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Hazard Identification, Risk, And Control Analysis Using the HIRADC Method For Material Lifting Activities at PT Repapesi Great River Bekasi

Rendi Sunandi[1], Handito Susmono[2], Tatan Sukwika[3*]

[1,2]Study Program of Master of Management, Sahid University, Central Jakarta, Indonesia
[2]Study Program of Environmental Engineering, Sahid University, South Jakarta, Indonesia

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** Corresponding author.*

E-mail addresses:
tatan.swk@gmail.com
(T. Sukwika).

ABSTRACT

Material lifting activities in the construction industry are considered high-risk operations due to the interaction of heavy equipment, dynamic work environments, and human factors. This study aims to analyze hazard identification, risk assessment, and control strategies in material lifting activities using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method. A qualitative approach was applied through field observations, in-depth interviews, and document analysis at PT Repapesi Great River, focusing on three work stages: material slinging, lifting, and placement. The results identified 15 hazards and 15 occupational risks, consisting of one extreme risk, four high risks, and ten medium risks, with no low-risk category. The lifting stage was found to be the most critical, containing the only extreme risk, primarily caused by unsafe worker behavior, particularly passing under suspended loads. Risks during the slinging and placement stages were primarily driven by procedural weaknesses, equipment condition, and environmental factors. The findings indicate that human factors play a dominant role in the occurrence of risk. The HIRADC method proved effective in systematically identifying hazards and prioritizing control measures. This study highlights the importance of strengthening safety culture, improving equipment inspection, and enforcing safety procedures to reduce workplace accidents

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1. INTRODUCTION

Occupational Safety and Health (OSH) is a critical component of the construction industry due to the inherently high level of risk associated with work activities involving heavy equipment, hazardous materials, and dynamic, often unpredictable work environments (Meidianto, 2025). Construction activities frequently require workers to operate under physically demanding conditions, interact with complex machinery, and perform tasks at height or in confined spaces, all of which increase the likelihood of occupational accidents and injuries. Therefore, the implementation of OSH is not merely a regulatory obligation but a strategic necessity to ensure worker protection, minimize operational disruptions, and sustain organizational performance. Effective OSH practices contribute not only to reducing accident rates but also to enhancing productivity, improving employee morale, and strengthening organizational resilience (Purwanto et al., 2023; Ginza & Sukwika, 2024).

In the Indonesian context, the urgency of strengthening OSH implementation is evident from the increasing trend of workplace accidents. According to data from BPJS Ketenagakerjaan, the number of occupational accidents reached 265,334 cases in 2022, reflecting a consistent rise compared to previous years (Pratiwi, 2023). This upward trend indicates that existing safety measures may not yet be fully effective or consistently implemented across industries, particularly in high-risk sectors such as construction. The persistence of workplace accidents suggests gaps in hazard identification, risk assessment, and control implementation, thereby emphasizing the need for more systematic, structured, and proactive approaches to occupational risk management.

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One of the most critical high-risk activities in construction projects is material lifting operations. These activities involve the use of cranes, hoists, and various lifting accessories to move heavy materials, equipment, or structural components from one location to another. Material lifting is categorized as a high-risk operation due to multiple hazard sources, including falling loads, equipment malfunctions, human error, and environmental factors such as wind speed and ground conditions (Putro, 2022). The interaction between these factors creates a complex risk environment in which a single failure can lead to severe consequences, including fatal injuries, equipment damage, and project delays. Recent studies have shown that lifting operations remain among the most critical construction activities due to the interaction of human, technical, and environmental factors, requiring integrated risk assessment approaches and systematic control measures (Yan et al., 2024; Aulia et al., 2025).

Previous studies have consistently highlighted that lifting and rigging activities are among the leading contributors to serious workplace accidents in the construction sector. Common causes of such incidents include improper sling selection and installation, failure to inspect lifting equipment, nonadherence to standard operating procedures, and unsafe worker behavior (Hutari, 2022). In addition, inadequate communication between crane operators and riggers, as well as insufficient supervision, further exacerbates the likelihood of accidents. Juniarto (2025) also emphasizes that exposure to suspended loads and unsafe positioning of workers remain critical hazards that often result in severe injuries or fatalities. These findings underline the multifactorial nature of risks in lifting operations, where technical, human, and environmental factors interact simultaneously.

