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Risk Analysis of Construction Delays in High-Rise Projects

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ABSTRACT: Delays in construction projects remain a critical challenge in project management, often resulting in schedule deviations, cost overruns, and reduced project quality. This study investigates the primary risk factors contributing to delays in a high-rise educational building project (XYZ School) in Indonesia. Adopting a descriptive qualitative approach, data were collected through structured interviews and questionnaires with ten experienced construction professionals. The analysis utilized the Fishbone (Ishikawa) diagram to trace causal pathways and a probability–impact matrix to assess the severity and likelihood of each identified risk. Findings reveal that financial instability—particularly due to fluctuations in material prices (e.g., steel rising from IDR 8,800 to IDR 12,000/kg)—and poor cash flow management are the most critical causes of delay. Other significant risks include frequent design revisions, labor fatigue from excessive overtime, and adverse weather conditions. The study concludes with strategic recommendations to mitigate these risks, emphasizing improved financial planning, enhanced design coordination, and proactive contingency scheduling.

KEYWORDS: Construction delay, Risk analysis, Fishbone diagram, High-rise building, Project management, Probability-impact matrix

I. INTRODUCTION

Construction projects are inherently complex undertakings, frequently subject to delays resulting from a variety of interrelated factors. Timely project completion is critical not only for meeting stakeholder expectations but also for achieving economic efficiency and avoiding contractual penalties (Doloi et al., 2012; Sambasivan & Soon, 2007). Such delays often stem from deficiencies in project planning, design inconsistencies, labor shortages, escalating material costs, and unforeseen environmental conditions (Love et al., 2016; Le-Hoai et al., 2008).

In Indonesia, the construction sector has experienced significant growth fueled by both public and private investments. Despite this expansion, numerous projects continue to face productivity inefficiencies and schedule overruns (Hwang et al., 2013). The XYZ School building project, a high-rise construction initiative, exemplifies these challenges, having experienced notable delays primarily due to material price volatility and internal cash flow disruptions.

Conducting a systematic risk analysis in such contexts is essential for identifying the root causes of delay and devising mitigation strategies. These strategies must be aligned with contemporary project management standards, such as those outlined in the Project Management Body of Knowledge (PMBOK® Guide) (PMI, 2021).

This study seeks to address this issue by investigating the key causes of delay in a real-world Indonesian high-rise construction project. Employing the Fishbone (Ishikawa) diagram and a probability–impact risk matrix, the study aims to generate actionable insights and propose practical recommendations to minimize future delays and enhance overall project performance.

II. METHODOLOGY

This study adopts a descriptive qualitative approach to investigate the root causes of delays in a high-rise school building construction project in Indonesia. The methodology combines primary data collection with established analytical tools to identify and evaluate key risk factors affecting project timelines.

A. Data Collection

Primary data were gathered through structured questionnaires and semi-structured interviews involving ten professionals directly engaged in the project. Respondents included project managers, site engineers, architects, quantity surveyors, and consultants. A **purposive sampling technique** was employed to ensure the inclusion of participants with relevant domain expertise (Creswell, 2013). The research instruments were assessed for validity and reliability using SPSS, with all items meeting the required thresholds for inclusion.

B. Risk Identification

Drawing from a combination of literature review and expert validation, risk factors were categorized into seven domains: materials and equipment, labor, contractual, implementation, design and technology, management, and force majeure. These categories incorporate and adapt variables from previous studies on construction risk assessment (Ade Asmi et al., 2010; Doloi et al., 2012).

C. Analytical Tools

1. **Fishbone Diagram (Ishikawa)**
   The Fishbone diagram was employed to systematically classify and visualize the root causes of delay, organizing them into causal branches aligned with the seven risk domains (Ishikawa, 1986).
2. **Probability–Impact Matrix**
   Each identified risk factor was assessed based on its likelihood of occurrence and potential impact severity. Risk scores were calculated using the formula: **R = P × I**, where *P* represents the probability of occurrence and *I* denotes the impact severity (Williams, 1993; PMI, 2021).

This methodological framework provides a structured and rigorous basis for understanding the multidimensional nature of construction delays and for prioritizing risks based on their relative significance to project performance.

