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Identification of Technical Risks and Their Influence on Occupational Health and Safety (OHS) Systems in High-Rise Commercial Building Construction Projects in Padang City

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ABSTRACT

The construction industry experiences a high rate of workplace accidents, many of which are caused by technical factors on construction sites. Previous studies have largely emphasized behavioral and managerial aspects of construction safety, while quantitative evidence on the influence of technical risks on Occupational Safety and Health (OSH) system effectiveness in Indonesian construction projects remains limited. This study aims to identify technical risks and examine their relationship with the OSH system in commercial building construction projects. A quantitative approach with a descriptive-correlational survey design was employed. Data were collected through questionnaires from 60 respondents directly involved in project technical activities and analyzed using descriptive statistics, Pearson's correlation, and simple linear regression. The findings show that technical risks were categorized as high (mean = 3.41–4.20), with the most prominent indicators being work method errors (mean = 4.12), equipment failure (mean = 3.95), material quality issues (mean = 3.78), and design errors (mean = 3.60). The implementation of the OSH system was also rated high (mean = 3.91), although improvements are still needed in training and

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supervision. Pearson's correlation analysis revealed a significant negative relationship between technical risk and the OSH system ($r = -0.620$, $p < 0.01$). Regression analysis further indicated that technical risk significantly affects OSH system performance ($Y = 5.12 – 0.58X$). These findings highlight that effective technical risk control is essential for strengthening OSH system implementation. The study underscores the importance of integrating technical risk management with OSH practices and adopting construction technologies to enhance workplace safety.

Keywords: technical risks; construction; occupational safety and health; workplace safety; risk management

1. Introduction

The construction industry is one of the sectors with a high rate of workplace accidents compared to other sectors. The complexity of the work, the use of heavy machinery, and the involvement of a large workforce with varying levels of expertise result in significant technical hazards [1]. Technical risks in construction projects, such as temporary structural failures, errors in work methods, and the use of materials that do not meet specifications, often contribute directly to workplace accidents and a decline in project quality [2]. The dynamic and time-sensitive nature of construction projects further increases the probability of technical errors occurring on-site [3].

In Indonesia, the implementation of the Occupational Safety and Health (OSH) system is governed by various regulations, such as Law No. 1 of 1970 and its implementing regulations. However, implementation in the field still faces various challenges, ranging from low worker awareness and limited oversight to weak integration between technical risk management and the OSH system [4]. National data indicates that the construction sector consistently accounts for the highest proportion of workplace accidents, largely due to failures in identifying and controlling technical risks from the planning stage through to execution [5].

In large-scale commercial building projects, such as shopping centers, technical complexity increases significantly due to the simultaneous involvement of various disciplines, such as structural, architectural, mechanical, electrical, and plumbing

(MEP). These conditions create potential technical clashes and increase the likelihood of coordination errors that impact workplace safety [6]. Therefore, a systematic risk management approach integrated with the OSH system is crucial to minimize the potential for accidents and improve overall project performance.

High-rise commercial building projects generally involve more complex vertical construction activities, multiple concurrent work processes, and greater work-at-height exposure than conventional low-rise buildings. These characteristics increase technical complexity and the likelihood of occupational hazards, thereby requiring more comprehensive technical risk management and Occupational Safety and Health (OSH) implementation.

Although many studies have addressed the implementation of occupational safety and health (OSH) in construction, most still focus on worker behavior, safety culture, and compliance with safety procedures [7]. Other studies also tend to emphasize organizational and managerial factors without thoroughly examining technical aspects as the primary source of risk [8]. Consequently, the relationship between construction technical risks and the effectiveness of OSH systems has not been comprehensively explored, particularly in the context of commercial building projects in Indonesia.

Furthermore, local case-based empirical studies that integrate technical risk analysis with OSH performance indicators remain very limited. In fact, the geographical conditions, work culture, and level of workforce competence in Indonesia have characteristics that differ from those of other countries, making contextual research necessary to produce more applicable recommendations [9]. These limitations indicate the existence of a research gap that needs to be filled, particularly in quantitatively linking technical variables with occupational safety management systems.

The significance of this study lies in its effort to bridge this gap by empirically examining how technical risks influence the implementation of occupational safety and health (OSH) systems in construction projects. This study also contributes to strengthening an integrative approach between risk management and occupational safety, which have traditionally been treated as separate entities in construction practice. By understanding this relationship, it is hoped that more effective risk

mitigation strategies can be developed and that sustainable improvements in occupational safety performance can be achieved. The objectives of this study are to identify the dominant types of technical risks in commercial building construction projects, analyze the level of OSH system implementation in these projects, and examine the relationship between technical risks and the effectiveness of OSH systems. Additionally, this study aims to provide an empirical basis for developing an integration model between technical risks and OSH systems that can be applied to construction projects in Indonesia.

