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

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Abstract: The construction industry is notorious for its high risk of accidents compared to other sectors, with 'struck-by' accidents ranking among the top three reported fatal incidents to the Department of Occupational Safety and Health (DOSH). Thus, investigating the primary causes of these accidents and implementing preventive measures is crucial. This study focuses on gathering data from fatal accidents caused by being struck by objects in the construction sector of Peninsular Malaysia, sourced from the DOSH web database. By analyzing real-case examples, key contributing factors and preventive practices are identified and synthesized into a questionnaire distributed solely to safety personnel. A comparison between the perceptions of security personnel and actual cases sheds light on discrepancies. The questionnaire study reveals that equipment malfunction is a significant contributing factor, emphasizing the importance of securely handling tools and equipment during overhead work as a preventive measure. Real-world examinations confirm this finding, highlighting the importance of avoiding the fall zone of heavy equipment, such as cranes and loaders, particularly when carrying loads. Spearman's rank correlation analysis demonstrates diversity in respondents' views on actual situations. Consequently, this study aims to raise awareness among construction practitioners about the importance of reducing struck-by-object accidents by addressing underlying causes effectively.

Keywords: Construction, Accident, Struck-by

1. Introduction

The construction industry plays a critical role in providing the socioeconomic framework for industrial development, manufacturing, and essential infrastructure. In the second quarter of 2018, the value of construction work increased by 5.3 percent year-on-year to RM 35.6 billion, as reported by the Malaysian Department of Statistics. This growth significantly contributed to enhancing Malaysia's gross domestic product (GDP).

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The primary driver of building demand is the broader economic landscape and the expectations regarding its future trajectory. However, the construction industry is characterized by a heightened risk of accidents, posing significant threats to the safety and lives of professionals involved, including employees, builders, and architects. Figure 1 illustrates that the construction sector experiences the highest number of fatal occupational incidents, surpassing other industries such as manufacturing, finance, insurance, real estate, business services, public services, statutory authorities, and others. This industry accounts for a staggering fatality rate of 54.76 percent, emphasizing its heightened risk compared to other sectors [4].

Table 1: Occupational Accident Statistics by Sector until March 2021 [4]

SECTOR	NPD	PD	DEATH	TOTAL
Hotel and Restaurant	40	1	0	41
Utilities (Electricity, Gas, Water and Sanitary Service)	43	0	0	43
Finance, Insurance, Real Estate and Business Services	102	6	5	113
Construction	43	4	23	70
Transport, Storage and Communication	68	1	2	71
Manufacturing	1172	58	10	1240
Wholesale and Retail Trade	64	1	0	65
Public Services and Statutory Authorities	25	0	0	25
Mining and Quarrying	12	1	2	15
Agriculture, Forestry and Fishery	262	3	0	265
TOTAL	**1831**	**75**	**42**	**1948**

LEGEND:
PD - PERMANENT DISABILITY
NPD- NON PERMANENT DISABILITY

Prioritizing construction injuries is paramount as the well-being of workers directly impacts project success and can lead to substantial financial losses for contractors [5]. Consequently, this research aims to investigate the diverse incidents occurring on construction sites, particularly focusing on injuries caused by object strikes. Identifying the primary factors contributing to struck-by-object accidents and proposing effective prevention measures are central objectives of this study.

2. Materials and Methods

The methodology employed in this study involved analyzing fatal incidents related to struck-by accidents through data sourced from the DOSH website. Additionally, questionnaire surveys were distributed to construction practitioners across Malaysia, focusing particularly on the Peninsular region. The aim was to examine the correlation between construction practitioners' perceptions of contributing factors and prevention practices related to struck-by-object accidents, using real cases extracted from DOSH website. Statistical analysis was conducted using Relative Importance Index (RII).

3.1 Document Analysis from DOSH Website

This study aims to investigate the characteristics of struck-by-object accidents. From a pool of 281 construction accidents in Malaysia, eighteen (18) cases involving struck-by-object incidents were identified [6]. The questionnaire was developed based on analysis of data from the Department of Occupational Safety and Health (DOSH) and relevant literature.

