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Occupational Health and Safety Risk Analysis in High-Rise Urban Building Construction Projects

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ABSTRACT

Occupational Safety and Health (OHS) is a crucial aspect in the implementation of construction projects, especially in the construction of high-rise buildings in urban areas that have a high level of complexity and risk. Unmanaged OHS risks can cause work accidents, project delays, and significant financial losses. This study aims to create solution steps by analyzing OHS risks and knowing the factors that cause an increase in OHS risks in buildings at the Ministry of Finance State Flats, Jl. Kemanggisan, Palmerah District, West Jakarta, Jakarta. The research method used is a qualitative and quantitative approach with data collection techniques through questionnaire surveys, interviews with related parties (contractors, supervisors, and workers), and field observations. Risk analysis was carried out using the HIRARC (Hazard Identification, Risk Assessment and Risk Control) method, which categorizes risk levels based on probability and impact. The identification results show that each sector faces varying OHS risks, ranging from moderate, high to extreme categories, especially in work at heights, use of heavy equipment, exposure to chemicals, and electrical risks. These findings emphasize the importance of implementing a structured OSH system, including mitigation planning, routine supervision, safety training, and work area management. An effective OSH strategy is expected to improve workplace safety, reduce accidents, and support the smooth running and overall success of the project.

Keywords: Occupational Safety and Health (OSH), construction risk management, HIRARC, Urban High-Rise Building, State-Owned Apartment Project.

INTRODUCTION

Occupational Safety and Health (K3) currently occupies a strategic position in the industrial world, particularly in the construction sector. Construction work carries high risks that can threaten worker safety, so that worker protection is a primary requirement for companies in creating a safe and comfortable work environment. The implementation of K3 not only aims to ensure the safety of project workers, but also increases workforce productivity as mandated by Law No. 1 of 1970 and Law No. 13 of 2003 concerning Manpower, which require employers to protect workers from potential hazards in the workplace and create safe, healthy working conditions, and free from accidents and occupational diseases [1]. However, the implementation of K3 in the field is still not optimal, so the expected results have not been achieved [2]. Based on BPJS Ketenagakerjaan data throughout 2024, 462,241 cases of work accidents were recorded in Indonesia, indicating a high risk in the employment sector [3]. K3 is closely related to production activities, both in the service and industrial sectors. Along with the increase in development after Indonesia's independence, work intensity has also increased, which directly increases the potential for accidents in the workplace [5]. Workplace accidents not only cause material and moral losses, as well as death, but also impact productivity, public welfare, and environmental pollution [6]. This phenomenon indicates a gap between OHS regulations and implementation in the field, especially in high-scale construction projects. To reduce or eliminate these risks, effective OHS risk management is required. Risk management activities can minimize accident rates, prevent project losses, and ensure systematic risk control. The implementation of an Occupational Safety and Health Management System (SMK3) in construction projects ensures that operational activities meet applicable legal and policy requirements, and supports the achievement of zero workplace accidents and zero losses [7].

Occupational safety covers all aspects related to the use of machines, tools, materials, production processes, as well as the workplace environment and work methods used [8]. Based on the description above, this study aims to analyze OHS risks in urban high-rise construction projects, with a case study of the Ministry of Finance's State-Owned Apartments in West Jakarta. The approach used is the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method, which not only identifies potential hazards but also assesses risks and establishes control strategies. The HIRARC method was chosen because it is systematic, easy to understand, supports training documentation, and facilitates internal company audits.

The problem formulation is: 1) What are the potential hazards in the Ministry of Finance's State-Owned Apartments construction project in West Jakarta? 2) What is the level of OHS risk in the Ministry of Finance's State-Owned Apartments construction project in West Jakarta? 3) What are the best recommendations for implementing OHS in the construction of high-rise building projects?

