



Risk Analysis of The Underpass Construction Project on HM Yamin Street Medan Timur District (Case Study: Structural Works)

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ABSTRACT

The construction industry is widely recognized as one of the sectors that makes a major contribution to a nation's economic growth, since it supports infrastructure development, employment generation, and broader economic activity. However, despite its strategic importance, risk evaluation in construction project activities is often not given sufficient attention, even though risks can strongly influence project progress and performance. When risks are not identified and managed properly, their effects may extend beyond delays and additional costs, ultimately influencing the quality of the final outcome as well as client satisfaction. For this reason, the analysis of risk factors affecting project progress is essential in order to support the success, efficiency, and sustainability of construction projects. In this study, the Purposive Sampling method was employed to obtain data from respondents considered to have relevant knowledge and experience regarding the project conditions. Based on the findings, the identified risks can be grouped into three categories, namely high, moderate, and low risk. Among these, material damage and loss were found to fall into the high risk category, indicating that they have the greatest potential to disrupt project implementation. To reduce the impact of this risk, several mitigation measures are proposed, including strengthening project security personnel, improving the organization of materials, and arranging material placement in effective and secure storage facilities. Together, these actions provide a practical basis for reducing uncertainty and improving project control during construction implementation.

Keywords: *Construction Project Risk Evaluation, Construction Risk Management, Project Progress, Purposive Sampling, Risk Categorization*

1. Introduction

Construction projects are infrastructure development activities with primary objectives of cost, quality, and time. However, every project faces uncertainties that generate risks in terms of materials, labor, execution, design, and natural factors. Uncontrolled risks may lead to delays, cost overruns, and quality degradation [1]. The construction of the HM Yamin Underpass in Medan Timur serves as a concrete example, where delays occurred due to changes in work plans, weather conditions, and internal contractor issues. The research problem formulation includes identifying risks in the project, determining risk categories classified as high risk, and establishing appropriate measures to address these risks. The objective of this study is to classify risks, evaluate those categorized as high risk, and formulate mitigation actions to reduce their impact on project progress [2]. The literature review indicates that construction risks encompass materials, labor, execution, design, and natural factors [3]. Risk mapping is employed to identify and measure risk levels based on probability and consequence, thereby enabling the determination of mitigation priorities. Previous studies, such as the underpass construction in Denpasar, demonstrated that risk mapping is effective in determining risk categories as a basis for decision-making [4]. This serves as the foundation for the present study, which analyzes risks in the HM Yamin Underpass project, thereby contributing to the improvement of risk management in construction projects in Indonesia.



1.1 Construction projects

Construction projects may involve new development, renovation, or expansion of existing structures. The primary objectives of such projects are cost, quality, and time [5].

1.2 Construction project risks

Project risk refers to an uncertain condition that may result in negative consequences affecting cost, quality, and time. The types of risks commonly encountered in construction projects include:

1. Material and equipment risks (availability, damage, delayed delivery).
2. Labor risks (accidents, disputes, strikes).
3. Execution risks (changes in scope, poor workmanship).
4. Design risks (design errors, design changes).
5. Natural risks (rain, flooding).

Construction projects may involve new development, renovation, or expansion, with cost, quality, and time as their core performance targets. Construction Project Risk classification in this context is defined as follows:

1. High Risk refers to threats such as material damage and financial loss. These risks combine a high probability of occurrence with severe consequences, directly influencing project costs and execution time. Because of their potential to disrupt core performance targets, high-risk factors demand immediate attention and are prioritized in mitigation strategies.

2. Moderate Risk includes issues like delays in material delivery and labor disputes. While their impact is less severe than high-risk factors, they still pose significant challenges to project continuity. Effective supervision, proactive communication, and contingency planning are essential to manage these risks and prevent escalation.

3. Low Risk is characterized by relatively low probability and limited impact. Although they are less threatening, they should not be ignored; anticipating them helps avoid unnecessary disruptions to the project schedule and ensures the final quality of the work.