To address these complex risks, a structured and systematic approach is required. One widely adopted method in occupational safety management is the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method. HIRADC provides a comprehensive framework for identifying potential hazards, evaluating the likelihood and severity of associated risks, and determining appropriate control measures based on risk prioritization (Kabul, 2021). This method allows organizations to move beyond reactive safety practices and adopt a proactive risk management approach that focuses on prevention and continuous improvement.

The effectiveness of the HIRADC method has been demonstrated in various studies, particularly in high-risk industrial and construction environments. For instance, Mukti et al. (2024) found that HIRADC is effective in identifying critical hazards in crane operations, including load instability, equipment failure, and environmental risks. Similarly, Ananda et al. (2025) reported that HIRADC helps systematically identify unsafe work practices, such as improper use of personal protective equipment (PPE) and noncompliance with safety procedures, which are often overlooked in routine operations. These studies confirm that HIRADC is not only a diagnostic tool but also a decision-support system that facilitates the implementation of targeted and effective risk control measures.

Despite the availability of such methods and the implementation of safety programs, including standard operating procedures (SOPs), PPE provision, and safety training, many organizations still face challenges in achieving optimal safety performance. This is also evident in PT Repapesi Great River, a company engaged in construction and installation projects involving material lifting activities. Preliminary observations indicate that hazards persist across various stages of lifting operations, suggesting that existing safety measures may not fully address the complexity of risks involved. In particular, recurring hazards have been identified in three main stages of material lifting activities: slinging, lifting, and placement.

The slinging stage involves attaching lifting equipment to the material, which requires precision, proper technique, and effective communication. Errors at this stage, such as improper sling configuration or failure to inspect equipment, can compromise load stability and increase the risk of accidents. The lifting stage, which involves the actual movement of the load using cranes, is considered the most critical phase due to the potential for catastrophic failures, such as load سقوط, crane collapse, or workers being struck by moving materials. Meanwhile, the placement stage involves positioning the material at the designated location and presents risks related to worker positioning, environmental conditions, and equipment limitations.

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Although these hazards are consistent with those identified in previous studies, context-specific analysis is needed to understand how these risks manifest in real-world work environments and to determine their relative severity. Each project may have unique characteristics, including site conditions, equipment types, and workforce competencies, which influence the nature and magnitude of risks. Therefore, a detailed and systematic analysis using the HIRADC method is necessary to identify dominant hazards, assess their risk levels, and develop appropriate control strategies tailored to the organization's specific context.

Based on these considerations, this study aims to analyze hazard identification, risk assessment, and control strategies in material lifting activities at PT Repapesi Great River using the HIRADC method. The study focuses on three main stages of lifting operations—slinging, lifting, and placement—to identify dominant hazards and evaluate their risk levels based on likelihood and severity. By doing so, the study seeks to provide a comprehensive understanding of the distribution of risk across different stages of work and to identify critical points that require immediate attention.

Furthermore, this study is expected to contribute to the development of more effective and targeted safety interventions by providing empirical evidence on the application of HIRADC in real-world construction settings. The findings are also anticipated to support decision-making processes in occupational safety management, particularly in prioritizing risk control measures and improving existing safety practices. In a broader context, this study contributes to the growing body of knowledge on occupational risk management in the construction industry and highlights the importance of integrating systematic risk assessment methods into daily operational practices.

2. RESEARCH METHOD

2.1. Type and Research Design

This study employs a qualitative, descriptive research design to analyze hazard identification, risk assessment, and control strategies in material lifting activities. This approach is considered appropriate due to the complex, dynamic, and context-specific nature of occupational safety risks in construction environments, particularly in high-risk lifting operations (Mukti et al., 2024).

The qualitative design enables an in-depth exploration of hazards arising from interactions among workers, equipment, work processes, and environmental conditions, aligning with the risk characteristics described in the introduction (Hutari, 2022). Data were collected through direct field observations, in-depth interviews, and document analysis to ensure comprehensive identification of hazards and risks in lifting material activities.

The study adopts the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method as the main analytical framework. This method was selected because it provides a systematic and structured approach to identifying hazards, evaluating risk levels based on likelihood and severity, and determining appropriate control measures (Kabul, 2021). Furthermore, HIRADC is widely recognized as an effective tool in construction safety management, particularly for high-risk activities such as crane operations and lifting processes (Ananda et al., 2025).