RESEARCH METHODS

This research uses a quantitative descriptive approach with a case study method, aiming to systematically describe and analyze Occupational Safety and Health (OHS) risks in high-rise construction projects. Data were collected through questionnaires and field observations, then analyzed numerically to assess the level of likelihood, impact, and priority of risks. The sampling technique used was probability sampling, a method that ensures every member of the population has an equal opportunity to be selected as a sample [9]. The research focused on a specific high-rise construction project as a representation of real conditions in the field. The approach applied follows risk management, consisting of three main stages: first, hazard identification to reveal potential risks that may occur during project implementation; second, risk assessment using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method with the main parameters being the likelihood of risks occurring and the level of impact on occupational safety and health; and third, risk evaluation and control, which determines the priority of risk handling and provides recommendations for appropriate mitigation strategies, including elimination, substitution, engineering, administration, and the use of personal protective equipment (PPE). Data collection in this study was conducted through literature studies, field observations, interviews, and questionnaires to obtain comprehensive information regarding the role of construction management consultants in the Ministry of Finance's State-Owned Apartments Development project in West Jakarta. The literature study was used to obtain theoretical foundations, concepts, and previous research findings related to OHS risks and the HIRARC method. Primary data was obtained directly from project management and workers through observations of environmental conditions and the use of personal protective equipment, semi-structured interviews with stakeholders, and self-completed questionnaires using a 1–5 Likert scale to assess hazard types, likelihood levels, risk impacts, and implemented mitigation measures. After the identification process was completed, the next stage was conducting a risk assessment using questionnaires distributed directly at the project site. This assessment is divided into two main approaches: risk analysis and evaluation. The purpose of this stage is to determine the level of risk by considering the likelihood of an incident occurring and the impact if an accident occurs. The assessment follows the likelihood and consequence standards [10]. This approach ensures that the collected data is valid, relevant, and can be used to systematically analyze OHS risks. The Likert scale is shown in Table 1.

Table 1. Likert Scale

No	Statement	Definition	Score
1.	Very Often (SS)	a. The probability of a workplace incident is high b. The probability of an accident occurring more than twice a year	5
2.	Often (S)	a. Accidents can occur at work in almost any condition b. The probability of having an accident once in the past year	4
3.	Maybe (M)	a. In some circumstances, an accident can occur during work	3

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No	Statement	Definition	Score
		b. The probability of an accident occurring twice in the past three years	
4.	Rarely (J)	a. In some circumstances, an accident at work is unlikely	2
		b. The probability of having an accident once in the past three years	
5.	Very Rarely (SJ)	a. In some circumstances, an incident can occur at work	1
		b. The probability of an accident occurring more than once in the past three years	

(Source: Minister of Public Works and Public Housing Regulation Number 10 of 2021)

Likelihood values are determined based on the AS/NZS 4360 standard, as shown in Table 2.

Table 2. Likelihood Scale in the AS/NZS 4360 Standard

Level	Description	Remarks
5	Almost Certain	Very Frequent
4	Likely	Frequently Occurs
3	Possible	Possibly Occurs
2	Unlikely	Rarely Occurs
1	Rare	Very Rarely Occurs

(Source: AS/NZS 4360:2004)

The following is a table of severity scales in the AS/NZS 4360 standard, shown in Table 3.

Table 3. Severity scale table in the AS/NZS 4360 standard

Level	Description	Remarks
1	Insignificant	There are no injuries, but the financial loss is very small.
2	Minor	There are minor injuries, where the financial loss is small.
3	Moderat	There are injuries requiring medical treatment and moderate financial loss.
4	Major	There are serious injuries requiring hospitalization and significant financial loss.
5	Catastrophic(extreme)	There are deaths and significant financial loss.

(source: AS/NZS 4360:2004)

The risk assessment, which has been carried out based on the criteria in Tables 2 and 3, is followed by the process of determining the risk level. This determination is made by comparing the probability of occurrence and the level of impact or severity. Complete information regarding the risk level scale can be seen in Table 4 below.

