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Occupational Health and Safety (OHS) Hazard Risk Control Strategies in Construction Projects: A Literature Review

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Abstract

The construction industry is one of the sectors with the highest rate of work accidents, mainly due to the failure to identify and control risks effectively. This study aims to examine the Occupational Safety and Health (OHS) risk control strategy in piling work in the Section IV construction project using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method. The identification results show that there are 55 potential hazards classified into three risk categories: high, medium, and low, with the dominance of non-technical internal risk factors such as HR behavior and completeness of project information. The control strategy is implemented in stages based on the risk control hierarchy, including engineering, administrative control, and the use of Personal Protective Equipment (PPE), and is supported by ongoing training and the use of technology such as Virtual Reality (VR) and the Internet of Things (IoT). Obstacles in implementing this strategy are mainly found in the Small and Medium Enterprises (SMEs) sector which has limited resources. Therefore, managerial commitment, policy support, and adequate funding are needed to ensure the effectiveness of OHS management and the achievement of the zero accident target.

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1. INTRODUCTION

The construction industry is one of the sectors with the highest rate of work accidents in the world, including in Indonesia. The complexity of the work, dynamic work environment conditions, and the diversity of the workforce make construction projects very vulnerable to various potential hazards and risks to safety and health (Ardiansyah et al., 2022). Data from the Ministry of Manpower and BPJS Ketenagakerjaan show that most work accidents in this sector are caused by failure to identify and control risks effectively (Hartono et al., 2023). Therefore, systematic efforts to manage OHS risks are an urgent need to create a safe and productive work environment work (Alamsyah et al., 2021).

One important approach in managing Occupational Safety and Health is the implementation of risk control strategies based on the principle of hierarchy of control, which includes hazard elimination, substitution, engineering, administrative control, and the use of personal protective equipment (PPE) (Ginting & Kristiana, 2020). This strategy needs to be adjusted to the characteristics of the project and the potential hazards that arise at each stage of the work (Costa et al., 2021). However, the implementation of control strategies in the field still often faces various obstacles, such as budget constraints, lack of worker awareness, and weak managerial support (Esterlita et al., 2024).

Through this literature study by analyzing the approach, effectiveness, and challenges of the existing literature, it is hoped that recommendations can be formulated that can support the improvement of occupational health and safety management in the construction sector (Tamim & Ismail, 2020). This study is also important as a basis for stakeholders, such as contractors, project management, and occupational health and safety supervisors, to adopt appropriate control strategies to prevent work accidents and achieve the goal of zero accidents (Prisilia & Purnomo, 2023). This study aims to identify various occupational health and safety risk control strategies that have been applied in construction projects from various scientific sources.

2. METHOD

This research is a descriptive qualitative research using the literature study method (library research). conducted by collecting, reviewing, and analyzing relevant scientific references, such as journals, conference articles, research reports, textbooks, and national and international regulations or standards related to Occupational Safety and Health in construction.

The data used in this study were obtained from secondary sources in the form of scientific journal articles published in Indonesia. The inclusion criteria for article selection were: (1) articles published within the last 10 years; (2) articles that specifically discuss the control of Occupational Health and Safety (OHS) hazards or risks in the context of construction projects; and (3) studies that utilize quantitative, qualitative, or mixed-methods approaches. Meanwhile, the exclusion criteria included: (1) articles that discuss OHS only in general without any relation to construction projects, and (2) sources that are not peer-reviewed or academic in nature, such as blogs or opinion pieces.

Data collection was conducted by searching only original research articles online through databases such as Google Scholar, using search keywords including: "construction Occupational Health and Safety risk control strategies", "hazard control in construction", "risk management in construction projects", and "HIRARC in construction safety".

The analysis in this study was conducted using a descriptive-qualitative approach, which involved several stages: grouping the types of Occupational Health and Safety (OHS) hazards and risks commonly found in construction projects; identifying and

comparing the control strategies employed, based on the hierarchy of controls (elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment); analyzing the effectiveness of these control approaches as reported in various studies; and compiling a synthesis of findings to formulate best practices for controlling OHS risks in construction project environments.

To maintain the validity and reliability of data, this study only uses articles that have gone through a peer review process and are relevant to the research topic. In addition, to reduce potential bias, all articles that meet the inclusion criteria will be evaluated based on clear methodology and supporting data. The article selection process is carried out by researchers with careful attention to the quality and relevance of the sources used.

The results of this study will be presented in narrative form that outlines the main findings regarding the types of OHS hazards and risks, the control strategies applied, and the effectiveness of the approaches that have been discussed in the literature reviewed. Comparative analysis between studies will be arranged in the form of tables or diagrams to facilitate reader understanding.