By applying this method, the study aims to develop a detailed understanding of the distribution of risk across different stages of lifting activities and to support the development of targeted and effective safety interventions (Juniarto, 2025).

2.2. Research Object

The object of this study is the potential hazards and occupational safety risks identified in the stages of material lifting activities using the HIRADC method. The analysis focuses on three main stages of lifting operations: material slinging, material lifting, and material placement, which are recognized as critical phases with high accident potential in construction projects (Putro, 2022; Gultom et al., 2025).

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The subjects of this research include workers directly involved in lifting operations at the SBNP (Navigational Aids Facilities) installation project at PT Repapesi Great River. To obtain in-depth and reliable data, three key informants were selected through purposive sampling: one HSE staff member, one crane operator, and one rigger. These informants were chosen for their direct involvement and experience in lifting activities, enabling them to provide accurate insights into field hazard conditions and risk factors (Purwanto et al., 2023).

2.3. Research Data Sources

This study utilizes both primary and secondary data sources to ensure data validity and triangulation.

(a) Primary data were obtained through direct field observations and in-depth interviews with workers involved in lifting activities. Observations were conducted to examine actual work conditions, equipment usage, work procedures, and worker behavior in real-time operational settings. This approach enables the identification of both visible hazards and unsafe practices that may not be formally documented (Juniarto, 2025). In addition, interviews were conducted to capture workers' perceptions, experiences, and knowledge related to occupational risks. This is important because human factors, such as awareness, behavior, and communication, significantly influence the occurrence of workplace accidents in lifting operations (Hutari, 2022; Gultom et al., 2025).

(b) Secondary data were collected from internal company documents and relevant literature, including standard operating procedures (SOPs), safety manuals, company reports, and previous research studies. These data serve to support and validate findings from primary data while also providing a theoretical basis for risk analysis (Kabul, 2021).

2.4. Research Instruments

Several research instruments were utilized to facilitate systematic data collection and analysis. *First*, observation sheets were used to record hazards observed directly in the work environment, particularly those related to lifting processes and worker activities. *Second*, the HIRADC table was employed as the primary analytical tool to identify hazards, assess risks, and determine control measures. This tool enables structured classification of risks based on likelihood and consequence levels (Mukti et al., 2024). *Third*, interview guidelines were developed to ensure consistency in data collection from informants. The interview questions focused on identifying potential hazards, understanding worker behavior, and evaluating existing safety practices. This instrument is essential for capturing qualitative insights that complement observational data (Ananda et al., 2025). Additional tools included documentation equipment, such as cameras for visual records and field notes, to support data accuracy and reliability.

2.5. Location, Time, and Data Collection Procedures

This research was conducted at PT Repapesi Great River Bekasi, focusing on the SBNP installation project, which involves intensive material lifting activities. The study was conducted from January 10, 2023, to March 10, 2025, providing sufficient time for comprehensive observation and data collection. The data collection process began with obtaining research permits and conducting preliminary surveys to identify high-risk work areas. Subsequently, systematic observations were conducted during lifting operations to capture real working conditions.

Interviews were conducted using a semi-structured approach, allowing flexibility to explore relevant issues while maintaining consistency on key topics. In addition, document reviews were conducted to analyze the company's safety policies and procedures. The combination of observation, interviews, and document analysis ensures methodological triangulation, which enhances the validity and reliability of the research findings (Purwanto et al., 2023).

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2.6. Data Analysis Technique

Data analysis in this study follows the HIRADC framework, which consists of three main stages: hazard identification, risk assessment, and determination of control measures. The first stage involves identifying potential hazards based on data obtained from observations, interviews, and documents. All identified hazards are categorized by work stage: slinging, lifting, and placement. The second stage is risk assessment, in which each hazard is evaluated based on its likelihood and consequences. The risk value is calculated using the formula: ***R = C × L,*** where R represents the risk level, C represents the consequence (severity), and L represents the likelihood (probability of occurrence). This approach is widely used in occupational risk assessment due to its simplicity and effectiveness in prioritizing risks (Kabul, 2021).

The calculated risk values are then mapped into a 5×5 risk matrix, which classifies risks into four categories: low, medium, high, and extreme. This classification helps determine the urgency of control measures and supports decision-making in safety management (Mukti et al., 2024).