3.2 Questionnaire Survey

To fulfill the second objective, a questionnaire survey was employed as the primary data collection method. Google Forms was utilized to create and distribute the questionnaire, leveraging the convenience of online delivery. The survey was specifically targeted at safety personnel within the construction industry, including safety and health officers (SHOs), site safety supervisors (SSS), safety managers, and other individuals responsible for safety and health management on construction sites.

3.3 Questionnaire Design

The questionnaire form is structured in three sections, as follows:

- Section A: Demographic profile
- Section B: A Likert scale of contributing factors to struck by objects accidents
- Section C: A Likert scale of preventive practice to struck by objects accidents

The questionnaire was distributed to respondents responsible for occupational safety and health in various workplaces, particularly on construction sites in Malaysia. This includes Site Safety Supervisors, Safety and Health Officers, Safety Managers, and Safety Promoters. Sections B and C of the questionnaire required measurement of respondent opinions, for which the Likert scale was employed in this investigation. Respondents were prompted to select their preferred options using the Likert scale, as detailed in Table 3. Higher values on the scale indicate greater levels of agreement among responses.

Table 3: Level of Agreement from 1 to 5 [8]

Scale	Level of agreement
1	Strongly disagree
2	Disagree
3	Moderate
4	Agree
5	Strongly agree

3.4 Pilot Study: Content Validation of the Questionnaire

The questionnaire underwent validation by two expert panels to ensure timeliness, accuracy, and the acceptability of its phrases. These experts have experience as safety and health officers and are currently involved in construction projects. After validation, ten questionnaire samples were distributed to respondents for completion. The self-administered questionnaire was shared using Google Forms. It is crucial for respondents to understand their perspectives, as their conclusions are integral to the dependability analysis. The majority of responders are safety personnel from the Malaysian construction industry.

3.5 Relative Importance Index

The Relative Importance Index (RII) is used in this study to rank [9] the contributing factors and prevention actions for struck by objects accidents according to their relative importance. The RII of each criterion has been calculated by using the formula as shown follows: RII = Relative Importance Index; W = Weighting assigned to each component by respondents ranging from 1 to 5, A = Highest weight and N = the total number of respondents [10]. The ranking to each contributing factors and the preventive measures to struck by objects accidents from the respondents are compared with the real cases' ranking.

3.6 Relationship of Construction Practitioners on the Contributing Factors and the Preventive Practice to Struck by Objects Accidents with the Real Cases Extracted from DOSH

Two sets of data were gathered for this study: one from the DOSH website and the other from the questionnaire. This comparison aimed to assess the perspectives of construction professionals regarding the primary factors contributing to struck-by-object accidents and the most effective preventive measures, in comparison to real-world data from DOSH. Achieving the third objective of the study was the purpose of this comparison. As a result, the Spearman's rank correlation will be employed. It is indicated by r_s, and the formula is as follows:

$r_s = 1 - \frac{6(\sum d_i^2)}{n(n^2-1)}$, 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, as shown in Table 3, has been used as a reference to indicate the strength of the connection,

Table 3: Index of r_s for Level of Strength [11]

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

3. Results and Discussion

Following expert assessment of the questionnaires, revisions were made based on their feedback. The updated questionnaire was subsequently distributed to safety officers within the construction industry across the country, with a particular focus on the Peninsular region of Malaysia.

4.1 Background of Respondents

The background of respondents was analyzed, and the findings are summarized in Table 4. The table indicates that the selected respondents possess the necessary qualifications to effectively respond to the questionnaire.

Table 4: Background of Respondents

Gender	Number of Respondents
Female	28
Male	61
Position	
Safety and Health Officer	28
Safety Manager	20
Safety Promoter	8
Site Safety Supervisor	33
Level of Education	
SPM/SPVM	2
STPM/Certificate	2
Diploma	34
Degree	44
Masters	7
PHD	0
Working Experience	
Less than 1 year	8
2 – 3 years	20
3 – 5 years	41
> 10 years	20
Total Respondents	**89**

