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Risk Assessment on The Bandung Hilton Hotel Construction Project Utilizing The FMEA and FTA Methods

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ABSTRACT

Risk is the possibility or uncertainty of unexpected events occurring during the implementation of work which could harm the party carrying out the activity, the example is a risk of work accidents. The potential risk of work accidents also occurs in the Hilton Hotel Construction Project in Kota Baru Parahyangan - West Bandung. The project is a high-rise building with a height of 23 floors which of course has a fairly high risk of work accidents. This research aims to find out the dominant risk and its factors.This research applied two methods in analyzing, those methods are Failure Mode and Effect Analysis Method (FMEA) and Fault Tree Analysis Method (FTA). Having can be identified and analyzed that risks by using those methods, this research did some steps by using Method for Obtain Cut Set (MOCUS) for finding basic event combination.The results of this research are to determine the dominant risk of work accidents using the FMEA method, namely the activity of workers falling from a height during glass installation work with an RPN value of 26,3. Based on the FTA method, it produces 16 basic events are feeling unwell, lack of concentration, lack of enthusiasm for work, excessive joking, not seeing signs, lack of communication, lack of supervision time, lack of K3 training, less comfortable using PPE, limited amount of PPE, lack of training, lack of experience, signs that are too small, signs blocked by objects, slippery roads due to rain, and a messy work environment.

Keywords: *Risk Analysis; Work Accident; High-Rise Building; Failure Mode and Effect Analysis Method; Fault Tree Analysis Method.*

INTRODUCTION

Every human action is frequently accompanied with potential risks. When engaging in various tasks, one potential hazard that can arise is occupational accidents. Workplace accidents can happen in various industries, including the construction sector. (Hakim et al., 2023) asserted that work accidents in the construction industry occur due to ineffective targeting of risk mitigation measures in addressing the risk of work accidents. The primary causes of work accidents include ambient circumstances, work equipment, and the workers themselves. In order to mitigate the occurrence of work-related accidents, it is imperative to effectively control and address the risks associated with construction projects. This is crucial not only for the well-being of workers, but also for the overall success of the project. The construction of a multi-storey building is a development that carries a significant likelihood of work-related accidents. The Hilton Hotel Construction Project in Kota Baru Parahyangan - West Bandung is a tall building consisting of 23 floors, which inherently carries a significant risk of work-related accidents.

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Based on interviews with the Project Manager of PT Contractor, Nusa Raya Cipta, a work accident took place at the Hilton Hotel Construction Project in Kota Baru Parahyangan - West Bandung. However, it was deemed a minor mishap. Instances of minor injuries sustained by workers include scratches on their hands from tying iron and injuries caused by wire bending. This occurrence is a result of insufficient vigilance during work, the diminished mental or physical state of the workers, and the absence of tidiness and cleanliness at the building site.

This study will employ the Failure Mode and Effect Analysis (FMEA) method to assess risks in the Hilton Hotel Construction Project in Kota Baru Parahyangan - West Bandung. The aim is to identify the most significant risks based on their Risk Priority Number (RPN) value. Subsequently, the Fault Tree Analysis (FTA) method will be utilised to analyse the root causes of the most prevalent risks. By analysing and mitigating the risk of work accidents on this project, we want to provide valuable insights for the successful implementation of similar initiatives in the future.

METHOD

Explaining The research commenced by identifying various work accident risks on hotel building projects, which were subsequently verified by three specialists from the Hilton Hotel Construction project contractor in Kota Baru Parahyangan - West Bandung. Subsequently, this data is used to ascertain the severity, occurrence, and detection values for each analysed possible failure mode. Data gathering is facilitated through the use of a questionnaire. The sample size for this study consisted of experts and staff in PT Contractor, Nusa Raya Cipta. The selection of respondents was done via purposive sampling. Utilising RPN (Risk Priority Number) and FTA (Fault Tree Analysis) for analysis. RPN is the result of multiplying severity, occurrence, and detection. The severity, occurrence, and detection values are presented in Tables 1, 2, and 3. The RPN values are utilised to ascertain the prioritisation of jobs in the implementation of mitigation actions, whilst the FTA approach is employed for analysing the causes of work accidents.