Table 1. Risk Matrix 5 by 5

Likelihood	**Consequence**				
	1	2	3	4	5
1	1 Low	2 Low	3 Low	4 Low	5 Medium
2	2 Low	4 Low	6 Medium	8 Medium	10 High
3	3 Low	6 Medium	9 Medium	12 High	15 High
4	4 Low	8 Medium	12 High	16 High	20 Extreme
5	5 Medium	10 High	15 High	20 Extreme	25 Extreme

Table 2. Risk Rating

Risk Rating	**Score**
Low	1-4
Medium	5-9
High	10-16
Extreme	20-25

Table 3. Risk Level Description

Color	Control Measures for Risk
Low	The risk is acceptable, and no additional controls are necessary. It is only required to monitor to ensure that the existing controls are properly maintained and implemented.
Medium	The risk is acceptable; only mitigation measures are required to reduce the risk, and responsibilities for implementation (within the work unit's program) must be clearly assigned to ensure operational controls are carried out.
High	The risk is unacceptable; control measures must be implemented to reduce it. Activities cannot proceed until the risk has been mitigated.
Extreme	The risk is unacceptable; activities must not be carried out or continued until the risk has been reduced. If risk reduction is not feasible with available resources, the work cannot proceed.

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To ensure consistency in risk evaluation and control prioritization, standardized risk matrix and classification criteria were adopted as shown in Tables 1–3. Each table functions as a risk analysis tool, a risk score classification, and a basis for determining control.

The final stage involves determining appropriate control measures based on the hierarchy of controls and field conditions. These controls are formulated by considering the results of risk assessment, worker input, and existing safety practices within the company. Through this systematic process, the study aims to provide a comprehensive analysis of occupational risks in material lifting activities and to recommend effective control strategies to reduce workplace accidents.

3. RESULTS AND DISCUSSIONS

3.1. Result

Overview of Hazard Identification and Risk Assessment. Using the HIRADC method, which combines field observations, in-depth interviews, and document analysis, this study identified 15 hazards and 15 associated occupational risks across three main stages of material lifting activities: slinging, lifting, and placement. These findings align with the research objectives outlined in the introduction, which emphasize the importance of systematically identifying and evaluating risks in high-risk lifting operations to support effective safety management practices (Kabul, 2021).

The classification of risk levels reveals a distribution dominated by moderate-to-critical categories, with one risk classified as extreme, four as high, and ten as medium, while no risks were identified as low. This pattern indicates that the majority of hazards present in material lifting activities carry significant potential consequences and likelihood, thereby requiring careful monitoring and control. The absence of low-risk categories further suggests that lifting operations inherently involve substantial risk exposure, even under routine working conditions.

This distribution confirms that material lifting activities are associated with moderate-to-high occupational risk, reinforcing the argument presented in the introduction that lifting operations are among the most hazardous activities in construction environments. The presence of an extreme risk, although limited in number, highlights critical safety gaps that could lead to severe accidents if not properly managed. Therefore, the findings underscore the need to implement systematic, structured risk control measures to minimize potential hazards and improve overall safety performance (Mukti et al., 2024).

Moreover, these results also validate the use of the HIRADC framework as an effective methodological approach for analyzing occupational safety risks. By integrating hazard identification, risk assessment, and control determination into a single structured process, HIRADC enables a comprehensive evaluation of workplace risks based on their likelihood and severity. This systematic approach not only facilitates the prioritization of critical risks but also supports decision-making in selecting appropriate control strategies, thereby enhancing the effectiveness of safety management systems in high-risk operational environments (Ananda et al., 2025).

Table 4. Results of Hazard and Occupational Safety Risk Analysis Using the HIRADC Method in Lifting Material Activities

Step Of Work	Number of Hazards and Risks	Risk Rating			
		Extreme	High	Medium	Low
Material Slinging	B 5 R 5	-	1	4	-
Material Lifting	B 6 R 6	1	2	3	-
Material Placement	B 4 R 4	-	1	3	-
Total	B 15 R 15	1	4	10	-

To provide a comprehensive overview of the hazards and occupational risks identified in material lifting activities, Table 4 presents the results of the HIRADC analysis, including the number of hazards and associated risks as well as their distribution across different risk rating categories for each stage of work.

