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Risk Analysis of the Supply Chain of Building Project Construction Materials (Hasna Medika Majalengka Heart Clinic)

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Abstract
This research aims to analyze risks in the construction material supply chain to ensure the efficiency and success of the project. The study focuses on the strategic project for the construction of the Hasna Medika Heart Clinic Building in Majalengka, where the dependence on material availability and supply chain complexity makes risk management crucial to prevent delays and cost overruns. The research methods used are a mixture of qualitative and quantitative, including field observations, interviews, and preliminary and main surveys to seven and ten expert respondents from contractors and suppliers. Data are analyzed to identify and assess the frequency of risk emergence. The results of the study identified 18 risk variables. The analysis shows differences in antara_kontraktor_dan_supplier perceptions of the most sering_terjadi risiko_yang. The contractor noted the main risk on the change of order (A2, 27.78%), additional requests from the owner (A5, 25.93%), and increases in material prices (A16, 27.78%). Meanwhile, suppliers are more concerned about inaccurate schedules from contractors (A1, 25.93%) and delivery delays due to payment problems (A9, 25.93%). However, both sides reached consensus on two of the most critical risks that are equally frequent, namely ineffective communication (A12) and rising material prices (A16). In conclusion, effective communication and price fluctuation management are the key priorities for mitigating supply chain risks in construction projects, and contractors and suppliers should establish transparent coordination mechanisms and adaptive budget planning to prevent delays and cost overruns.

INTRODUCTION

Construction projects are planned activities that involve various resources and parties to build infrastructure or buildings. The construction industry in Indonesia is growing rapidly, driven by high public demand. This growth gives rise to fierce competition that demands every actor to provide the best value and minimize waste, driving the adoption of efficient concepts such as Lean Construction.

This research focuses on the construction project of the Hasna Medika Heart Clinic Building in Majalengka. This four-story building with a reinforced concrete structure is a strategic initiative to improve heart health services for the local community. The smooth running of a project is highly dependent on the availability of key materials, requiring an integrated and efficient material management system (Pitkänen, 2024).

To ensure that materials are available at the right time and place, effective *Supply Chain Management* (SCM) is required (Kaushik, 2018; Okeagu et al., 2021). SCM regulates the entire material flow from planning to distribution, which is critical to avoid delays and cost overruns.

However, the supply chain of construction projects is very complex and dynamic, vulnerable to various disruptions that can disrupt the smooth running of the project.

In its implementation, construction projects are always faced with unexpected risks, one of which is the delay in the delivery of materials. These delays can hinder worker activities, slow progress, disrupt schedules, and trigger cost overruns (Al-Keim, 2017; Anysz, 2019; Gurumayum, 2025). Previous research has identified that the dominant risk factor causing delays is often related to materials, such as sudden design changes or financial issues that interfere with shipping. Therefore, to minimize negative events and losses, the implementation of effective risk management is crucial (Hopkin, 2018; Meyer & Reniers, 2025; Tupa et al., 2017). Risk management needs to be carried out from the beginning of planning through the process of identifying and evaluating potential risks, especially risks that have the potential to cause long-term problems, so that their negative impacts can be anticipated and prevented (Hopkin, 2018; Pratama, 2021).

Several studies have examined supply chain risks in construction projects. Koskela (1997) introduced the concept of construction supply chains as distinct from manufacturing, highlighting fragmentation and uncertainty as key characteristics. Pujawan (2005) and Indarjit (2002) emphasized that effective SCM can reduce waste and improve project performance. In the Indonesian context, Dei (2017) analyzed supply chain risks in building construction projects in Bali and identified several critical risk variables. Sutoni (2019) studied risk in construction supply chains for office renovation projects and found that communication problems and material price fluctuations are dominant. Hatmoko and Kistiani (2017) developed a simulation model for material supply chain risks in building construction, showing that delay risks can propagate through the supply chain. Marzouk (2014) analyzed delay causes in Egyptian construction projects and found that material-related factors are among the top causes. More recently, Anggun (2022) examined supply chain risks in a mall upgrade project in Makassar, highlighting differences in risk perception between contractors and suppliers. However, most prior studies focus on general building projects or commercial infrastructure, with limited attention to healthcare facility construction such as heart clinics, which have unique requirements for material quality, timeliness, and regulatory compliance.

Despite the growing body of literature on construction supply chain risks, several gaps remain: most existing studies focus on general buildings rather than specialized healthcare facilities like heart clinics, they analyze risks from either contractor or supplier perspectives separately without systematic comparison, and few identify consensus-based critical risks agreed upon by both parties (Alfaruqi, 2020; Hatmono, 2017; Sutoni & R., 2019). The novelty of this research lies in focusing on a heart clinic construction project with unique supply chain requirements, employing a comparative perception analysis between contractors and suppliers within the same project, using a mixed-method approach with expert and main surveys, and identifying consensus-based critical risks (ineffective communication and material price increases) that provide a practical foundation for collaborative mitigation.