Table 4. Risk Level Scale

Severity		1	2	3	4	5
Occurance	**5**	M (5)	H (10)	H (15)	E (20)	E (25)
	4	L (4)	M (8)	H (12)	E (16)	E (20)
	3	L (3)	M (6)	M (9)	H (12)	H (15)
	2	L (2)	L (4)	M (6)	M (8)	H (10)
	1	L (1)	L (2)	L (3)	L (4)	M (5)

(Source: AS/NZS 4360:2004)

Risk Level is used to calculate the score and risk level of potential hazards. Colors are used to differentiate risk levels:

c. Green indicates low risk = 1-4

d. Yellow indicates moderate risk = 5-9

e. Orange indicates high risk = 10-15

f. Red indicates extreme risk = 16-25

Validity Test

Content validity tests aim to assess the suitability of items to the material being measured, while construct validity tests are used to assess the clarity and logic of the conceptual framework in the study [11]. In this testing process, the Pearson coefficient value is used, where decisions are made based on a comparison between the calculated r value and the tabulated r value. Validation itself is a measurement process to determine the extent to which an instrument can be considered precise and accurate in measuring a variable [12]. The r value of the table used in the validity test

Reliability Test

The reliability test in this study was conducted to assess the reliability of the questionnaire as a data collection instrument, specifically in the context of identifying and assessing OHS risks in vertical construction projects. Reliability indicates the extent to which the instrument is able to produce stable and consistent answers when used under conditions that do not differ significantly. Reliability was measured using the Cronbach's Alpha (α) approach and analyzed using the SPSS statistical application. The obtained coefficient values can be seen in Table 5.

Table 5. Cronbach's Alpha Values

Cronbach's Alpha Value	Reliability Category
> 0,90	Very High
0,80 – 0,90	High
0,70 – 0,79	Fair
0,60 – 0,69	Low
< 0,60	Unreliable

The research flowchart is shown in Figure 1 below.

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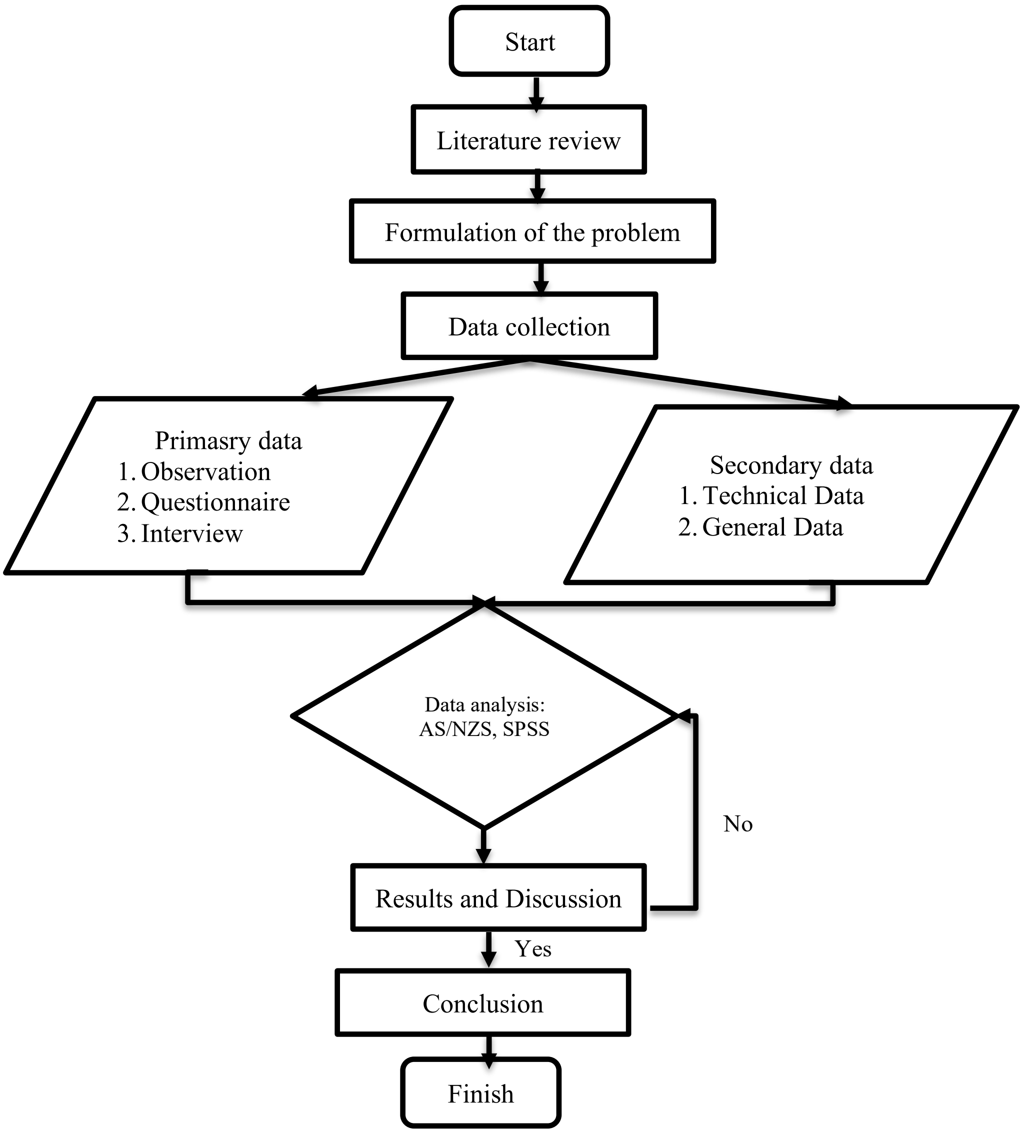