1.3 Risk mapping

Risk mapping is a process of measurement, calculation, and graphical representation using specific methods to produce either softcopy or hardcopy maps in data format [6]. It may also be defined as the process of creating a map. In the context of construction, risk mapping is used to identify and assess the level of risk.

2. Method

This research is a case study employing a descriptive quantitative approach using the purposive sampling method. Data collection was carried out through the direct distribution of questionnaires to respondents involved in the project. Respondents were selected based on their active roles in project implementation, ensuring that the data obtained were relevant and accurate. The focus of the research is directed toward the construction of the HM Yamin Underpass in Medan Timur, aiming to identify, classify, and analyze risks arising during project execution, so that appropriate mitigation strategies can be formulated based on factual data from the field.



Figure 1. Research Flowchart

The research process flowchart is designed to illustrate the stages of activities in a systematic manner. The flowchart illustrates a systematic procedure for construction risk management, beginning with the start of the assessment process and ending with the formulation of appropriate responses to the risks that have been identified. The first stage is risk identification, in which potential sources of uncertainty that may affect project performance are recognized. At this point, the project team seeks to determine all possible events or conditions that could influence cost, time, quality, safety, or overall implementation.

Once the relevant risks have been identified, the process continues with data collection, where information related to those risks is gathered from observations, project documents, field conditions, interviews, or previous experience. This stage is important because the quality of the analysis depends heavily on the completeness and reliability of the available data.

The next step is risk analysis, which involves examining the identified risks in order to understand their likelihood of occurrence and the magnitude of their consequences. Through this stage, risks are no longer viewed only as general possibilities, but as measurable factors that can be assessed in relation to their impact on project objectives. After the analysis is completed, the risks are grouped in the risk categorization stage. Here, each risk is classified, commonly into high, moderate, or low levels, based on the results of the analysis. This classification helps decision makers determine which risks require immediate attention and which can be monitored through routine control measures. The process then moves to mitigation strategy formulation, where suitable actions are developed to reduce, control, or respond to the identified risks according to their category and severity.

At this stage, practical strategies are prepared so that the project team can address the most critical threats while maintaining efficient management of less significant ones. Finally, the process reaches the end, indicating that the risk management cycle has produced a structured basis for decision making and for the implementation of preventive and corrective actions throughout the construction project.



2.1 *Research data sources*

The data used in this study consist of both primary and secondary data. Primary data were obtained through the distribution of questionnaires to workers, project managers, and contractors. The questionnaires were designed to identify risks that arise during project implementation. Meanwhile, secondary data were collected from project documents, implementation reports, and administrative records that support a comprehensive risk analysis.

2.2 *Data processing method*

The main research instrument is a questionnaire consisting of two parts: the respondent's personal information page and the risk survey page. The questionnaire format was designed to gather information related to risks involving materials, labor, execution, design, and natural factors. The questionnaire was structured based on common risk indicators in construction projects.

The research instrument applies a rating scale of I (Impact) and P (Probability) [7]. The risk value is calculated using the following simple formula:

$$R = P \times I \quad (1)$$

In this study, the Risk Score (R) is determined by multiplying the Probability (P) and the Impact (I). Probability represents the likelihood of a risk occurring, while Impact reflects the severity of the consequences if the risk materializes. By combining these two dimensions, the Risk Score provides a quantitative measure that captures both the chance of occurrence and the magnitude of potential effects. This integrated approach allows for clearer classification and prioritization of risks within the project context. The resulting scores are then summed and averaged to determine the level of risk [8]. For example, variable A7 (Material damage or loss) obtained a total score of 77 with an average of 15.4, thus categorized as high risk. This process produces a risk map that facilitates the visualization of project risk levels. The data obtained from the questionnaires were processed by measuring the probability and impact of each risk. The processed results were then mapped into a risk map to classify risks into three categories: high risk, moderate risk, and low risk. This analysis aims to prioritize risks that require immediate attention and to formulate appropriate mitigation strategies.

