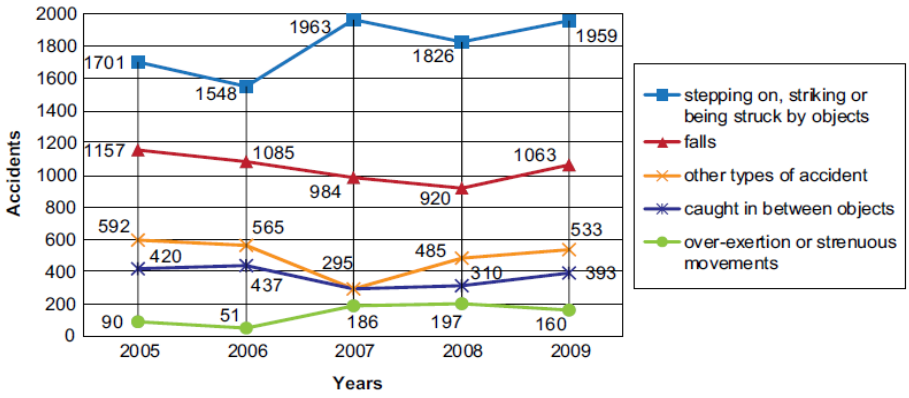

Fig. 1 - Causes of accidents from 2005 to 2009 [5]

In Malaysia, based on the Department of Occupational Safety and Health (DOSH) statistical data of fatal accident cases from the year 2013 to 2016, fall from height has recorded the highest percentage of 46.29% fatalities more than the other types of accidents. The second-highest fatal accidents were caused by struck-by objects or materials, with 17.36% of fatalities over the four years, followed by crushed-by vehicles with a percentage of 9.09% [6]. From the present analysis done on the fatal accident cases obtained from the DOSH website [7], it was found that the findings on the major types of fatal accidents are in agreement with Ayob et al. [6]. Apart from that, since this study is focused on Johor state only, a greater analysis on the types of fatal accidents that happened in Johor were analysed (Fig. 2). The findings have revealed that the most occurred types of fatal accidents in the Johor construction industry are in agreement with Ayob et al. [6] and DOSH [7]. It is also found that the struck-by accident occurs most in Johor, compared to other states (see Fig. 3) [7].

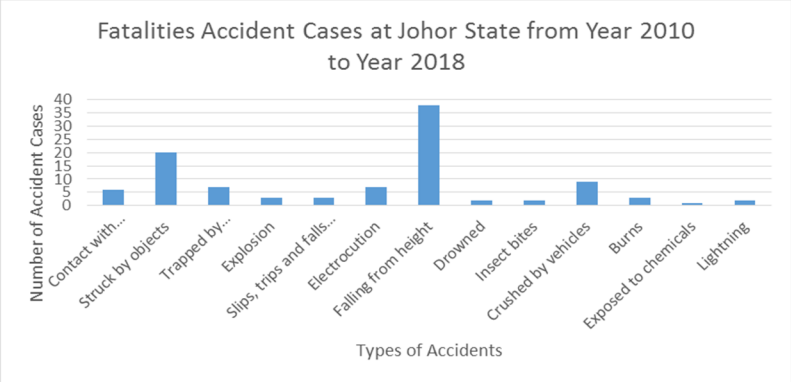

Fig. 2 - Fatalities Accident Cases at Johor States from 2010 to 2018 [7]

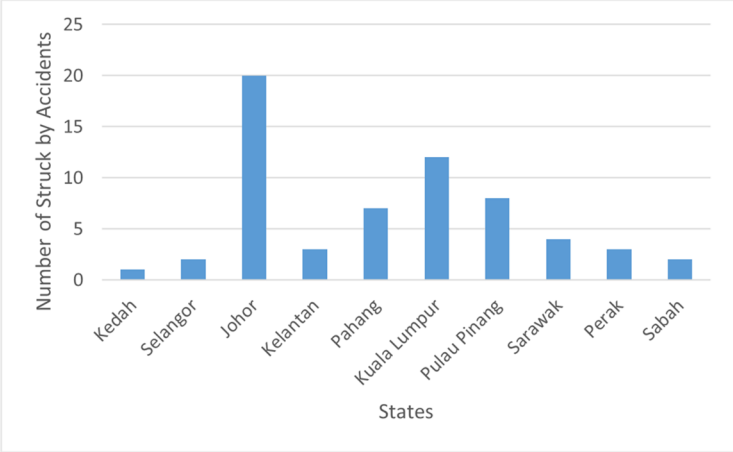

Fig. 3 - Struck by accidents in Malaysia: Proportion of Johor and other states from 2010 to 2018 [7]