III. RESULTS AND DISCUSSION

This section presents the empirical findings derived from the field investigation, focusing on the identification and analysis of key risk factors contributing to delays in the construction of a high-rise educational facility. The results are structured into thematic subsections based on data collected through interviews, questionnaires, and subsequent analytical evaluations. Key insights are organized around respondent characteristics, classification of delay risks, and the output of the Fishbone diagram and probability–impact matrix analysis. These findings are further interpreted in light of relevant literature to offer a comprehensive understanding of delay dynamics in complex construction environments.

A. Respondent Profile:

The study involved ten key informants representing various functional roles in the high-rise school construction project, including project managers, architects, site engineers, quantity surveyors, and consultants. The diversity in professional backgrounds ensured a comprehensive understanding of project risk from multiple perspectives (Table 1).

TABLE 1. RESPONDENT PROFILE

Role	Number of Respondents
Project Manager	2
Site Engineer	2
Architect	2
Quantity Surveyor	2
Consultant	2
Total	**10**

B. Identified Risk Factors

Through literature synthesis and expert input, delay risk factors were classified into seven major categories: materials and equipment, labor, contractual issues, implementation challenges, design and technology, management, and force majeure. A total of 25 specific risk indicators were examined based on this classification framework.

C. Fishbone Diagram Analysis

Figure 1 presents the Fishbone (Ishikawa) diagram, which visually maps the root causes of delay within each domain. For instance, under the management and materials category, significant issues included steel price volatility (e.g., increasing from IDR 8,800 to IDR 12,000/kg) and contractor cash flow constraints. In the design and technology domain, frequent revisions and delayed drawing approvals were major contributors. Meanwhile, excessive overtime led to fatigue and lower productivity in the labor domain. Force majeure factors such as prolonged rainy seasons disrupted on-site activities.

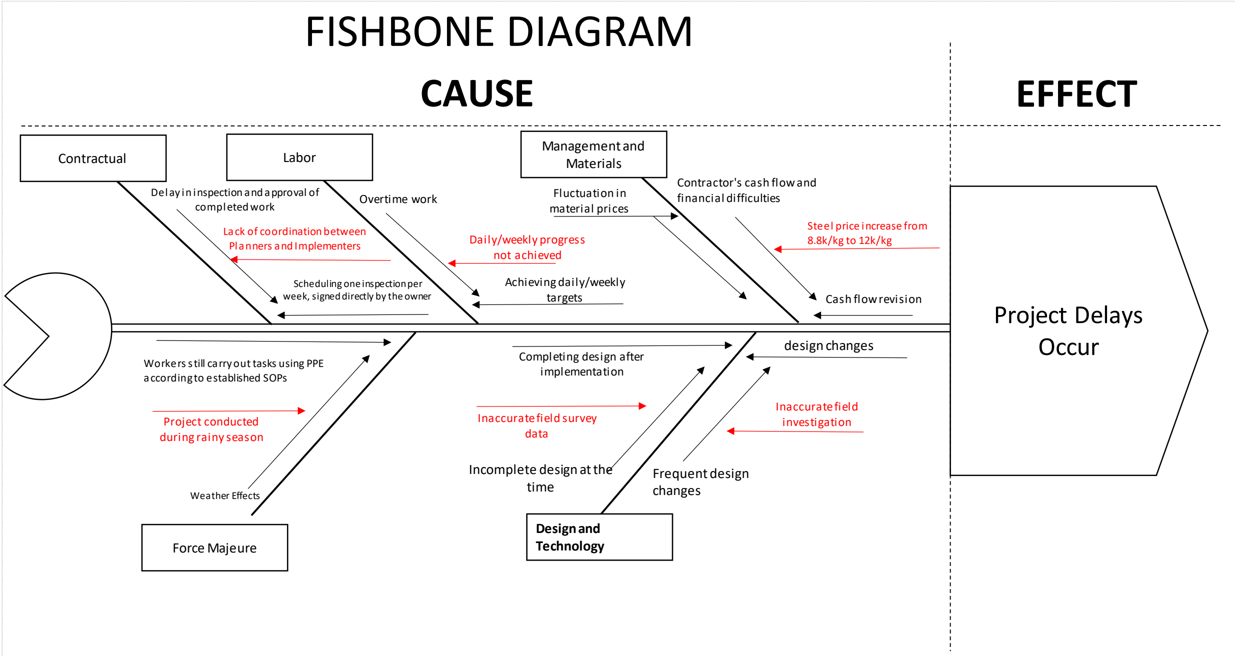

Figure 1. Fishbone Diagram of Project Delay Causes

D. Probability–Impact Risk Matrix

Each risk was scored based on probability and impact severity. Table 2 summarizes the top-ranked risks based on calculated risk scores:

Table 2. Top Delay Risk Factors Based on Risk Score (R = P × I)

Rank	Risk Factor	Risk Score
1	Material Price Escalation (Steel, Cement)	25
2	Cash Flow Problems	20
3	Frequent Design Changes	16
4	Adverse Weather Conditions	15
5	Labor Fatigue from Overtime	12

A **probability–impact (P–I) matrix** was employed to assess and quantify the severity of each identified delay factor. Risks were scored by multiplying the estimated probability of occurrence by the perceived impact severity ($R = P \times I$). Results revealed that **financial and material-related risks**—such as cash flow problems and price escalation—achieved the highest scores (risk score > 12), categorizing them as **'unacceptable'** per established risk thresholds (Godfrey, 1996; Hwang et al., 2013). These risks demand **immediate mitigation strategies** due to their potential to critically disrupt project timelines and budget allocations.

Subsequent high-risk categories included design inconsistencies and labor-related issues, which also pose considerable threats to project continuity. The use of the risk matrix provided a practical basis for **prioritizing mitigation actions**, ensuring that limited resources are allocated to the most critical concerns affecting project success.

F. Discussion

The analysis reveals that financial and material-related factors pose the most significant risks to project timelines. The escalation of steel and cement prices—such as the increase from IDR 8,800 to IDR 12,000/kg—combined with ineffective cash flow management, emerged as primary contributors to delay. These findings align with previous studies highlighting that price volatility and inadequate financial planning are among the most critical threats in construction projects, particularly in emerging markets (Doloi et al., 2012; Love et al., 2016; Hwang et al., 2013).

Frequent design changes were also identified as a high-impact risk, indicating deficiencies in design coordination and client–consultant communication. This supports Le-Hoai et al. (2008), who emphasize that design instability can cause cascading delays in construction sequencing and approvals. Similarly, excessive labor overtime resulting in fatigue and declining productivity resonates with the findings of Sambasivan and Soon (2007), who noted the detrimental effects of overextended work schedules on overall performance.

Environmental and force majeure risks—such as prolonged rainy seasons—further exacerbate project uncertainties. While such risks are partly predictable, their persistent neglect in planning documents indicates a gap in strategic risk preparedness. The integration of semi-quantitative tools (e.g., risk matrix) with visual diagnostics (Fishbone diagram) proved effective in capturing both systemic and operational causes of delay. This multi-method approach reflects current best practices in project risk management, as recommended in the PMBOK Guide (PMI, 2021) and corroborated by Williams (1993) in construction risk modeling.

The study highlights the need for institutionalizing risk management protocols at the early project stages, emphasizing pre-contract financial analysis, stakeholder design validation, and weather-adjusted scheduling. By addressing these dimensions proactively, construction firms in Indonesia and similar contexts can significantly enhance project delivery outcomes.

IV. CONCLUSION AND RECOMMENDATIONS

This study explored the dominant factors contributing to delays in the construction of a high-rise school building project in Indonesia using a risk-based framework. The findings highlight that financial instability due to material price fluctuations and contractor cash flow issues are the most significant causes of delay. Other major contributors include frequent design revisions, inadequate labor management, and extreme weather conditions.

Through the integration of the Fishbone Diagram and the Probability-Impact Matrix, the study has systematically identified and prioritized key delay risks. Such an approach allows for more structured mitigation planning and aligns with globally accepted project risk management practices.

Recommendations from this study include:

1. Strengthening contractor financial health through improved budgeting and contingency funds.
2. Enhancing early-stage project planning with complete and approved designs to reduce revisions.
3. Improving coordination between design consultants and site teams to minimize rework.
4. Instituting weather-contingency scheduling during the rainy season.
5. Employing regular risk reviews using established frameworks like PMBOK.

Future studies could expand by incorporating quantitative models such as Monte Carlo simulations or machine learning to predict delay probabilities under uncertainty.

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