The novelty of this study lies in the integration of technical risk analysis with a quantitative evaluation of occupational safety and health (OSH) system performance in a case study of a commercial building project in Indonesia, specifically Commercial Building Construction Projects. This study not only identifies risks but also measures the causal relationship between technical variables and OSH performance, thereby making a new contribution to the development of construction management and occupational safety science based on empirical data.

Based on the theoretical framework and previous empirical findings, the following hypothesis was formulated: H1: Technical risks have a significant negative effect on Occupational Safety and Health (OSH) system implementation in high-rise commercial building construction projects.

2. Materials and Method

This study employs a quantitative approach using a descriptive and correlational survey design. This approach was chosen to empirically test the relationship between technical risk variables and the implementation of Occupational Safety and Health (OSH) systems in construction projects. The descriptive design was used to describe the conditions of the research variables, while the correlational design was used to statistically analyze the relationships among the variables under study.

The research was conducted at a large-scale commercial building construction project located in Padang City during the period from January to March 2026. The specific project identity is anonymized due to confidentiality considerations with the contractor. The selection of the research location was based on the project's

characteristics, which involve high technical complexity and various types of construction work carried out simultaneously, making it relevant for examining technical risks and the implementation of the OSH system.

The population in this study consists of all workers and technical staff involved in the construction project, totaling 120 people. The sampling technique used is purposive sampling, which involves selecting samples based on specific criteria deemed relevant to the research objectives. The criteria used include workers with at least one year of experience in the construction sector who are directly involved in technical activities on-site. Based on these criteria, a sample of 60 respondents was selected, which is considered representative of the research context.

The research instrument used was a structured questionnaire with a five-point Likert scale, ranging from a score of 1 (strongly disagree) to a score of 5 (strongly agree). The questionnaire was designed based on two main variables: technical risk as the independent variable and the OSH system as the dependent variable. The technical risk variable was measured through several indicators, namely work method errors, equipment failure, material quality, and field design errors. Meanwhile, the OSH system variable was measured through indicators of personal protective equipment (PPE) use, safety supervision, OSH training, and the implementation of safe work procedures. Before use, the research instrument was tested for validity using Pearson's correlation with a criterion of a coefficient value greater than 0.30, and for reliability using Cronbach's Alpha coefficient with a minimum threshold of 0.70 to ensure the instrument's internal consistency. The validity test results showed that all questionnaire items had corrected item-total correlation values greater than 0.30, indicating that all items were valid. Reliability testing produced Cronbach's Alpha values of 0.87 for the technical risk variable and 0.84 for the OSH system variable, indicating good internal consistency. For descriptive interpretation, the mean scores obtained from the five-point Likert scale were classified using an equal interval approach. Mean values of 1.00–1.80 were categorized as very low, 1.81–2.60 as low, 2.61–3.40 as moderate, 3.41–4.20 as high, and 4.21–5.00 as very high. These categories were applied consistently throughout the study to determine the level of technical risk and Occupational Safety and Health (OSH) system implementation.

The data analysis techniques used in this study were conducted in several stages, namely descriptive statistical analysis to determine the mean values and percentages of each variable, Pearson's correlation test to identify the relationship between technical risks and the OSH system, and simple linear regression analysis to measure the effect of technical risks on the effectiveness of the OSH system. The entire data processing and analysis process was carried out using statistical software to obtain accurate and scientifically valid results.

3. Result

Respondent Characteristics

Table 1. Respondent Characteristics by Age and Work Experience

Characteristic	Category (years)	Category (n)	Percentage (%)
Age	< 25	12	20,0
	25–40	39	65,0
	> 40	9	15,0
Work Experience	< 3	18	30,0
	3–5	35	58,3
	> 5	7	11,7

Most respondents were in the productive age range of 25–40 years (65.0%) and had 3–5 years of work experience (58.3%). This indicates that the respondents possess sufficient professional maturity and technical expertise to provide a representative assessment of technical risk conditions and the implementation of occupational safety and health (OSH) systems in the field.