Figure 1. Flowchart

RESULTS AND DISCUSSION

This study, which analyzes Occupational Safety and Health (OHS) risks in high-rise construction projects in urban areas, focused on the Ministry of Finance's State-Owned Housing project on Jalan Kemanggisan, West Jakarta, involved a sample of 200 construction workers. Using the Slovin formula with a 10% margin of error, a sample of 67 respondents was selected. The characteristics studied included age, highest level of education, length of work experience in construction projects, job title, and gender. Understanding this data is crucial in describing the respondents' backgrounds, which may influence their perceptions of the OHS risks in the project.

a. Respondent Age

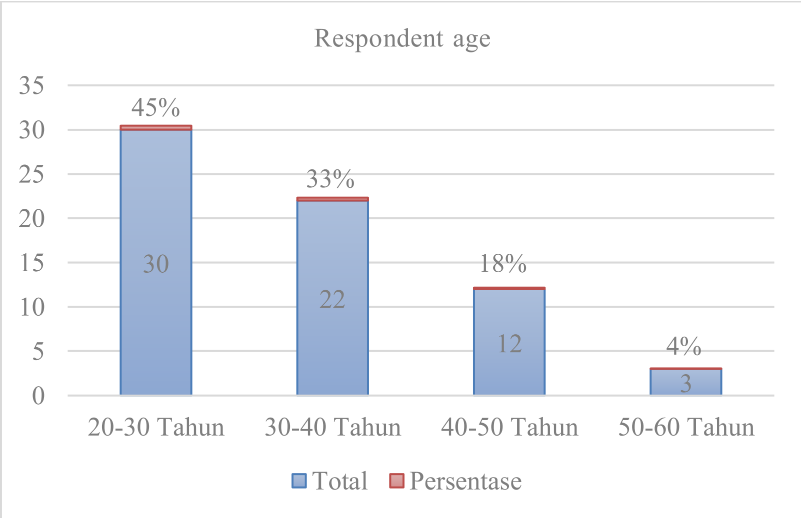

Figure 2. Respondent Age

Figure 2. The age distribution of respondents shows that the majority are of productive age. Of the 67 respondents, 45% were aged 20–30, 33% were aged 30–40, 18% were aged 40–50, and 4% were aged 50–60. The young to middle-aged group dominates the workforce, demonstrating high work potential and sufficient experience, while also providing opportunities for competency development in the application of OHS principles.