2.2 Contributing Factors to Struck by Objects Accidents

The contributing factors that lead to the stuck-by objects accidents are obtained through journals, handbooks and fatal cases from the DOSH website. The contributing factors to struck-by objects are explained in the following sections and summarized in Table 1. It can be seen that the top 3 cited struck-by accident causes are lack of training, unsafe supervision and inadequate inspection.

2.2.1 Lack of Training

Goh et al. [8] pointed out that the workers' lack of guidance on safety matters has engaged them at the construction site accidents. The workers who are lack of training will be not aware of the danger that may occur due to their unsafe acts [9]. Thomson [10] investigated the equipment-related injuries and fatalities and construction and found that one of the significant contributing factors is the operator's incompetency in handling and operating the equipment. He suggested that heavy equipment operators should possess a license for operating such equipment and attend annual safety training to renew certification. This factor was also highlighted by several authors such as Wong et al. [11], Suraji et al. [12], Tam et al. [13], Haslam et al. [14] and Cheng et al. [15].

2.2.2 Unsafe Working Conditions

According to Dong et al. [16], the workers are often suffering from injuries when working or walking below the elevated surfaces, from the falling objects when the materials are being moved overhead and the falling objects when carrying or lifting the heavy loads. Besides, the power tools and the activities that produce flying objects such as sparks, metal and wood can also make the safety of the worker at the highest risk. Unsafe conditions can be due to defective tools and equipment, excessive noise and inadequate lighting [17]. Ineffective housekeeping is also one of the important contributory factors of struck-by accident highlighted in the previous study [18]-[20].

2.2.3 No Safe Operating Procedure

The inadequate safe operating procedure implemented at the workplace is one of the factors cause construction accident Goh & Chua [20]. Meanwhile, the record of the struck-by objects accidents that was obtained from Malaysian Department of Occupational Safety and Health (DOSH) [7] revealed that the main factor of struck by objects accident are the inadequacy of safe operating procedures (SOP) and failure to conduct the HIRARC (Hazard Identification, Risk Assessment and Risk Control) in their work. SOP is essential to help workers understand the process and procedure of their job tasks. Even if the worker is an experienced worker, he may need the SOP to assist him in performing a job or task he has not done recently [21].

2.2.4 Weather

Bad weather is also one of the contributing factors that lead to accidents [12], [14]. According to a report produced by the Hong Kong Labour Department [22], there was a site agent that was struck by the falling object due to the typhoon. During the strong wind event, there can also be a risk of materials such as roof tiles and tools which are placed at the higher level to be blown below and strike a person underneath. In addition, there is a possibility of workers cannot hear the approaching vehicles during strong wind event and later being struck by the vehicle [23]. It is recommended that all of the construction activities need to be postponed for a while during bad weather events.

2.2.5 Unsafe Supervision

Fass et al. [24] pointed out that unsafe supervision is also one of the causes for the occurrence of struck by objects. The unsafe supervision stated covers the supervisory violations, failure to correct a known problem, inadequate planning for supervision and inadequate planning for operations. Examples of supervisory violations are the use of faulty equipment and operation carried out without permits or substandard work conditions. The unsafe supervision highlighted the role of supervisor or the senior manager which they bear the responsibility to ensure that only a competent operator is on duty and the workers have adequate rest to perform optimally. Among other scholars that postulated this factor are Suraji et al. [12], Haslam et al. [14], Cheng et al. [15], Kartam & Bouz [18], Abdelhamed & Everett [19] and Fass et al. [24].