4.2 Contributing Factors of Struck by Objects Accidents Based on the DOSH Website

Based on the findings from real cases (DOSH website), it was revealed that the most significant contributing factor to 18 cases of struck-by accidents in Malaysia was malfunctioning equipment, accounting for 5 cases (27.7%). Following this, faulty materials or structural elements leading to breakdowns or collapses were responsible for 4 cases of struck-by-object accidents (22%). Additionally, factors such as improper stacking of materials, failure to adhere to safety standards, and neglecting to use safety equipment designed to prevent falling objects and debris, each accounted for 2 cases (11%). Conversely, failure to properly secure tools or machine components, cranes, hoists, or loads resulted in only one case of struck-by-object accidents, while incorrect tool or equipment usage and absence of posted warning signs appeared to have less significant impact on such accidents.

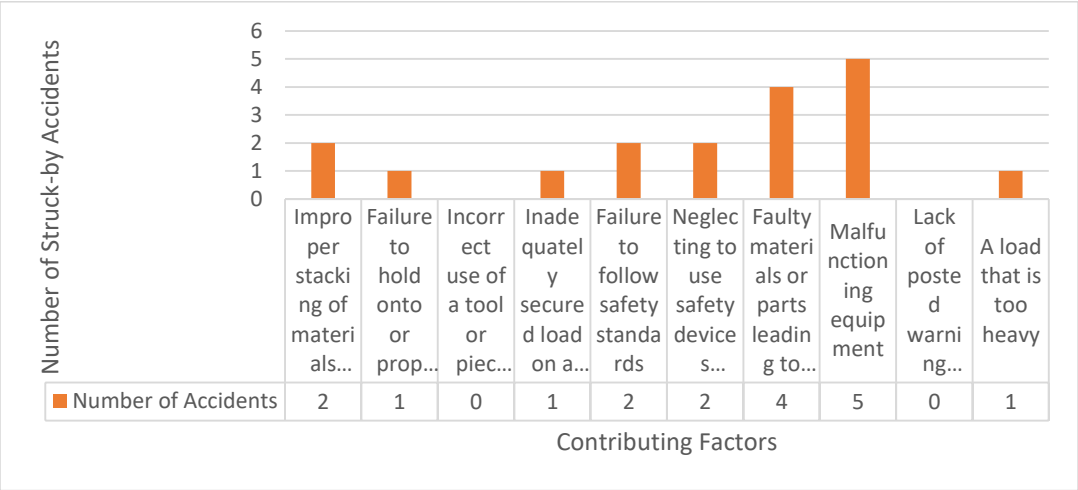

Figure 1: Number of Struck-by Accidents according to the Contributing Factors

4.3 Preventive Practice to Struck-by Objects Accidents Based on the DOSH Website

The most effective preventive measure to address struck-by accidents involves avoiding the fall zone under cranes, hoists, front loaders, or other heavy equipment, especially when they are carrying loads. Equipment inspection emerged as the top-ranked preventive measure, accounting for 5 cases (27.8%). The second-ranked measure involves staying away from barricaded hazard areas, contributing to 22.2% in reducing the incidence of struck-by-object accidents. Additionally, avoiding areas with warning signs indicating the risk of falling objects ranked third, with a percentage of 11.1 in prevention efforts. However, practices such as stacking materials excessively high and neglecting to inspect tools and equipment for proper function showed less effectiveness, with only a 5.6% reduction in struck-by accidents in Malaysia. It is essential to prioritize safety by ensuring proper equipment maintenance, utilizing appropriate safety gear, and adhering to recommended procedures to mitigate the risk of such accidents effectively.