a. Gender

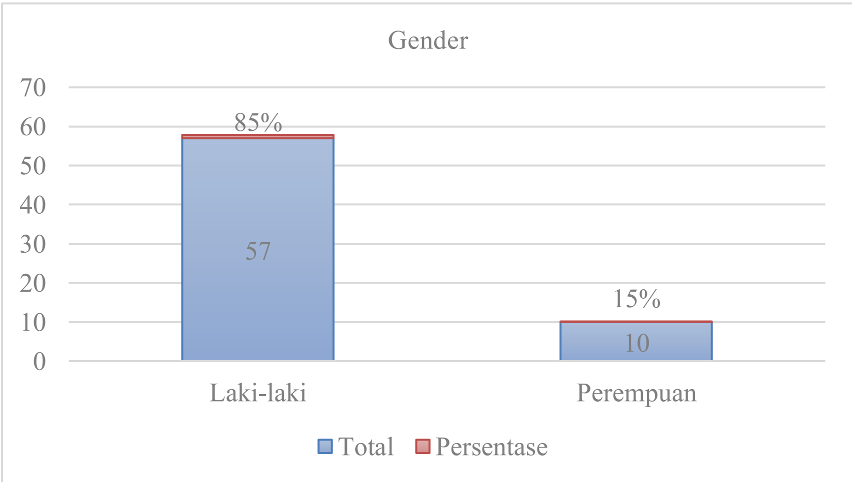

Figure 3. Gender

Figure 3. Data shows that of the 67 respondents, 85% were male and 15% were female, indicating a male workforce dominance in the Ministry of Finance's State-Owned Apartments development project.

b. Last Education

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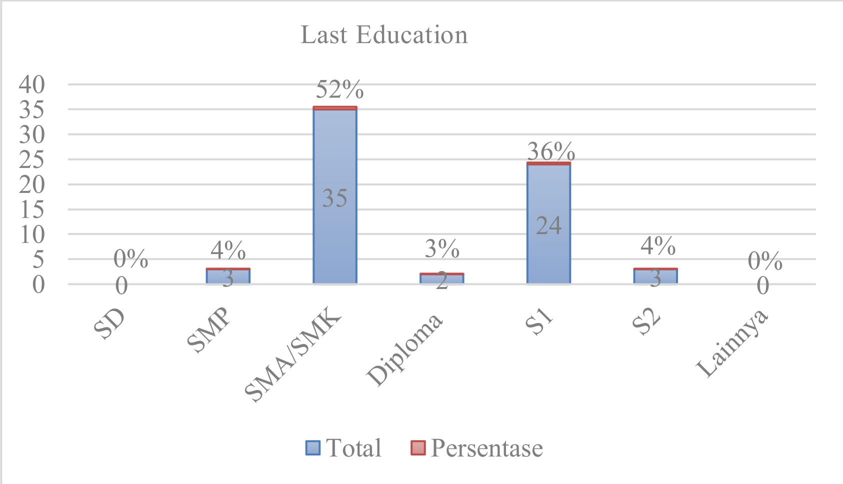

Figure 4. Last Education

Figure 4. The majority of respondents had a high school education background, with 52% high school/vocational school graduates and 36% bachelor's degree graduates, indicating a predominance of technical and supervisory workers. Diploma (3%) and master's (4%) graduates played a role in the managerial and strategic aspects of OHS, while 4% of junior high school graduates also contributed. This relatively high level of education supports the understanding and implementation of occupational safety procedures on projects.