2.2.6 Misjudgment of Hazardous Situation or Distracting Actions by Others

Suraji et al. [12] stated that a construction activity carried out needs the correct judgment and perception of the workers. Once the workers underestimated the risks of carrying out the task given by the employers, the accidents may result from the misjudgment and wrong perception of the workers. Other than that, the workers that may easily get distracted by the others also caused the accident to occur. Based on Hinze et al. [25], misjudgment of a hazardous situation is the most common human factor contributing to the accident in the USA (35.8% out of a total 743 accident cases analysed).

2.2.7 Personal Protective Equipment or Safety Device

Appropriate use of personal protective equipment and safety device will prevent the workers suffer from struck by objects accidents. Tam et al. [13] however pointed out that some of the employers did not provide adequate PPE and safety devices to the workers. Not only that, the project managers also did not play their role to guide the workers on the uses of PPE and safety devices [12], [15].

2.2.8 Improper Equipment Usage

Goh & Chua [20] pointed out that improper equipment usage is one of the factors that contribute to the occurrence of the struck by objects accidents. The workers must not use the defective equipment such as the equipment with loose, cracked or splintered handles as the components of the equipment might fly off, striking the workers or others. According to Hinze et al. [25], faulty back-up alarms, failing brake systems and no roll-over protection systems have resulted in injuries. These causes are due to the failure of employers to ensure the equipment is in full compliance with the relevant safety regulations. This factor is also mentioned by several authors such as Suraji et al. [12], Holt [17] and Abdelhamid & Everett [19].

2.2.9 Inappropriate Operation

Cheng et al. [15] stated that inappropriate operation can cause the struck-by objects accidents to occur. An appropriate operation is necessary for safety. Some operations such as working under the cranes, hoists and scaffolds expose workers to a high chance of injuries if an accident happens. The workers are advised to stay clear of lifted loads and never work under a suspended load. This is also supported by Suraji et al. [12] and Mattila et al. [9].

2.2.10 Inadequate Inspection

Proper inspection is required for every construction site to ensure the safety of the workers is not at risk [16]. Different working conditions require different inspection procedures. There must have a regular inspection on the working site to ensure the working condition is safe for the workers. Among authors who agreed that inadequate inspection is the cause of the accident are Mattila et al. [9], Goh & Chua [20], Suraji et al. [12], Haslam et al. [14], Cheng et al. [15] and Hinze et al. [25].

3. Methodology

The method used for this study was by analysing the fatality cases due to struck-by accidents through the DOSH website (secondary data analysis) and distributing the questionnaire survey form to the safety personnel who are working at construction sites in Johor.

3.1 Analysis from Secondary Data

In order to achieve the first objective of this study which is to analyse the nature of struck by objects accidents, the real cases of the reported fatal accident due to struck by objects on website of DOSH were investigated [7]. In order to attain specific information on the fatal case at construction sites in Johor from year 2010 to 2018, keywords such as “construction”, “Johor”, “Struck-by” were used to filter the results. Among the 103 cases of construction accidents

happened at Johor, 20 cases of struck by objects accidents were extracted to identify the significant contributing factors of struck-by object accidents. Based on the contributing factors identified from DOSH database and the literature review obtained, the questionnaire form was designed.

3.2 Questionnaire Survey Procedure

A questionnaire survey was used to attain respondents' perceptions on the contributing factors and preventive measures for struck-by object accident. The respondents of this study are those who held responsibility on occupational safety and health at the workplace, such as safety managers, safety and health officer (SHO), site safety supervisors (SSS), and other types of positions that are also held responsibility on OSH such as a member of the safety committee, safety executive, etc. The questionnaires were distributed to selected 150 respondents and the total questionnaire returned was 116 (77.3% response rate).

The questionnaire consists of 2 parts, namely: i) Part 1 – Demographics of respondents; and ii) Part 2 – Significant contributing factors for struck-by object accident. In Part 2, the respondents were asked to rate the level of significance of 10 contributing factors listed, based on a 5-point Likert scale, ranging from 1 (very insignificant) to 5 (very significant).