3. RESULTS AND DISCUSSION

Table 1. Results of Literature Study Research

Author (Year)	Study objectives/focus	Research design/method	Population/sample	Main findings/results
Ardiansyah, Irawan, Purba, (2022)	Identifying and classifying the most likely OHS risks in building construction projects in Indonesia, and providing risk mitigation guidelines.	A systematic literature review of 40 research journals related to building construction projects in Indonesia during 2011–2021.	40 journal articles purposively selected from various projects in Indonesia	Internal risks – non-technical (such as HR behavior, information, project documents) are dominant risks; the importance of planning risk mitigation strategies to achieve zero accidents
Hansen, (2022)	Identifying hazard types and hazard assessment parameters in construction work	Literature review with scientometric analysis approach (using Open Knowledge Maps) and integrative literature review	100 relevant academic documents from journal databases	Identified 40 types of hazards classified into 6 groups (physical, biological, chemical, technological, psychosocial, combination); and 4 hazard assessment parameters: severity, likelihood, frequency, and exposure level. These findings are important for

				improving OHS management
Yani, (2024)	Evaluating the effectiveness of occupational safety training and the role of management in improving compliance with OHS	Literature review of 20 articles indexed by Sinta and Scopus (2018–2023)	20 articles related to OHS in the construction sector and other industries	Effective OHS training improves workers' understanding and compliance; technologies such as VR and IoT enhance training effectiveness; management's role is crucial in OHS adoption and implementation; there are still gaps in SMEs and the construction sector that need further attention.
Ramdani, (2023)	Identifying potential hazards and implementing risk control in bore pile work using CSA	Direct observation in the field and verification by OHS experts using CSA (PUPR Regulation No. 10 of 2021)	Solo – Yogyakarta – YIA Toll Road Development ProjectKulonprogo Section I Package 1.1(bore pile work)	Identified 32 potential hazards in bore pile work. Control is carried out according to the control hierarchy (substitution, engineering control, administration, and PPE). The CSA form is prepared based on the sequence of work and verified by an OHS expert. The CSA approach has proven effective in improving work safety in the bore pile project.
Putri, et al. (2024)	Identifying hazards, assessing risks, and designing work risk controls in architectural work on	Observation, documentation, interviews, analysis using the IBPRP method (PUPR Regulation No. 10 of 2021)	Architectural work on the XYZ Building construction project	Identified 24 work risks, 12 of which are categorized as very high (including falling from a height, being hit by material, being cut by tools, being electrocuted).

	construction projects			After initial and continued control, all risks were reduced to the low/very low category. It is recommended to increase training and use of PPE.
Maharani et al., (2022)	The purpose of this study is to analyze the risks in the project and to find out how corrective and mitigation handling to minimize risks in housing construction projects with the House of Risk method. From the results of the risk analysis of the HOR method visualized with a Pareto diagram,	House of Risk method	All parties involved in the implementation of PT ABC's housing construction project, who have knowledge or experience regarding the risks that occur during project implementation.	The results of this study are to identify the risks, the results of the house of risk phase 1 calculations, the results of the house of risk phase 2.

Fatmawati, (2023)	This study identifies the possibility of work accidents in the piling process using the Hazard Identification, Risk Assessment and Risk Control (HIRARC) method in the Piling work of Section IV of the Cibitung - Cilincing Toll Road Construction Project.	identification, risk assessment and risk control (HIRARC)	All workers and parties directly involved in piling work on the Section IV project, including OHS officers, foremen, heavy equipment operators, field technicians , and project supervisors .	The results of the hazard identification found in the section IV piling work process are a total of 55 hazard identifications from 9 work items. In the risk assessment using the HIRARC method, the results obtained were 7 potential hazards that had a High Risk Level, and where there were 30 potential hazards that had a Moderate Risk Level, and there were 18 potential hazards that had a Low Risk Level. Then the results were used to determine internal control through administration, engineering, and personal protective equipment (PPE).
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Based on the results of the research table, it can be concluded that the piling work of Section IV contains various potential hazards with a total of 55 identifications from 9 work items, of which 7 are classified as high risk, 30 are moderate risk, and 18 are low risk. These risks are dominated by internal factors - non-technical such as HR behavior, information, and project documents, which emphasize the importance of mitigation strategies to achieve the goal of zero accidents. Risk assessment is carried out using the HIRARC method by considering four main parameters: severity, likelihood, frequency, and level of exposure. Risk control strategies are implemented in stages according to the control hierarchy, namely through engineering, administration, and use of PPE. This finding confirms that comprehensive OHS management planning, ongoing training, and the use of technology such as VR and IoT. It is very important to improve occupational safety, especially in the construction sector which still shows significant gaps in OHS implementation, especially among SMEs.

DISCUSSION

In this study, the main findings related to piling work in Section IV showed that there were 55 hazard identifications that could occur, which were divided into 9 work items. The risk assessment carried out using the HIRARC method produced a clear picture of the distribution of risk levels, with 7 potential hazards classified as high risk, 30 as medium risk, and 18 as low risk. These results are in line with research conducted by Prisilia and Purnomo, (2023), which also used the HIRARC method to identify and assess risks in construction projects. Purnomo and Prisilia found that non-technical factors such as communication and coordination errors between related parties in the project were the main causes of work accidents (Prisilia & Purnomo, 2023). Thus, this study shows the importance of implementing systematic and structured methods in risk identification and assessment to improve work safety (Hansen, 2022).