As shown in Table 4, a total of 15 hazards and 15 risks were identified, with the majority classified as medium to high risk, indicating significant occupational safety concerns. While this table provides a general overview of the risk profile, a more detailed discussion of risk distribution by work stage is presented in the following subsection. To better understand the characteristics and sources of occupational risks in material lifting activities, the following subsection examines the distribution of hazards and risks across the stages of work in greater detail.

Risk Distribution by Work Stage: Material Slinging. The material slinging stage identified a total of five hazards and five associated risks, consisting of one high-risk category and four medium-risk categories, with no extreme or low risks observed. This distribution indicates that although the slinging phase does not involve critical or catastrophic risk levels, it still poses a considerable occupational risk that warrants attention. The dominant hazards identified at this stage include pinching injuries caused by miscommunication between workers, falling materials due to improper sling configuration, slipping or falling from elevated surfaces such as flatbed trucks, failure to use personal protective equipment (PPE), and lack of equipment inspection prior to use. These findings suggest that the risks during the slinging stage are primarily driven by human factors and procedural weaknesses rather than by mechanical or structural failures. In particular, inadequate communication and non-compliance with safety procedures appear to be the main contributors to hazard occurrence, indicating the need for improved safety awareness, training, and supervision to reduce the likelihood of accidents in this phase.

Similar findings were reported by Hutari (2022), who identified improper sling installation and communication failures as major contributors to lifting-related incidents. Likewise, Ananda and Santyorini (2025) emphasized that worker compliance with safety procedures and proper PPE utilization are critical factors in reducing occupational risks during construction activities.

Material Lifting. The material lifting stage had the highest risk among all stages, with six hazards and six associated risks: one extreme, two high, and three medium. The presence of extreme risk at this stage underscores the critical nature of the lifting phase and confirms that it is the most hazardous part of material handling operations. The identified hazards include sling failure, workers being struck by suspended loads, crane collapse due to overload, uncontrolled load movement caused by wind, materials colliding with surrounding objects, and unsafe worker behavior, particularly passing under suspended loads. Among these, the highest risk is associated with workers moving or standing beneath lifted materials, which constitutes a serious violation of safety protocols and significantly increases the risk of fatal accidents. This finding indicates that the lifting stage is influenced by a combination of technical, environmental, and behavioral factors, with interactions among these elements creating a highly complex risk environment. Consequently, this stage requires the most stringent safety controls, including strict enforcement of procedures, enhanced supervision, and continuous monitoring of both equipment performance and worker behavior.

This finding is consistent with the study of Juniarto (2025), which identified exposure to suspended loads as one of the leading causes of severe injuries and fatalities in lifting operations. Similarly, Yan et al. (2024) reported that the interaction between load stability, equipment performance, and environmental conditions significantly influences the overall safety of lifting activities and increases the probability of catastrophic accidents when control measures are inadequate.

Material Placement. The material placement stage identified four hazards and four associated risks, consisting of one high-risk category and three medium-risk categories, with no extreme risks observed. Although this stage does not present the same level of critical risk as the lifting stage, it still involves significant hazards that can lead to workplace injuries if not properly managed. The main hazards identified include pinching or crushing injuries during material positioning, crane instability due to excessive working

radius, unsafe worker positioning, and poor housekeeping conditions, such as scattered tools and materials. These findings indicate that risks in the placement stage are influenced by both technical factors, such as crane operation limits, and workplace conditions, including environmental organization and worker positioning. In addition, ergonomic and situational factors play an important role in this phase, as workers must interact closely with materials during placement. Therefore, effective risk control at this stage should focus on improving workplace organization, enforcing PPE use, and ensuring proper coordination between workers and equipment operators to minimize the potential for accidents.

These findings are supported by Fajar et al. (2024), who highlighted the importance of workplace organization and operational discipline in reducing construction-related risks. Furthermore, Purwanto et al. (2023) found that inadequate housekeeping practices and poor coordination among workers contribute significantly to workplace accidents during material handling and operational activities.

3.2. Discussion

Alignment with Research Objectives and Methodology. The findings of this study demonstrate a strong alignment with the research objectives, which aimed to identify hazards, assess occupational risks, and determine appropriate control strategies in material lifting activities using the HIRADC method. The successful identification of 15 hazards across three distinct work stages—material slinging, lifting, and placement—indicates that integrating qualitative field-based analysis with a structured risk assessment framework effectively captures complex, context-specific safety issues. This result confirms that HIRADC provides a systematic approach for analyzing occupational risks in high-risk construction activities, particularly those involving lifting operations (Kabul, 2021; Gultom et al., 2025).