A pilot study was done to check the validity and reliability of the survey instrument. The result from content validity was positive, whereas the result from Cronbach's Alpha reliability value is 0.97, suggesting that there is no change needed in the questionnaire instrument [26]. Next, the real data collection started by distributing the questionnaire to the respondents (i.e. safety personnel) who were working at construction sites in Johor.

3.3 Measures for Data Analysis

3.3.2 Relative Importance Index

The Relative Importance Index (RII) was used in this study to rank the contributing factors and preventive measures to struck by objects accidents according to their relative importance [27], [28]. The RII of each criterion was calculated by using the formula as shown follows:

$$RII = \frac{\sum W}{(A \times N)} \tag{1}$$

where, RII = Relative Importance Index, W = Weighting given to each factor by respondents that is ranging from 1 to 5, A = Highest weight and N = the total number of respondents. The ranking of each contributing factor and the preventive measures to struck-by object accidents from the respondents were then be used to investigate the relationship with the real cases, as described in the next section.

3.3.3 Correlational Relationship between Respondents' Perceptions on Contributing Factors of Struck-by Object Accidents and the Real Cases Extracted from DOSH Website

Spearman's rank correlation was used to analyze the correlational relationship between respondents' perceptions of contributing factors for the struck-by object with the findings from the real cases extracted from the DOSH website. It is denoted by r_s and the formula is shown below [29]:

$$r_s = 1 - \frac{6\left(\sum d_i^2\right)}{n\left(n^2 - 1\right)} \tag{2}$$

where d_i is the difference in the ranks given to the two variable values for each item of data. The absolute index value of r_s can be used as a guide to describe the strength of the correlation which shown in Table 2.

Table 2 - Index of r_s for Level of Strength [27]

Index of r_s	Level of Strength
$0.00 \le r_s \le 0.19$	Very Weak
$0.20 \le r_s \le 0.39$	Weak
$0.40 \le r_s \le 0.59$	Moderate
$0.60 \le r_s \le 0.79$	Strong
$0.80 \le r_s \le 1.00$	Very Strong

4. Data Analysis and Discussions

The analysis comprises two parts which include data analysis of real fatal accident cases from secondary data analysis (DOSH website) and the questionnaire survey from safety personnel. It should be noted that the analysis of real cases from secondary data was based on the relevant perceptions and assumptions of the authors to determine the contributing factors to the struck-by accidents. This is because the accident case presented on the website was the qualitative type of data and the causes of each accident stated were not the root cause of the accident. The authors need to analysed the data of each accident case to determine the causes for each accident case selected.

4.1 Analysis of Struck-by Fatal Accident Cases from DOSH Website

4.1.1 Frequency of Cases by Materials/Equipment Involved in Struck by Objects Accidents

The analysis of the frequency of fatal accident cases due to struck-by accidents in Johor is shown in Table 3. It can be seen that among 20 fatal cases due to struck-by objects at the construction site in Johor reported to DOSH, the most types of striking agents are related to materials (65%), as compared to equipment (35%). The findings are in contrast with Hinze et al.'s [25] results, which they found equipment caused 61.8% injuries due to struck-by incidents, whereby 39.2% struck-by incidents involved materials. The categories with the largest number of struck-by fatal cases in Johor involved brick/block, formwork and concrete wall. However, it is to be noted that the present study only covered the fatal cases involved in Johor state only, whilst Hinze et al. [25] covered all incidents (either fatal or non-fatal) in the entire states of the USA.

One such case involved a construction worker who is dead after being struck-by falling brick in the head while doing cleaning activities. In another accident involving concrete work, the incident occurred while the worker was doing housekeeping work when suddenly a wall collapsed and crushed onto the victim. The victim suffered whole body injury which leads to his death. In one case involving equipment, the victim is believed to be lifting a pipe using a tractor at the time of the incident. He was trying to lose the chain once the pipe was laid on the ground, then suddenly the bucket at the back of the tractor alighted and hit the victim's head, causing his death.