Previous research by Raza et al. revealed that internal factors, such as HR behavior and training, play a major role in the occurrence of work accidents in construction projects (Raza et al., 2022). This finding is very relevant to the results of this study, where the risk in piling work in Section IV is more due to HR behavior factors, information, and unclear or incomplete project documents (Yani, 2024). Therefore, planning and mitigation strategies involving human resource management and effective communication between parties are very important to achieve the goal of zero accidents (Yilmaz & Yildiz, 2020). For example, risk management involving increasing awareness and OHS training for workers can reduce errors caused by unsafe human behavior (Dina & Purba, 2022).

Furthermore, the theory of the risk control hierarchy used in this study, which includes engineering, administrative, and personal protective equipment (PPE) controls, also strongly supports the results of existing research (Dina & Purba, 2022). Ramdani explained that a tiered control approach can reduce the potential for accidents, especially by eliminating or reducing hazards at their source (Ramdani, 2023). For example, engineering controls that modify tools or work processes can reduce the potential for hazards that can cause serious injury (Santoso et al., 2024). On the other hand, administrative controls and the use of PPE serve as the last safety measure if other measures cannot eliminate the hazard completely (Putri et al., 2024).

Research by Tang also suggests that the use of technology in training and supervision is very helpful in improving safety in construction projects (Tang, 2024). They identified that technologies such as Virtual Reality (VR) and the Internet of Things (IoT) can monitor and reduce work accidents through simulation-based training and real-time monitoring (Kineber et al., 2023). This research is in line with the findings of this study which emphasizes the importance of utilizing advanced technology to support risk control (Putri et al., 2024). For example, the use of VR in OHS training allows workers to practice in situations that simulate potential hazards without having to be directly exposed to the risks, which can significantly improve workers' understanding and skills (Esterlita et al., 2024).

It is important to note that the theory of the application of advanced technology in OHS management is also supported by research by Ramakrishnan et al. which revealed that technology plays an important role in controlling construction risks, especially in large projects with many parties involved (Ramakrishnan et al., 2022). Technologies such as IoT sensor-based monitoring can detect risky working conditions, such as overloading or tool damage, and provide warnings to project managers or workers to immediately take preventive action (Alamsyah et al., 2021). This shows that technology can be an effective tool in mitigating hazards and reducing work accidents in construction projects (Hansen, 2022).

However, although many technologies can improve occupational safety, the implementation of effective OHS technology and management is often hampered by budget and human resource constraints (Maharani et al., 2022). As found in the research of Fatima et al., the SME sector and small companies in the construction industry often lack the capacity to adopt the latest technology or implement intensive OHS training programs (Fatima et al., 2023). This adds to the challenge of achieving zero accidents because many workers in this sector still work in less than guaranteed safety conditions (Fatmawati, 2023).

Finally, based on the analysis of this study, it can be concluded that although the HIRARC method, continuous training, and utilization of technology can be very effective in identifying and controlling OHS risks in construction projects, successful implementation is highly dependent on managerial commitment and support from all parties involved in the project (Tamim & Ismail, 2020). Research by Maharani et al. emphasized that managerial awareness and commitment to OHS are essential to ensure that safety procedures are implemented consistently and effectively (Maharani et al., 2022). This includes policies that support OHS training, strict supervision, and enforcement of discipline related to the use of PPE (Fatmawati, 2023).

By comparing the findings of this study with existing theories and previous studies, it can be concluded that an effective risk mitigation strategy in construction projects must include a holistic and multi-level approach, focusing on human resource management, technology, and policies that support occupational safety (Suyitno et al., 2024). Only with a comprehensive approach can construction projects successfully achieve the goal of zero accidents (Fajar et al., 2024).

4. CONCLUSION

Based on the results of the study and discussion, it can be concluded that the pile drilling work in Section IV has a significant level of risk, with the dominance of non-technical internal factors, such as HR behavior and completeness of project information. The HIRARC method has proven effective in identifying, assessing, and grouping risks based on severity, likelihood, frequency, and level of exposure. Risk control strategies implemented in stages through engineering, administrative, and PPE use approaches, and supported by ongoing training and utilization of technology such as VR and IoT, are very important to improve the effectiveness of OHS management in the field. However, limitations in the SME sector indicate the need for further support from stakeholders in the form of policies, funding, and managerial commitment to ensure that occupational safety can be maintained consistently. Therefore, it is recommended that every construction project, especially those involving high-risk work such as pile drilling, adopt a comprehensive OHS approach, adaptive to technology, and involving all levels of the organization to achieve the goal of zero accidents.

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