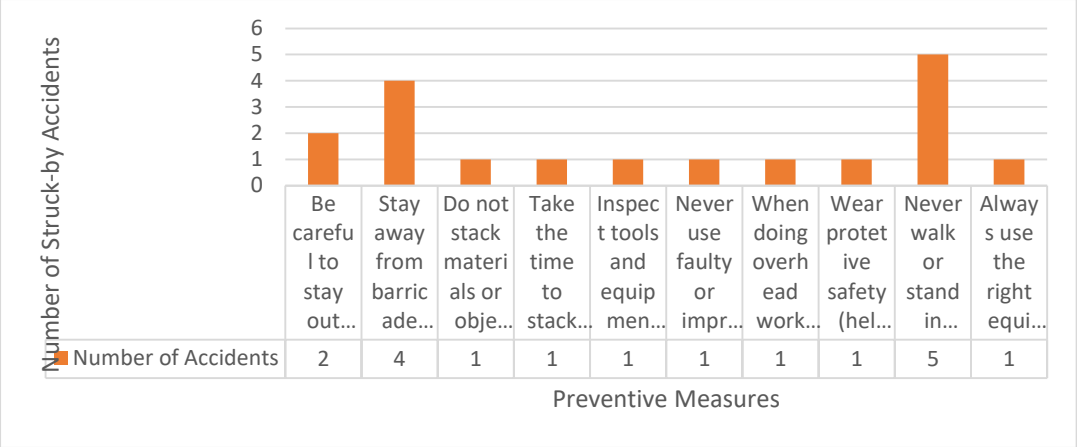

Figure 2: Number of Struck-by Accidents According to the Preventive Measures

4.4 Contributing Factors to Struck by Accidents

According to respondents, the most significant contributing factor to struck-by-object accidents is equipment malfunction, with the highest RII value of 0.876404. This is followed by the factor of faulty materials or structural elements leading to breakdowns or collapses, with an RII value of 0.869662. The third-ranking contributing factor is a crane, hoist, or boom with an inadequately secured load, with an RII value of 0.853.

Table 5: Summary of Respondent's Perceptions to Contributing Factors to Struck by Accidents

No.	Significant Cause of Struck-by Objects Accidents	RII	Ranking based on RII
1	Improper stacking of materials or supplies	0.856179	4
2	Failure to hold onto or properly secure a tool or machine component	0.833708	8
3	Incorrect use of a tool or piece of equipment	0.829213	9
4	A crane, hoist, or boom with an inadequately secured load	0.860674	3
5	Failure to follow safety standards	0.849438	5
6	Failure to use safety equipment that can catch or stop falling objects and debris	0.835955	6
7	Faulty materials or elements that cause a breakdown or collapse of the structure	0.869662	2
8	Equipment that is not working properly	0.876404	1
9	There are no marked caution signs	0.824719	10
10	A load that is too heavy	0.835955	7

4.5 Preventive Practice to Struck by Accidents

The majority of respondents advocate that the most effective preventive practice against struck-by-object accidents is ensuring proper securing of tools and equipment during overhead work, with the highest RII value of 0.874157 compared to other preventive measures. Following closely, the second most effective preventive practice involves avoiding the fall zone under cranes, hoists, front loaders, or other heavy equipment, especially when carrying loads, with an RII value of 0.869662. In third place, wearing appropriate safety equipment while on the job—such as helmets, goggles, and hard-toe boots—is ranked, with an RII value of 0.860674.

Table 6: Summary of Respondent's Perception to Preventive Practice to Struck by Accidents

No.	Preventive Practice to Struck-by Objects Accidents	RII	Ranking based on RII
1	Stay away from areas where there are warning signs concerning the possibility of falling objects	0.849438	7
2	Stay clear from hazard zones that have been barricaded	0.829213	9
3	Stacking materials or objects too high is not a good idea	0.860674	4
4	Take the time to stack items in a way that protects them from sliding, falling, or collapsing	0.815731	10
5	Before utilizing any tools or equipment, make sure they are in good working order	0.853933	5
6	Never use equipment or tools that are defective or poorly maintained	0.853933	6
7	Secure your tools and equipment correctly when undertaking overhead work	0.874157	1
8	While on the work, always wear proper safety equipment (helmet, goggles, hard-toe boots, etc.)	0.860674	3
9	Under a crane, hoist, front loader, or other piece of heavy equipment, never walk or stand in the fall zone, especially if it is carrying a load	0.869662	2
10	Always use the tools that are suited for the job or task at hand	0.831461	8

4.6 Comparison of Safety Personnel's Perceptions on Contributing Factors to Struck by Objects Accidents with Real Cases

Table 7 presents the comparison of safety personnel perceptions regarding contributing factors of struck-by-object accidents with real cases. The Spearman's rank correlation coefficient for each factor is calculated using SPSS.