Furthermore, the use of direct observation and in-depth interviews proved highly valuable for identifying hazards closely related to real working conditions. Unlike purely quantitative approaches, which often rely on numerical data and predefined indicators, this qualitative approach enables a deeper understanding of behavioral and procedural factors that contribute to workplace risks. In particular, unsafe work practices, communication gaps, and non-compliance with safety procedures were more clearly identified through direct engagement with workers, highlighting the importance of combining observational and experiential data in occupational safety analysis (Purwanto et al., 2023).

Dominance of Human Factors in Risk Occurrence. One of the most significant findings of this study is the dominant influence of human factors in the occurrence of occupational risks across all stages of material lifting activities. Unsafe behaviors, such as failure to use personal protective equipment (PPE), passing under suspended loads, and neglecting equipment inspection procedures, were consistently observed and identified as major contributors to the occurrence of hazards. These behaviors indicate gaps in safety awareness, discipline, and adherence to established safety standards.

This finding is consistent with previous studies that highlight human error and unsafe actions as primary causes of workplace accidents in construction environments (Hutari, 2022; Ananda et al., 2025). In high-risk operations such as lifting activities, where heavy loads and complex equipment are involved, even minor deviations from safety procedures can result in severe consequences. The identification of an extreme risk during the lifting stage further emphasizes the critical role of human behavior, particularly in high-energy operations where the margin for error is minimal. Therefore, improving worker behavior through training, supervision, and the development of a safety culture is a key priority for reducing occupational risks.

Critical Risk in the Material Lifting Stage. The lifting stage is identified as the most critical phase in material handling operations, as evidenced by the presence of an extreme risk and multiple high-risk categories. This finding reinforces the argument presented in the introduction that lifting operations are inherently high-risk due to the interaction of various hazard sources, including mechanical, environmental, and human factors (Putro, 2022).

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The extreme risk identified in this study is associated with workers passing under suspended loads, which represents a serious violation of fundamental safety principles in lifting operations. This behavior significantly increases the likelihood of fatal accidents, particularly in the event of load failure or equipment malfunction. The occurrence of this risk indicates deficiencies in several key aspects of safety management, including worker awareness, supervision, and enforcement of safety regulations.

This finding is supported by previous research, which identifies exposure to suspended loads as one of the leading causes of severe injuries and fatalities in lifting operations (Juniarto, 2025). The persistence of such high-risk behaviors suggests that existing safety measures may not be adequately enforced or internalized by workers, highlighting the need for stronger safety management systems, including stricter supervision and the implementation of disciplinary measures for unsafe practices.

Equipment and Environmental Risk Factors. In addition to human factors, this study identifies significant risks associated with equipment condition and the environment. Hazards such as sling failure, crane overload, uncontrolled load movement due to wind, and unstable ground conditions were found to contribute substantially to the overall risk profile of lifting activities. These technical and environmental risks are particularly critical because they can lead to sudden and severe accidents if not properly managed.

The findings are consistent with previous studies, which emphasize that equipment reliability and environmental conditions play a crucial role in determining the safety of lifting operations (Mukti et al., 2024). For example, failure to inspect slings or operating cranes beyond their capacity limits can result in catastrophic equipment failure, while strong winds and uneven ground conditions can affect load stability and crane performance. The findings support recent evidence indicating that equipment reliability, load stability, and environmental conditions collectively influence lifting safety performance and contribute to accident occurrence in construction projects (Yan et al., 2024; Fajar et al., 2024). These studies further suggest that risk mitigation strategies should not only focus on worker behavior but also incorporate continuous equipment monitoring, environmental assessment, and preventive maintenance programs to ensure safe lifting operations.

Importantly, the interaction between human, technical, and environmental factors creates a complex risk system in which accidents are rarely caused by a single factor. Instead, incidents typically result from a combination of contributing elements, such as inadequate equipment maintenance, unsafe worker behavior, and unfavorable environmental conditions. This complexity underscores the need for a holistic approach to risk management that addresses all potential sources of hazards simultaneously.