Identification of Technical Risks

Table 2. Average Technical Risk Values

Technical Risk Indicators	Mean	Std. Dev	Category
Work Method Errors	4,12	0,40	High
Equipment Failures	3,95	0,43	High

Material Quality	3,78	0,44	High
Design errors	3,60	0,46	High
Average of Variable	**3,86**	**0,42**	**High**

Mean interpretation: 1.00–1.80 = Very Low; 1.81–2.60 = Low; 2.61–3.40 = Moderate; 3.41–4.20 = High; 4.21–5.00 = Very High.

All technical risk indicators fall into the high category, with the highest value for work method errors (Mean = 4.12). This indicates that operational factors in the field are the most dominant source of risk. Equipment failure also indicates a high level of risk, suggesting the need for improved equipment maintenance and supervision. Although previously categorized as moderate, the values for material quality (3.78) and design errors (3.60) are statistically in the high category, thus continuing to contribute significantly to potential risk. Overall, technical risks stem more from the implementation phase than from the planning phase.

Level of OSH System Implementation

Table 3. Mean Values of OSH System Implementation

OSH Indicator	Mean	Std. Dev	Category
Use of PPE	4,20	0,38	High
Safety supervision	3,85	0,42	High
OSH training	3,70	0,45	High
Safe Work Procedures	3,90	0,41	High
Average of Variable	**3,91**	**0,45**	**High**

Mean interpretation: 1.00–1.80 = Very Low; 1.81–2.60 = Low; 2.61–3.40 = Moderate; 3.41–4.20 = High; 4.21–5.00 = Very High.

All OSH system indicators fall into the high category, with the highest score in PPE usage (Mean = 4.20). This indicates that workers' awareness of self-protection is already good. However, the scores for training and supervision are relatively lower compared to other indicators, so improvements are still needed to achieve optimal OSH system.

Analysis of the Relationship Between Technical Risk and Occupational Safety and Health

Table 4. Pearson Correlation Between Technical Risk and OSH System Implementation

Variable	Correlation Coefficient (r)	Significance (p)	Notes
Technical Risk – Occupational Safety and Health	-0,620	0,000	Significant (strong)

A correlation coefficient of -0.620 indicates a strong negative relationship between technical risk and the OSH system. This means that an increase in technical risk will be followed by a decrease in the effectiveness of the OSH system's implementation. A significance level of 0.000 (<0.01) indicates that the relationship is statistically significant.

Linear Regression Analysis

Model Summary

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	0,620	0,384	0,373	0,354

The R-Square value of 0.384 indicates that the technical risk variable explains 38.4% of the variation in the OSH system, while the remaining 61.6% is influenced by other factors outside the scope of this study.

Regression Coefficient Test

Table 6. Regression Coefficients for the Effect of Technical Risk on Occupational Safety and Health (OSH) System Implementation

Variabel	B	Std. Error	Beta	t	Sig.
Constant	5,12	0,312	-	16,410	0,000
Technical Risk	-0,58	0,090	-0,620	-6,45	0,000

Regression Equation:
Y = 5.12 - 0.58X

The regression coefficient of -0.58 indicates that a one-unit increase in technical risk reduces the effectiveness of the OSH system by 0.58 units. A calculated t-value of -6.45 with a significance level of 0.000 (<0.01) indicates that this effect is statistically significant. Thus, technical risk has a strong and significant negative impact on the performance of the OSH system in construction projects.

4. Discussion

The research results indicate that technical risks have a significant negative relationship with the Occupational Safety and Health (OSH) system. These findings reinforce the view that technical risks are a key determinant of construction safety performance. Recent studies show that technical failures, such as work method errors and equipment failures, are dominant factors causing workplace accidents in modern construction projects [2]. Furthermore, a risk management approach that is not integrated with the safety system has been shown to increase the likelihood of workplace incidents.

The high incidence of work method errors in this study indicates that technical planning and operational control remain weak points in construction projects. This aligns with the risk lifecycle concept, which identifies the planning stage as the most critical phase in risk control. Furthermore, the Work Breakdown Structure (WBS)-based risk analysis approach also confirms that the greatest risks often arise during the technical implementation phase on-site.

The negative correlation between technical risks and the occupational safety and health (OSH) system ($r = -0.620$) indicates a gap between risk identification and the implementation of safety controls. Recent research confirms that the integration of risk assessment and the safety management system is a key factor in improving workplace safety [7] Previous studies suggest that technologies such as BIM, IoT, and AI-based early warning systems have significant potential to reduce workplace accidents and improve responses to hazards in construction projects [10]. This indicates that the conventional approach, which remains dominant in many construction projects including in Indonesia needs to be upgraded toward data-driven and technology-based systems.