3. Result and Discussion

The findings of this study were obtained through the collection of both primary and secondary data, which were then processed using the purposive sampling method. Primary data consisted of questionnaires distributed to stakeholders involved in the HM Yamin Underpass project, while secondary data were derived from project documents. The analysis was conducted by classifying risks based on their probability and consequence, resulting in three categories: high risk, moderate risk, and low risk.

3.1 *Project overview*

The construction of the HM Yamin Underpass in Medan Timur District aims to reduce traffic congestion and improve interregional connectivity. The project is carried out by PT. Galih Medan Persada, with an implementation period spanning from 2023 to early 2025. During its execution, the project encountered several challenges, including changes in work plans, unpredictable weather conditions, and internal constraints within the contractor's organization, all of which affected project progress.



3.2 Recapitulation of observations

The recapitulation of observations was conducted by grouping risks according to their probability and consequence. This classification produced three main categories: high risk, moderate risk, and low risk.

Primary data were obtained from 13 risk variables related to materials and labor (such as requests for increased overtime wages, insufficient labor availability, low productivity, delays in material delivery, rising material costs, material damage or loss, worker accidents, and strikes). Respondents included the Project Manager, Site Manager, HSE Manager, Foreman I, and Foreman II, ensuring that the data reflected perspectives from various parties directly involved in the project. Secondary data consisted of project documents, implementation reports, and administrative records supporting the risk analysis, including notes on work delays and accident reports.

Table 1. Questionnaire Data on Material and Labor Risk

Risk Code	Risk Variable	Project Manager		Site Manager		HSE Manager		Foreman I		Foreman II		Data Processing	
		I	P	I	P	I	P	I	P	I	P	Total (PxI)	Average
A1	Request for increased overtime wages	3	2	2	3	3	2	4	4	3	4	46	9,2
A2	Insufficient number of workers	4	2	4	3	4	4	4	2	5	3	59	11,8
A3	Low labor productivity	2	3	4	2	5	3	4	3	3	2	47	9,4
A4	Delayed delivery of equipment and materials	4	4	4	2	3	4	2	1	4	3	50	10
A5	Increase in material prices	2	3	3	3	3	3	3	2	2	4	38	7,6
A6	Inaccurate volume of delivered materials	2	4	4	1	4	4	4	3	3	3	49	9,8
A7	Material damage or loss	2	4	3	4	5	5	5	4	4	3	77	15,4
A8	Insufficient material storage space	4	3	3	1	3	3	2	1	3	2	32	6,4
A9	Lack of waste disposal facilities	3	3	2	2	3	3	2	2	3	2	32	6,4
A10	Worker accidents	4	4	1	3	5	5	3	1	5	4	67	13,4
A11	Worker disputes	2	3	2	4	4	4	1	1	2	2	35	7
A12	Labor strikes	2	2	5	1	5	5	4	3	3	5	61	12,2
A13	Unskilled labor	4	1	3	3	5	5	2	1	5	3	55	11

From Table 1 (Material and Labor Risks), it can be observed that the variables with the highest scores are material damage/loss (A7) and worker accidents (A10). Both are classified as high risk because they have a direct impact on project costs and safety. Meanwhile, variables such as insufficient material storage space (A8) and lack of waste disposal facilities (A9) have low scores (6.4) and are therefore categorized as low risk.