Table 1. Severity Rating Scale

Effect	Occurrence Criteria	Scale
Extremely High	The consequences of failure are highly detrimental	5
High	Severe consequences of failure	4
Moderate	The consequences of failure are seldom significant	3
Low	Mildly significant consequences of failure	2
Extremely Low	The consequences of failure are not significant	1

Table 2. Occurrence Rating Scale

Effect	Occurrence Criteria	Scale
Frequently happen	Inevitable failure	5
Occurs often	Recurring and persistent failures	4
Infrequent	Common failures	3
Infrequently	Multiple failures occurred	2

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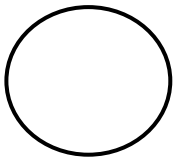
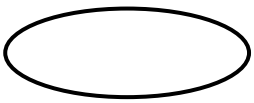
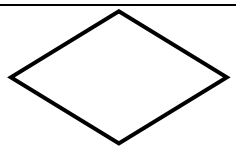
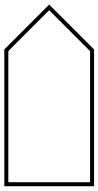
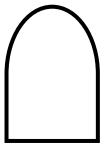
occurring	on a single occasion	
Rarely occur	Most failures occur frequently	1

Table 3. Detection Rating Scale

Effect	Occurrence Criteria	Scale
Difficult	Possible failures are difficult to detect	5
Quite difficult	The possibility of failure is quite difficult detected	4
Challenging	The possibility of failure is quite difficult to detect	3
Normally	The possibility of a simple failure being detected	2
Almost certainly	Possible failures are almost guaranteed to be detected	1

The symbols used in the FTA method can be seen in the following table:

Table 4. Symbols in the FTA Method

Symbol	Content
	*Basic Event* Basic error initiation that does not require further development
	*Conditioning Event* Specificity conditions that can be applied to various logic gates
	*Undevelopment Event* Events that cannot be developed further because information is not available
	*External Event* The expected event appears
	AND Gate Errors arise due to all input problems that occur
	OR Gate Errors arise due to one of the input problems that occurs

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RESULTS AND DISCUSSION

Proficient professionals and individuals knowledgeable in the execution of tall structures. Three experts will conduct an initial expert validation of work accident variables and compile a list of potential events that are associated with an explanation of the reasons of the work accident. Subsequently, the variables are eliminated by a systematic method. The FMEA method will be used to assess variables that are not eliminated. After the initial expert review, only 60 out of the remaining 64 signs were deemed legitimate. The assessment of severity (S), probability of occurrence (O), and detection (D) is achieved through diverse procedures including experienced individuals who specialize in recognizing accident risks in projects. Severity refers to the level of seriousness associated with the potential impact of work accidents, including injuries, illnesses, and hazards to machinery or equipment. Occurrence refers to the rate at which potential work accidents, which are causes of failure, happen within a project. Meanwhile, detection refers to the capacity to identify or manage (possible work accidents) that may arise. The outcomes of these three variables represent the mean of the subjective evaluations provided by a group of 6 participants. The RPN calculation findings for the Hilton Hotel Construction project in Kota Baru Parahyangan - West Bandung may be seen in Tables 5. The maximum RPN value was recorded at 26.3 when workers experienced falls from elevated positions while performing glass installation tasks.

Table 5. RPN value

No	Task	Potential work accident-inducing events	Code	S	O	D	RPN
1	Preliminary Tasks	Hand injured when installing bauwplank	X1	2,3	2,0	1,7	7,8
2	Excavation Work	Landslides/collapse of side walls	X2	2,8	2,2	2,0	12,3
		Workers/vehicles fall into excavation holes	X3	1,7	1,8	2,2	6,6
3	Backfill Work	The backfill substance causes eye contact and obstructs the respiratory function of workers.	X4	2,3	2,7	2,2	13,5
		The compactor vibrator hit the worker's leg	X5	2,3	1,8	2,2	9,3
4	Pilecap Work	Worker falls in excavation site	X6	2,8	2,5	1,8	13,0
		Wall damage hitting workers	X7	2,5	2,2	2,0	10,8
5	Beam Work	Formwork boards and iron fell on workers	X8	2,8	2,8	3,0	24,1
		Worker fell from a height while installing beam formwork	X9	3,8	2,5	2,3	22,4
6	Sloof Work	Rebar hits workers	X10	2,2	2,5	2,7	14,4
		Wire bends injure workers' hands	X11	1,3	2,2	1,8	5,3
7	Column Work	Formwork and iron fell on workers	X12	3,0	2,0	2,3	14,0
		Worker falls from height	X13	3,7	2,2	2,5	19,9
		A worker's hand is hit by a hammer when installing column formwork	X14	2,3	2,0	1,8	8,6
8	Floor Plate Work	Worker's hand injured during formwork assembly	X15	1,7	2,0	2,2	7,2