d. Length of service on construction projects

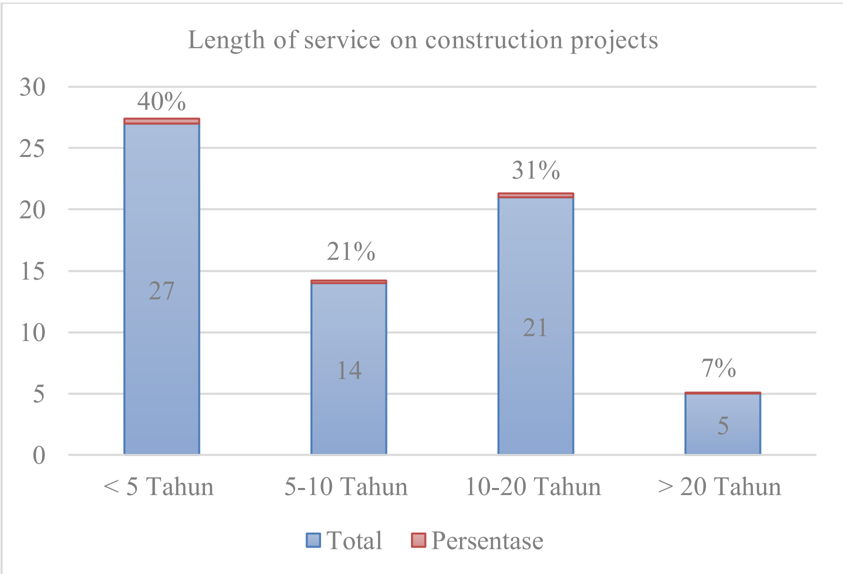

Figure 7. Length of Service on Construction Projects

Based on Figure 5, work experience, the majority of respondents (40%) have less than 5 years of service, including new workers still adjusting to technical procedures and OHS. Those with 5–10 years of experience account for 21%, while 31% have worked for 10–20 years, demonstrating significant experience. The remaining 7% have more than 20 years of experience and serve as role models in implementing occupational safety.

Identification of OHS hazards in the stages of the Ministry of Finance's Apartment Building project

a. Substructure

The main risks relate to the movement of heavy equipment, operational vehicles, broken slings, pile debris, excavator buckets, exhaust fumes, injuries from metal installations, cuts, concrete splashes, as well as the potential for short circuits and oxygen deprivation. Safe zone management, equipment inspections, training, and PPE are crucial for mitigation.

b. Superstructure

High risks arise from working at heights, operating heavy equipment, and installing materials. Potential injuries include being struck by falling materials, falling from unstable surfaces, injuries caused by substandard scaffolding, and the risk of worker fatigue or dehydration.

c. Architecture

Potential hazards arise in the installation of ceramic tiles, painting, sanitary ware, ceilings, interiors, and door/window frames. Risks include hand injuries, skin irritation, respiratory problems, being struck by falling materials, and accidents caused by sharp tools or welding processes.

d. MEP (Mechanical, Electrical, Plumbing)

High risks arise in the installation of air conditioning systems, fire protection systems, piping networks, electrical systems, elevators, and gondolas. Potential accidents include falls, being struck by falling objects, being trapped, electrocuted, refrigerant explosions, and respiratory problems due to dust. Confined space, poor ventilation, and the use of inadequate tools increase the risk.

Validity Test

Table 6. Validity Test Results

Indicator	Rvalue	Rtable	Description
Substructure Work 1	0,509	0,236	Valid
Substructure Work 2	0,663	0,236	Valid
Substructure Work 3	0,790	0,236	Valid
Substructure Work 4	0,499	0,236	Valid
Substructure Work 5	0,504	0,236	Valid
Substructure Work 6	0,449	0,236	Valid
Superstructure Work 1	0,562	0,236	Valid
Support Structure Work 2	0,576	0,236	Valid
Support Structure Work 3	0,606	0,236	Valid
Support Structure Work 4	0,766	0,236	Valid
Support Structure Work 5	0,835	0,236	Valid
Support Structure Work 6	0,893	0,236	Valid
Architectural Work 1	0,833	0,236	Valid
Architectural Work 2	0,821	0,236	Valid
Architectural Work 3	0,905	0,236	Valid
Architectural Work 4	0,681	0,236	Valid
Architectural Work 5	0,737	0,236	Valid
Architectural Work 6	0,770	0,236	Valid
MEP Work 1	0,845	0,236	Valid
MEP Work 2	0,819	0,236	Valid
MEP Work 3	0,636	0,236	Valid
MEP Work 4	0,619	0,236	Valid
MEP Work 5	0,758	0,236	Valid
MEP Work 6	0,397	0,236	Valid
Potential Hazard Risk 1	0,689	0,236	Valid
Potential Hazard Risk 2	0,810	0,236	Valid
Potential Hazard Risk 3	0,726	0,236	Valid

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Indicator	Rvalue	Rtable	Description
Potential Hazard Risk 4	0,775	0,236	Valid

Based on the validity test results in Table 6, administered to 67 respondents from the Ministry of Finance's State-Owned Apartments project, all items demonstrated correlation values above the r-table of 0.236 at a 5% significance level. This demonstrates that all questions are valid and accurately describe the research variables, making them a reliable instrument for analyzing OHS risks in high-rise construction projects.

Reliability Test

Table 7. Reliability Test Results

Reliability Statistics	
Cronbach's Alpha	N of Items
0,961	28

Table 7 shows that the reliability test using Cronbach's Alpha yielded a value of 0.961. This figure significantly exceeds the minimum standard of 0.70, indicating that all questions in the questionnaire exhibit very strong consistency. Therefore, this instrument is considered highly reliable for use in the data collection process.