Table 3 - Frequency of cases by materials/equipment involved in struck by objects accidents

Material	Frequency
Brick/ block	3
Formwork	3
Concrete wall (collapse)	3
Pallet	2
Truck	2
Tractor	2
Forklift	1
Machine	1
Metal fragments	1
Trailer	1
Other (flying object)	1
Total	20

4.1.2 Contributing Factors of Struck-by Object Accidents Based on Secondary Data (DOSH Website)

Table 4 shows the contributing factors to struck-by objects accidents identified from the analysis of the data obtained from the DOSH website. From the findings of real cases obtained, it was found that the majority of fatal accident cases involved human factors (80%), whereas environmental factors (i.e. unsafe working conditions and weather) yielded 20% results. According to Hinze et al. [25], 'Human factors are involved when the causes of accidents are attributed to the failure of an individual to act promptly to avoid it. The individual may be the injured party or any other person who may have been in a position to prevent the accident. Human factors are involved in virtually all accidents if it is assumed that all accidents are avoidable.'

From the secondary data analysis, the most significant contributing factors to 20 cases of struck-by fatal accidents at the construction site in Johor was related to no safe operating procedure which contributed to 5 cases. It was followed by unsafe working conditions, inappropriate operation, improper equipment usage and inadequate PPE. These authors

agreed with Hinze et al. [25] that the accidents may result from the lack of or inappropriate action by any one person in the activities that lead up to the accident, and not necessarily caused directly by the victims. For example, the accident caused by 'no safe operating procedure (SOP)' can be avoided if the employer through the role of the project manager or safety personnel prepared sufficient and appropriate SOP for every task at the workplace.

Table 4 - Frequency of contributing factor of struck-by object accident identified from secondary data (DOSH Website)

No.	Contributing Factors of Struck-by Object Accidents	Frequency	Ranking based on frequency
1	No safe operating procedure	5	1
2	Unsafe working conditions	4	2
3	Inappropriate operation	3	3
4	Personal protective equipment or safety device	2	4
5	Improper equipment usage	2	4
6	Lack of training	1	6
7	Unsafe supervision	1	6
8	Misjudgment of hazardous situation or distracting action by others	1	6
9	Inadequate inspection	1	6
10	Weather	0	10

4.2 Analysis of Questionnaire Survey Form

4.2.1 Background of Respondents and Reliability Analysis

The background of respondents was analysed, and the information is summarised as in Table 5. From the table, it can be seen that the respondents selected are those who are capable to answer the questionnaire. The reliability test has been run to check the reliability of the results and the overall consistency of a measure for the entire survey. The Cronbach's Alpha values obtained for contributing factors and preventive measures are 0749. The result indicates that an acceptable internal consistency for the scales used and all measurements are reliable to conduct [29].

Table 5 - Background of respondents

Designation/Position	Number of respondents
Safety and health offier (SHO)	67
Safety manager	17
Site safety supervisor	31
Others	1
Level of education	
Bachelor's degree	67
Diploma	32
STPM/Certificate	11
SPM	6
Experience (in years)	
More than 20 years	21
Between 3 to 10 years	79
Between 1 to 3 years	11
Less tahn 1 year	5
Total respondents	**116**

4.2.2 Contributing Factors to Struck by Objects Accidents from the Analysis of Questionnaire Survey Form

Table 6 shows the respondents' perception towards the contributing factors to struck by objects accidents where the overall mean index is 4.15 and the level of factor is significant. The ranking based on the Relative Importance Index (RII) was used to identify the significant contributing factors to struck by objects accidents.

The respondents infer that the most significant contributing factor of struck-by object accidents is due to lack of training which the RII value of 0.900. It is then followed by the factor of personal protective equipment or safety device (RII = 0.857) and improper equipment usage (RII = 0.853). The lowest perceived contributing factor for the struck-by

accident is no safe working procedure (RII = 0.795). The result is consistent with the literature review, in which the lack of training is the most frequently stated cause of the struck-by accident by scholars. From table 6, it can be seen that the top 4 perceived significant contributing factors to struck-by accidents can be avoided or minimized through enhancing worker skills and providing more related training to workers. In a particular study regarding the causal factors of fall and struck-by incidents [24], the authors analysed the causal factors and found that limited worker skills and training ranked as the top factor. Their study attained experts' insights on the causal factors of incidents, and the experts strongly agreed that periodic, relevant training is necessary to enable workers to improve their skill sets, including improving their risk perception, more awareness of risk hazards and better worker behaviors [24].