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No	Task	Potential work accident-inducing events	Code	S	O	D	RPN
		The worker's eye was struck by particles of wood dust	X16	1,5	2,7	2,7	10,7
9	Ground Water Tank Work	Worker descends into excavation	X17	2,2	2,7	2,5	14,4
		Hands are injured due to assembling iron and installing formwork	X18	1,5	1,7	2,0	5,0
10	Sewage Pit Work	The leg was struck by a hoe while excavating	X19	1,8	1,8	1,8	6,2
		Punctured by an iron/sharp object	X20	2,2	2,5	3,2	17,2
11	Generator Work	Workers suffer from respiratory issues as a result of engine exhaust emissions	X21	1,7	1,8	1,5	4,6
		An explosion occurred in the generator, resulting in a fire	X22	2,3	1,5	2,2	7,6
12	Ladder Work	Workers fall/hit by formwork	X23	2,8	2,3	2,3	15,4
		Hand injured while assembling reinforcement	X24	2,5	2,2	2,2	11,7
		Struck with droplets of molten metal	X25	1,5	2,7	1,8	7,3
13	Welding Work	Workers exposed to welding fire	X26	2,2	2,3	2,5	12,6
		Inhalation of welding fumes	X27	1,5	3,0	1,8	8,3
14	Roofing Work	Workers fall from heights	X28	3,3	2,5	2,3	19,4
15	Glass Installation Work	Workers fall from heights	X29	3,5	2,5	3,0	26,3
		Workers were hit by broken glass	X30	2,0	2,0	1,8	7,3
16	Electrical / Mechanical Electrical Installation Work	The worker was electrocuted	X31	2,7	2,2	2,0	11,6
		Sparks cause fires	X32	3,2	2,3	2,3	17,2
		Workers fall from scaffolding	X33	3,0	2,0	2,5	15,0
17	Ceramic Installation Work	Exposure to ceramic shards (into skin/eyes)	X34	1,8	2,2	2,3	9,3
		Inhalation of ceramic dust	X35	1,5	3,2	1,8	8,7
		Hand exposed to ceramic cutting machine	X36	2,3	1,8	1,5	6,4
		The worker was electrocuted	X37	2,2	2,3	3,0	15,2
		Noise when pushing ceramics (hearing loss)	X38	1,8	3,0	2,2	11,9
18	Door and Window Installation Work	Contact with sharp materials, such as hinge edges and broken glass	X39	2,5	2,0	2,7	13,3
19	Painting Work	Workers fall from heights	X40	3,0	2,0	2,5	15,0
		Eyes covered in paint	X41	1,7	1,3	1,7	3,7
		Workers' health is affected by inhaling chemicals in paint	X42	1,8	2,0	1,7	6,1
20	Iron Cutting	Hand exposed to cutting machine	X43	2,8	2,5	2,7	18,9

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No	Task	Potential work accident-inducing events	Code	S	O	D	RPN
	Work	Iron hurts hands	X44	2,5	2,7	1,8	12,2
21	Plumbing Work	Workers fall from scaffolding	X45	3,2	2,3	2,5	18,5
		Injured while installing pipe	X46	1,5	1,8	3,0	8,3
22	Aluminum Composite Panel Ornament Work	The worker's hand was trapped/injured while drilling	X47	2,3	2,0	2,8	13,2
		Workers fall from heights	X48	3,2	1,7	2,2	11,4
23	Scaffolding Installation Work	Scaffolding collapses/collapses (falling on workers)	X49	2,7	2,2	2,3	13,5
		Workers fall from heights	X50	2,8	2,3	2,5	16,5
		Head hit the scaffolding	X51	2,5	2,5	2,7	16,7
		Hands are pinched, punctured and scratched	X52	2,2	2,5	2,3	12,6
24	Hebel Installation Work	Workers fall from heights	X53	2,8	2,0	1,8	10,4
		Hebel fell (hitting a worker)	X54	2,7	2,3	1,8	11,4
25	Wall Installation Work	Workers fall from heights	X55	3,2	1,8	2,7	15,5
		Work equipment fell onto workers below	X56	3,0	2,2	2,5	16,3
		Inhalation of cement dust (respiratory problems)	X57	1,7	3,0	1,7	8,3
		The leg was hit by a falling brick during mobilization	X58	2,3	2,3	1,8	10,0
26	Tower Crane Work	Being hit by equipment from a height	X59	2,8	1,8	2,8	14,7
		Sling broke	X60	3,2	2,2	3,2	21,7