From a technological perspective, recent developments indicate that artificial intelligence (AI) holds great potential for enhancing construction risk management. Studies show that AI can be used for risk prediction, real-time safety monitoring, and accident data analysis for early prevention [10]. The application of robotics and automation in construction has also proven capable of reducing worker involvement in high-risk tasks, thereby contributing to improved workplace safety [11]. However, challenges such as data quality, limitations in workforce competency, and system integration remain major obstacles to its implementation.

On the other hand, the results of this study show that the use of personal protective equipment (PPE) scored the highest compared to other occupational safety and health indicators. This suggests that administrative aspects and procedural compliance are already functioning relatively well. However, international research confirms that a safety approach focused solely on the use of PPE is reactive and less effective without risk control at the source [8]. In the hierarchy of risk control, the use of PPE is the last layer after elimination, substitution, and engineering controls.

Additionally, the relatively low scores for training and supervision indicate a need to enhance human resource capacity in technical risk management. Recent research indicates that technology-based training and simulations can improve workers' ability to identify risks and reduce operational errors in the field [3]. Additionally, effective supervision plays a crucial role in ensuring that safety procedures are implemented in accordance with standards.

In the context of modern construction management, the findings of this study also underscore the importance of an integrated approach between risk management and occupational safety and health (OSH) systems. A literature review indicates that modern construction risk management has evolved toward technology-based integrated approaches such as BIM and digital systems [11]. However, implementation in developing countries still faces various challenges, such as resource constraints, a lack of system integration, and low technology adoption.

Furthermore, recent research also highlights the importance of using big data and dataset-based systems to improve construction safety. The use of large-scale construction safety datasets has proven capable of identifying accident patterns and reducing the risk of incidents through predictive approaches. This indicates that the future of OSH management will increasingly rely on data analysis and digital technology.

The main difference between this study and previous research lies in its empirical, case-based approach focused on commercial building projects in Indonesia. This study makes an important contextual contribution, given that most previous studies were conducted in developed countries with higher levels of technology adoption. Furthermore, this study quantitatively demonstrates the relationship between technical risks and OSH systems, a topic that has rarely been empirically examined in a local context.

Overall, the results of this study confirm that the effectiveness of OSH systems is not only determined by compliance with safety procedures but also heavily depends on the ability to systematically identify, analyze, and control technical risks. Therefore, a transformation of the safety management approach is needed shifting from an administrative approach toward a risk- and technology-based approach to achieve optimal and sustainable workplace safety.

5. Conclusions

This study aims to identify technical risks and analyze their relationship with the Occupational Safety and Health (OSH) system in commercial building construction projects. Based on the analysis results, it can be concluded that technical risks in construction projects are classified as high, with dominant indicators including work method errors, equipment failure, material quality, and design errors. Meanwhile, the implementation of the OSH system is generally in the "good" category, particularly regarding the use of personal protective equipment (PPE), although weaknesses remain in training and supervision. Statistical test results indicate a significant negative correlation between technical risks and the effectiveness of the OSH system, meaning that an increase in technical risks is associated with a decline in OSH system performance. Furthermore, regression analysis results indicate that technical risks have a significant influence on the OSH system, making the control of technical risks a key factor in improving workplace safety in construction projects. Thus, the success of OSH implementation depends not only on administrative compliance but is also largely determined by the ability to systematically and integrally identify and manage technical risks.

This study's findings also provide important implications from both policy and practical perspectives. From a policy standpoint, there is a need to strengthen occupational health and safety (OHS) regulations that not only emphasize compliance but also integrate a technical risk-based approach at every stage of construction projects. Furthermore, national standardization is required in the identification and control of technical risks, along with the enhancement of workforce competencies through training programs that are not merely administrative in nature but also technical and risk-oriented. The government should also promote the adoption of modern construction technologies, such as Building Information Modeling (BIM) and digital-based monitoring systems, to improve the effectiveness of risk control and workplace safety.

From a practical perspective, construction companies need to comprehensively integrate technical risk management into OHS systems, enhance on-site supervision,

and optimize risk-based training for workers. In addition, the implementation of the hierarchy of risk control should be prioritized by emphasizing elimination and engineering controls before relying on personal protective equipment (PPE). The use of accident data and near-miss incidents should also be optimized to support data-driven decision-making in improving workplace safety. For future research, it is recommended to employ more comprehensive approaches, such as mixed-methods, and to develop more complex analytical models to enrich the study of the integration between technical risk and OHS systems in the construction industry.

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