Percentage of Risk Level

Percentage of Risk Level in the implementation phase of the Ministry of Finance's State-Owned Apartments Construction project. Based on the results of hazard identification and risk assessment conducted using the HIRARC method with AS/NZS 4360:2004 standards, the percentage (%) of risk level results is shown in Table 8.

Table 8. Percentage of Risk Level

No.	Job Stage	Percentage of *Risk Level*			
		Low	Medium	High	Extreme
1.	Substructure Work Stage	0,00 %	46,43 %	42,86 %	10,71 %
2.	Superstructure Work Stage	0,00 %	50,00 %	45,83 %	4,17 %
3.	Architectural Structure Work Stage	0,00 %	80,00 %	20,00 %	0,00 %
4	MEP Structure Work Stage	0,00 %	57,58 %	36,37 %	6,05 %

The percentage graph of risk levels is shown in Figure 8.

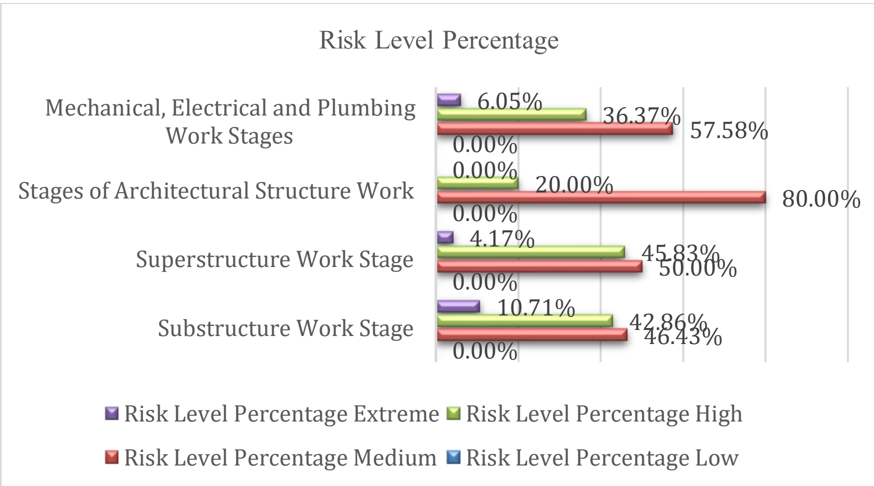

Figure 8. Risk Level Percentage Graph

The project's risk assessment was conducted according to AS/NZS 4360:2004, which categorizes risks into low, moderate, high, and extreme. The substructure stage had no low risk, with moderate and high risks accounting for 46.43% and extreme risks at 7.14%, respectively. The superstructure stage recorded moderate risks at 50.00%, high risks at 45.83%, and extreme risks at 4.17%. Architectural work was dominated by moderate (80%) and high risks (20%), while MEP had moderate risks at 57.58%, high risks at 36.37%, and extreme risks at 6.05%. These data indicate that most construction work carries moderate to high risks, emphasizing the need for proactive and ongoing risk management.

CONCLUSION

The conclusions of this study indicate that each construction stage has different potential hazards. Both substructure and superstructure work face high risks related to working at heights, the use of scaffolding, and the potential for falling objects. Architectural work poses risks of chemicals, dust, and accidents during finishing, while MEP work is prone to electric shock, fire, and confined space risks. Risk level analysis revealed that the majority of construction activities fall into the moderate to high category, with MEP work predominantly high risk at 57.58% and architecture predominantly medium risk at 80%. The lower and upper structures are relatively balanced between medium and high risks. These findings emphasize the need for strict risk management, consistent OHS supervision, and increased worker awareness and competence. Recommended risk control strategies include strengthening the OHS management system through top management commitment, improving workforce competence, providing protective facilities such as safety nets, safety decks, guard railings, fall arresters, and area barriers, and establishing a participatory safety culture. Periodic evaluation and continuous improvement are also needed to ensure the effectiveness of risk control throughout the construction project.

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