The method involved in working on FTA entails performing a thorough examination of the literature to identify the underlying sources of risks, as well as the intermediate events associated with those risks. Subsequently, interviews are conducted with stakeholders. Interviews are done to assess the appropriateness of risk causes and to determine the relationship between the collected risk causes. Once the interview findings are obtained, a failure tree analysis (FTA) diagram is generated, as depicted in Figure 1. Once the diagram is completed, the Method for Obtaining Cut Set (MOCUS) is used to examine a combination of risk sources or fundamental events. Fault tree analysis yields a compilation of causes or basic events that enable the occurrence of a risk. Table 6 displays the fundamental combinations of events for diagrams generated using MOCUS.

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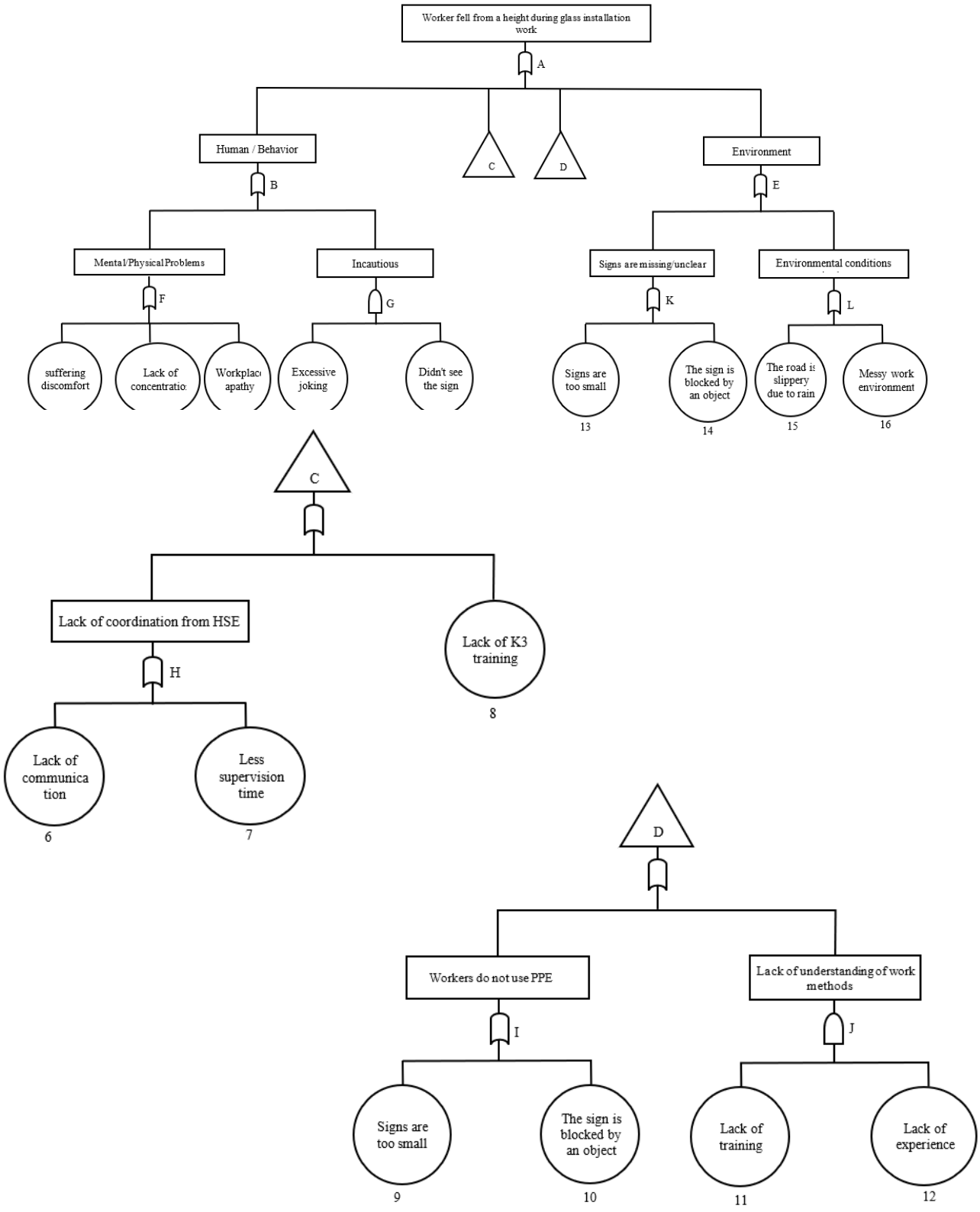