Risk Distribution Across Work Stages. Another key finding of this study is that occupational risks are distributed across all stages of material lifting, rather than concentrated solely in the lifting phase. Each stage presents distinct types of risks with different underlying causes. The slinging stage is primarily characterized by procedural and behavioral risks, such as improper sling installation and lack of PPE usage. The lifting stage, on the other hand, is dominated by high and extreme risks related to technical failures and unsafe behaviors. Meanwhile, the placement stage involves risks related to environmental conditions, ergonomics, and workplace organization.

This distribution supports the concept that lifting operations should be viewed as a continuous, integrated risk system in which each stage contributes to overall safety performance (Kabul, 2021). Failure to manage risks effectively in one stage can increase the likelihood of incidents in subsequent stages. Therefore, risk control measures must be implemented comprehensively across all stages of the lifting process to ensure consistent and effective safety management.

Implications for Risk Control. The findings of this study have important implications for the development of risk control strategies in material lifting activities. Based on the identified risk patterns, control measures should focus on three main areas: behavioral, technical, and administrative controls.

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Behavioral control involves improving safety awareness and compliance among workers through training, safety campaigns, and the development of a strong safety culture. Technical control focuses on ensuring the reliability and proper functioning of equipment through regular inspection, maintenance, and certification processes. Administrative control includes the enforcement of standard operating procedures (SOPs), supervision, and the implementation of safety management systems.

The application of the HIRADC method proved effective in identifying priority risks, particularly those categorized as high and extreme, which require immediate attention and intervention. This supports previous research indicating that structured risk assessment methods enable organizations to allocate resources more efficiently and implement targeted safety measures that address the most critical hazards (Ananda et al., 2025).

Theoretical and Practical Contribution. From a theoretical perspective, this study contributes to the existing body of knowledge by confirming that the HIRADC method is effective in analyzing complex occupational risks in construction environments. The findings also demonstrate that risk distribution varies across different stages of work processes and that human factors remain a dominant influence in the occurrence of workplace hazards. These insights reinforce existing theories on occupational risk management and highlight the importance of integrating behavioral aspects into safety analysis.

From a practical perspective, this study provides several valuable contributions for industry practitioners. First, it offers a structured risk map of material lifting activities that can serve as a reference for identifying critical hazards in similar projects. Second, it presents evidence-based recommendations for improving safety practices, particularly in high-risk lifting operations. Third, it provides a practical framework for implementing proactive safety management strategies through the HIRADC approach, helping organizations reduce accident rates and improve overall safety performance.

4. CONCLUSION

This study concludes that material lifting activities at PT Repapesi Great River involve significant occupational risks distributed across three main stages: material slinging, material lifting, and material placement. Using the HIRADC method, a total of 15 hazards and 15 associated risks were identified, with one categorized as extreme, four as high, and ten as medium. The absence of low-risk categories indicates that lifting operations inherently involve moderate to critical risk levels that require systematic management. The material lifting stage was identified as the most critical phase due to an extreme risk, particularly related to unsafe worker behavior, such as passing under suspended loads. Meanwhile, the slinging and placement stages were dominated by medium and high risks stemming from procedural weaknesses, equipment conditions, and workplace environmental factors. These findings confirm that occupational risks in lifting activities are multidimensional, involving the interaction of human, technical, and environmental elements. The study also demonstrates that human factors play a dominant role in the occurrence of workplace hazards, particularly in relation to non-compliance with safety procedures, inadequate use of personal protective equipment, and insufficient awareness of potential risks. Therefore, improving worker behavior through safety training, supervision, and the development of a strong safety culture is essential in reducing accident risks. From a methodological perspective, the HIRADC approach has proven effective in providing a structured framework for identifying hazards, assessing risk levels, and determining appropriate control measures. This method enables organizations to prioritize critical risks and implement targeted interventions more efficiently. The effectiveness of HIRADC in identifying critical hazards and prioritizing mitigation strategies has also been demonstrated in recent studies on construction safety, confirming its suitability for proactive risk management in high-risk operations (Ananda & Santyorini, 2025; Maulana & Johari, 2026). This study contributes both theoretically and practically by confirming the effectiveness of HIRADC in analyzing complex risks in construction environments and by providing a structured risk profile for material lifting activities. Future research is recommended to integrate quantitative risk modeling or real-time monitoring systems to enhance the accuracy and responsiveness of occupational risk management.

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