Based on these gaps and novelty, this study aims to identify and analyze supply chain risks for the Hasna Medika Heart Clinic Building project in Majalengka, assess the frequency of each risk variable from both contractor and supplier perspectives, compare perceptions between the two parties, and determine common critical risks prioritized for mitigation.

Theoretically, this research enriches construction supply chain risk management literature by providing empirical evidence from a specialized healthcare context and introducing a comparative perception framework. Practically, the findings serve as strategic input for project owners, contractors, and suppliers in designing collaborative mitigation strategies, improving communication protocols, and developing contingency plans for material price fluctuations, while also offering a replicable risk assessment methodology for other healthcare infrastructure projects.

METHODS

This research utilized data from the projects under investigation, especially those related to material supply chain activities and risks from suppliers to project sites through contractors. The data collection techniques used include Direct Observation, which is direct monitoring at the project site of the material supply chain management system. Data collection with interviews was carried out through a question-and-answer dialogue with resource persons from contractors and suppliers in accordance with research variables regarding the material supply chain. An initial survey was carried out to test the suitability of risk variables from the literature with the actual situation in the field. Seven experts were asked to provide an assessment of the suitability of each variable (relevant/irrelevant) and could propose additional risk variables that had been experienced. The core survey aims to obtain an assessment of the risk variables that have been validated. Ten respondents (5 contractors and 5 *suppliers*) assessed the level of occurrence of each risk using a scale of 1-3 (never, ever, often). The results of this evaluation are then described as variable indicators for the next analysis process.

Data Analysis

Data from the predecessor and main surveys were then processed to segment the level of risk (low, medium, high) in the material supply chain, using frequency-based grouping techniques and statistical distribution to identify risk patterns that may arise from supply variability, material quality, or logistical disruptions. The steps of the data analysis include Risk Probability Calculation, which is carried out by calculating the probability percentage value for each risk variable based on the respondents' answer scale from the questionnaire, using precise calculation methods such as Bayes probability formulas or relative frequency analysis to ensure accuracy in assessing the likelihood of risk occurrence, so as to support strategic decision-making in construction project management. This process not only helps in risk mitigation but also allows integration with supply chain simulation models for large-scale civil engineering projects, such as in this case study of the Hasna Medika Majalengka heart clinic building project, where timeliness and material quality are crucial.

$$\text{Percentage (\%)} = \frac{\text{Jumlah Skor Responden} \times 100\%}{\text{Jumlah Skor Jawaban Ideal}}$$

$$\text{Percentage (\%)} = \left(\frac{(a_1x_1+a_2x_2+a_3x_3)}{18\times(x_1+x_2+x_3)}\right) \times 100\%$$

Description:
a = Assessment constant (1 to 3)
xi = Respondent’s assessment

Furthermore, the probability percentage of a risk event can be classified according to the following risk-level scale:
0% < Percentage (%) < 25% = very low
25% < Percentage (%) < 50% = low
50% < Percentage (%) < 75% = high
75% < Percentage (%) < 100% = very high

Drawing conclusions after risk variable gets its category level, conclusions are drawn based on the results of the data that has been obtained and analyzed.

Research Steps

This research was carried out systematically through eight consecutive stages. The first step is Literature Study with the collection and deepening of theory as the basis for research. The second step is to determine the research object by determining the focus of the study to be researched. The third step is to identify risks by collecting risk data through direct observation and interviews using questionnaires (preliminary and main surveys). The fourth step is Data Analysis by Analyzing the data by calculating the percentage of probability for each risk variable. The fifth step is Risk Assessment by Grouping each risk into its level category (low, medium, high) based on the results of the percentage calculation. The sixth step is Data Verification by Validating the correctness of the data by requesting confirmation from the relevant parties. The seventh step is to discuss the results by discussing the findings obtained from the data analysis. The eighth step is Conclusions and Suggestions by summarizing the results of the research and providing recommendations.

RESULTS AND DISCUSSION

Analysis Results

The process begins with a literature study to obtain initial risk variables that are general. These variables were then validated by expert respondents who had at least 4 years of experience in their fields and were directly involved in the supply chain of the Hasna Medika Heart Clinic Building project. Respondents consisted of representatives of contractors (such as *Project Managers, Site* Managers) and *suppliers* (such as *ready-mix* concrete *suppliers*).

Validation was carried out by asking respondents to assess the suitability of each variable with field conditions, by choosing "relevant" or "irrelevant". Variables are considered "relevant" if they ever occur and will be included in the risk list, while "irrelevant" ones will be excluded. Respondents were also given the opportunity to add other risk variables based on their experience in the field.