Figure 1. FTA Diagram of a Worker Falling from a Height During Glass Installation Work

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Table 6. RPN value

No	Code	Minimal *Cut Set* (MOCUS)
1	1	experiencing poor health
2	2	Lack of concentration
3	3	Lack of enthusiasm for work
4	4, 5	Excessive joking, Not seeing signs
5	6	Lack of communication
6	7	Less supervision time
7	8	Lack of K3 training
8	9	Workers are less comfortable using PPE
9	10	Limited amount of PPE
10	11, 12	Lack of training, Lack of experience
11	13	Signs are too small
12	14	The sign is blocked by an object
13	15	The road is slippery due to rain
14	16	Messy work environment

The procedure for interpreting the Method for Obtain Cut Set (MOCUS) table for Workers Falling From The height during glass installation operation is as outlined below: The cause of the accident was a worker falling from a height while working on glass installation. The worker may have been feeling unwell, lacking concentration, or lacking enthusiasm for work. There may have been a lack of communication, supervision, or training for the worker. Additionally, the worker may have been uncomfortable using personal protective equipment (PPE) or had limited training and experience with PPE. The presence of small or blocked signs, slippery objects or roads due to rain, and a limited work environment could have also contributed to the accident. The FTA analysis revealed that glass installation activity has resulted in 16 basic events related to the risk of worker accidents from falling from a height. Additionally, the analysis using MOCUS has identified 14 combinations of these basic events.

Subsequently, a final expert validation was conducted by an individual with over a decade of experience in the field. The purpose was to obtain an explanation regarding the measures taken to address the most significant prevailing risks in each factor. These measures include conducting safety briefings prior to commencing work, organizing K3 training within the project setting, ensuring the provision of comprehensive personal protective equipment (PPE), coordinating with HSE personnel, and installing warning signs and safety barriers in the designated work area.

CONCLUSION

The author can make conclusions based on the results of the risk analysis of work accidents on the Hilton Hotel Construction Project in Kota Baru Parahyangan - West Bandung, in accordance with the problem formulation:

1. Out of the total 64 indications of work accident risk, a total of 60 indicators were obtained specifically for the Hilton Hotel Construction Project in Kota Baru Parahyangan - West Bandung. These indicators were evaluated by specialists using questionnaires.
2. The data processing results obtained from FMEA indicate that the primary risk associated with work accidents is the risk of workers falling from a height during glass installation work, with a Risk Priority Number (RPN) value of 26.3.
3. The results of data processing with FTA on the causes of worker accidents falling from heights during glass installation work resulted in 16 basic events. The basic events are feeling unwell, lack of concentration, lack of enthusiasm for work, excessive joking, not seeing signs, lack of communication, lack of supervision time, lack of K3 training, workers not comfortable using PPE, limited amount of PPE, lack of training, lack of experience, signs are too small, signs are blocked by objects, roads are slippery due to rain, and the work environment is limited.
4. The response to the most dominant risk of work accidents in the Hilton Hotel Development Project in Kota Baru Parahyangan - West Bandung is conducting safety talks before work, holding K3 training in the project environment, providing complete PPE, having to coordinate with HSE staff, and installing clear warning signs and safety lines in the work area.

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