Table 7: Comparison of Perceptions of the Safety Personnel's on Contributing Factors of Struck by Objects Accidents with Real Cases

No.	Contributing Factors to Struck-by Objects Accidents	Ranking		$\|d\|$	d^2
		Real Cases	Safety Personnel		
1	Ranking 1: Equipment that is not working properly	1	1	0	0
2	Ranking 2: Faulty materials or elements that cause a breakdown or collapse of the structure	2	2	0	0
3	Ranking 3: Improper stacking of materials or supplies	3.5	4	0.5	0.25
4	Ranking 3: Failure to follow safety standards	3.5	5	1.5	2.25
5	Ranking 3: Failure to use safety equipment that can catch or stop falling objects and debris	3.5	6	2.5	6.25
6	Ranking 4: Failure to hold onto or properly secure a tool or machine component	4.5	8	3.5	12.25
7	Ranking 4: A crane, hoist, or boom with an inadequately secured load	4.5	3	1.5	2.25
8	Ranking 4: A load that is too heavy	4.5	7	2.5	6.26
9	Ranking 5: Incorrect use of a tool or piece of equipment	5.5	9	3.5	12.25

10	Ranking 5: There are no marked caution signs	5.5	10	4.5	20.25
				$\sum d^2$	62

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

$$r_s = 1 - \frac{6\,(62)}{10\,(10^2 - 1)}$$

$$= 0.624$$

∴ |r| ≤ 0.79, therefore the index of correlation is strong.

4.7 Comparison of Safety Personnel's Perceptions on Preventive Practice to Struck by Objects Accidents with Real Cases

Table 8 displays the comparison between safety personnel perceptions and real cases regarding contributing factors of struck-by-object accidents. The Spearman's rank correlation coefficient for each factor is derived from SPSS.

Table 8: Comparison of Perceptions of the Safety Personnel's on Preventive Practice to Struck by Objects Accidents with Real Case

No.	Contributing Factors to Struck-by Objects Accidents	Ranking		$\|d\|$	d^2
		Real Cases	Safety Personnel		
1	Ranking 1: Under a crane, hoist, front loader, or other piece of heavy equipment, never walk or stand in the fall zone, especially if it is carrying a load	1	2	1	1
2	Ranking 2: Stay clear from hazard zones that have been barricaded	2	9	7	49
3	Ranking 3: Stay away from areas where there are warning signs concerning the possibility of falling objects	3	7	4	16
4	Ranking 4: Stacking materials or objects too high is not a good idea	4.5	4	0.5	0.25
5	Ranking 4: Take the time to stack items in a way that protects them from sliding, falling, or collapsing	4.5	10	5.5	30.25
6	Ranking 4: Before utilizing any tools or equipment, make sure they are in good working order	4.5	5	0.5	0.25
7	Ranking 4: Never use equipment or tools that are defective or poorly maintained	4.5	6	1.5	2.25
8	Ranking 4: Secure your tools and equipment correctly when undertaking overhead work	4.5	1	3.5	12.25

9	Ranking 4: While on the work, always wear proper safety equipment (helmet, goggles, hard-toe boots, etc.)	4.5	3	1.5	2.25
10	Ranking 4: Always use the tools that are suited for the job or task at hand	4.5	8	3.5	12.25
				$\sum d^2$	125.75

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

$$r_s = 1 - \frac{6\,(125.75)}{10\,(10^2 - 1)}$$

$$= 0.238$$

$\therefore |r| \leq 0.39$, therefore the index of correlation is weak.

4. Conclusion

This research aims to enhance the construction industry's comprehension of the factors contributing to struck-by-object incidents and strategies for their prevention. The explanation and conclusion of findings are aligned with the study's objectives. Additionally, limitations, including inadequate data and outdated cases in the DOSH website, are discussed. Suggestions for further research include involving different categories of respondents such as Engineers, Managerial staff, Architects, or Consultants, considering their distinct roles in the construction industry. The research findings are firmly anchored in the study's objectives. Two research approaches utilized in this study were document analysis and a questionnaire survey, followed by a comparative analysis of these techniques.

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