Table 6 - Summary of respondents' perceptions on the significant contributing factors to struck-by object accidents

No.	Contributing Factors to Struck by Objects Accidents	RII	Ranking based on RII
1	Lack of training	0.900	1
2	Personal protective equipment or safety device	0.857	2
3	Improper equipment usage	0.853	3
4	Misjudgment of hazardous situation or distracting action by others	0.822	4
5	Inadequate inspection	0.821	5
6	Inappropriate operation	0.817	6
3	Unsafe working conditions	0.816	7
8	Unsafe supervision	0.812	8
9	Weather	0.810	9
10	No safe operating procedure	0.795	10

The results from Table 6 somehow contradict the results from secondary data analysis, i.e. real cases of struck-by fatal accidents in Johor construction sites. It is interesting to be noted that, while 'no SOP' is categorized as the most causal factor from secondary data analysis, respondents of the questionnaire perceived it as the least contributing factor to struck-by accidents. According to Spangenberg & Minnit [30], the application of SOP will reduce the level of errors and omissions that may be performed by a worker in carrying out the task, and thus reduce accident. This is confirmed by Hanafi and Sholihah [31] who found that there is a significant effect of the application of SOP to occupational accidents. Hence, it is crucial for construction stakeholders such as contractors and clients to inculcate the application of SOP towards accident prevention in their daily operations.

4.3 Correlational Relationship of Safety Personnels' Perceptions on Contributing Factors to Struck by Objects Accidents with Real Cases

This part is to investigate the relationship between safety personnel's perceptions on contributing factors to struck-by objects accidents with secondary data analysis of real fatal accident cases reported to DOSH (as gathered from the DOSH website). The analysis was conducted by using Spearman's rank correlation. From the formula stated in (2), the absolute index value, r_s obtained is 0.13, which is very weak. This indicated that respondents tend to perceive differently from what is actually happened.

According to Goh et al. [8], the omission of safe operating procedures was considered as the immediate factor that can result in the occurrence of struck-by object accidents. However, the respondents have a different perception that the lack of training is the major contributor factor of struck-by object accidents. The contradictions should be taken into attention as safety personnel are the advisor to the employer and usually the decision maker of which or preventive measures should be taken for hazards and risks at the workplace. The inconsistency of the perceived root cause of accidents also could result in the recurrence of a similar incident in the future.

Many measures can be taken to reduce the number of struck-by accidents. These include ensuring the safe operating procedures are in place, an inspection of equipment, the use of PPE and falling object protective structure equipment and regular training.

5. Conclusion

Generally, construction accidents can be avoided by promoting safety education and training. Zero fatalities, injuries and disease in construction are always considered as the common goal by the construction practitioners. However, without putting the effort to improve safety, the goal will only remain elusive. By improving safety at the construction site, it does not only protect the welfare of the workers. Meanwhile, the employers will also gain the advantages that the progress of the project is keeping in track with the schedule and help in building a good company profile with the clients or customers.

In this research, struck-by object accidents were studied in more detail although less study was conducted out there even it is already been recorded as the second highest fatalities accident. This study has identified several causes that contribute to the struck-by fatal accident in the Johor construction industry based on the real cases reported to DOSH. The causes were then compared with the selected safety personnel's perceptions on the causes of the struck-by accident at the construction site. The findings revealed that the selected safety personnel perceived the causes of accidents differently from the actual cases. This creates major eye-opening on the weak correlational relationship between the safety personnel's perceptions and what the real cause is. This study provides awareness on the issue and further actions should be taken to ensure the fatality rate of struck-by object accidents could be reduced. This study has limitations that it only focused on Johor and did not represent the Malaysian construction industry as a whole. Future study is sought to extend the research scope to other states in Malaysia so that the data can be generalized.

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