Table 2. Questionnaire Data on Implementation Risk

Risk Code	Risk Variable	Project		Site		HSE		Foreman I		Foreman II		Data Processing	
		I	P	I	P	I	P	I	P	I	P	Total (PxI)	Average
B1	Loss due to design errors	2	3	4	2	4	3	4	2	4	3	46	9,2
B2	Cracking or ground settlement	3	3	3	2	4	4	4	3	3	3	52	10,4
B3	Poor implementation timing	2	4	4	3	3	3	5	1	3	2	40	8
B4	Errors in construction and electrical equipment/machinery	2	3	3	4	4	4	3	2	4	3	52	10,4
B5	Uneven installation during concrete casting	3	4	4	4	5	5	4	1	4	2	65	13
B6	Issues during piling/drilling	2	3	4	2	5	5	3	2	3	2	51	10,2
B7	Delays and scheduling issues	1	4	5	3	3	3	2	3	4	3	46	9,2
B8	Coordination problems during implementation	3	4	3	3	3	3	3	2	2	4	44	8,8
B9	Concrete quality not meeting specifications	2	3	2	2	3	3	4	1	3	2	29	5,8
B10	Errors in structural calculations and analysis	3	3	4	2	5	5	3	3	4	3	63	12,6
B11	Incorrect assumptions during planning stage	4	1	3	1	5	5	2	1	2	4	42	8,4

From Table 2 (Implementation Risks), the variables with the highest scores are uneven installation during concrete casting (B5), with a score of 65 (average 13), and structural calculation errors (B10), with a score of 63 (average 12.6). Both are categorized as moderate to high risk because they have the potential to reduce construction quality.

The risk classified as high risk is material damage and loss. This risk has both a high probability and severe consequences, as it directly affects project costs and execution time. Addressing this risk is therefore a top priority in mitigation strategies.

Moderate risks include delays in material delivery and labor disputes. Although their impact is not as severe as high-risk factors, they still affect project continuity and must be managed through effective supervision and communication systems.

Low risks consist of minor design changes and weather-related factors [9]. These risks have relatively low probability and impact, but they should still be anticipated to avoid disruptions to the project schedule and final quality.

3.3 Risk mitigation

Mitigation strategies are formulated based on the identified risk categories [10]. The proposed strategies include:



For risks classified as high, the mitigation approach must be more intensive because these risks have the greatest potential to disrupt project performance in terms of time, cost, and quality. In this context, strengthening security supervision becomes essential to reduce the possibility of material loss or damage on site. This effort should be supported by proper material organization, including systematic arrangement, clear identification, and controlled access to construction materials. In addition, materials should be placed in secure and suitable storage locations so that their condition can be maintained and the likelihood of theft, misplacement, or deterioration can be minimized.

For moderate risks, the emphasis of mitigation lies in improving operational coordination and workflow reliability. Material delivery systems need to be managed more effectively to avoid delays that may interrupt construction activities and create idle time for labor and equipment. At the same time, coordination among foremen should be enhanced to ensure that daily activities remain synchronized across different work sections. Communication between project management and workers also needs to be strengthened so that instructions, responsibilities, and project targets are clearly understood and potential disputes can be addressed before they affect project execution.

Meanwhile, risks categorized as low still require attention, even though their impact is relatively limited. Anticipatory actions such as adjusting work schedules in response to weather conditions can help maintain continuity of activities and prevent avoidable delays. Likewise, closer coordination with the planning team is necessary to ensure that minor design changes are communicated and implemented efficiently, so that they do not develop into larger disruptions during construction. Taken together, these mitigation measures reflect a structured risk management approach in which preventive and corrective actions are aligned with the severity of each risk category, thereby supporting smoother and more controlled project implementation.

4. Conclusion

This study demonstrates that the construction of the HM Yamin Underpass project is exposed to various risks that influence cost, quality, and time performance, with material damage and loss identified as the most critical risk due to its significant effect on project progress and its need for special handling. Overall, the project risks can be classified into three levels, namely high, moderate, and low risk. The high risk category is represented by material damage and loss, while moderate risks include delays in material delivery and labor disputes, and low risks consist of minor design changes and unpredictable weather factors. To address these uncertainties, risk mitigation measures are implemented through strengthened security supervision, better material organization, and the placement of materials in effective storage locations. In general, the application of appropriate risk management can reduce the negative impact of uncertainty and support the success of construction projects. With proper risk identification, analysis, and mitigation, the HM Yamin Underpass project may also serve as a useful reference for managing risks in similar construction projects in the future.

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