Table 1. Survey Questionnaire Question Form

No	Risk Identification	Relevant	Not Relevant	Reference
1	Change in material orders because the contractor did not schedule properly			Josefineer (2007)
2	Additional material orders due to specification changes			Nurcahyo & Wiguna (2016)

3	Material re-delivery due to work errors and drawing discrepancies	Josefineer (2007)
4	Material wastage due to inaccurate material planning	Josefineer (2007)
5	Requests for additional items from the owner outside the initial design	Marzook (2014)
6	Changes in material delivery due to limited supplier stock	Nugraheni (2012)
7	Reordering to cover incomplete work	Jumiadi (2014)
8	Difficulty in finding materials	Marzook (2014)
9	Changes in material delivery due to payment issues	Marzook (2014)
10	Long material delivery time	Marzook (2014)
11	Re-delivery due to material quality not matching specifications	Josefineer (2007)
12	Poor communication between subcontractors	Josefineer (2007)
13	Late material delivery due to production issues at the factory	Hartoko & Kistiani (2017)
14	Reordering due to damaged/missing materials in storage	Josefineer (2007)
15	Reassembly of materials that have already been installed	Jumiadi (2014)
16	Material price increases	Marzook (2014)
17	Sudden material orders	Marzook (2014)
18	Material delivery delayed due to full storage	Josefineer (2007)

Source: Authors' design based on literature review and expert validation (2024)

The percentage probability value for each risk variable was then used to compile the data obtained from the respondents' assessment findings. This approach allows the identification of specific risks such as material shortages or quality issues that often occur in civil engineering projects. The selected respondents amounted to 5 people from the contractor's side, selected based on their experience in project management to ensure the validity of the data collected through a structured questionnaire. The results of the calculations that have been carried out will then be classified based on risk categories, such as low, medium, or high, to facilitate the prioritization of mitigation and the development of prevention strategies in accordance with construction industry standards. As an illustration, an example of the risk calculation can be seen in the description below, which shows how the percentage value is calculated and categorized to provide practical insights for construction practitioners in effectively managing supply chain risk. This approach not only improves assessment accuracy but also supports integration with modern project management tools, such as risk simulation software, for large-scale projects that require high precision in planning and execution. The example of risk calculation can be seen in the description below:

Table 2. Contractor-to-Supplier Risk Assessment

Code	Risk Identification	Risk Occurrence Scale		
		1	2	3
A4	Material wastage due to inaccurate material planning	2	2	1

Source: Primary data processed

Based on Table 2 above, respondents appear to have rated one of the risk variables as follows: two votes for scale 1 "never happened," two votes for scale 2 "never happened," and one vote for scale 3 "happened often." The Risk Probability calculation equation is then used to perform the calculation, resulting in a percentage by 16.67%. Therefore, the variable A4 risk falls into the risk group 0% < Percentage (%) < 25% or very low. This shows that these risks are rare in project activities and have little influence on project implementation.

Risk Grouping

Each risk variable is then categorized based on the previous analysis stage which is carried out on data from the perception of each respondent, both from the contractor and the supplier. The authors then respond to each of these risk variables after identifying hazards with low or common categories in construction project operations. The findings of the grouping of risk factors classified as low in supply chain management activities in the Hasna Medika Majalengka heart clinic construction project are shown in Tables 3 and 4. The grouping of risks is as follows:

Table 3. Results of Frequent Risk Grouping from Contractor Research Perceptions of Suppliers

Code	Risk Variable	Value %
A2	Additional material orders due to specification changes	27.78
A5	Requests for additional items from owner outside the initial design	25.93
A16	Material price increases	27.78

Source: Primary data from contractor survey

Table 4. Results of Frequent Risk Grouping from the Perception of Supplier Assessment of Contractors

Code	Risk Variable	Value %
A1	Change in material orders because the contractor did not schedule properly	25.93
A9	Changes in material delivery due to payment issues	25.93

Source: Primary data from supplier survey

There are hazards faced by both suppliers and contractors, as shown in tables 3 and 4 above. These shared risks can affect the project's ability to run smoothly, as well as cause losses for both parties. Two common risk variables with percentage values above 20% were revealed from the analysis findings. Table 5 below shows the categorization of shared risks between suppliers and contractors:

Table 5. Results of Risk Grouping between Contractors and *Suppliers*

Code	Risk Variable	Value %	
		Contractors	Suppliers
A12	Poor information and communication	22,22	27,78
A16	Rising material prices	20,37	22,22

Source: Primary data processed from main survey questionnaire

The implementation of good project management, including effective material supply chain management, is essential to guarantee the success of the project. In the Hasna Medika Heart Clinic Building project, supply chain management involves a direct relationship between contractors (PT. Assad Dian Abadi) with two *main suppliers* (PT. Multibrata Anugerah Utama and CV Puncak Jaya Baja). The procurement method is carried out directly by the contractor, starting with a price survey to ensure quality and competitive prices.

Although the contractor has control over supply chain activities, the research in the field identifies various undesirable events from both parties (the contractor and *the supplier*) that are categorized as risks at the material procurement stage.

Based on the analysis of data from the survey, the implementation of supply chain management in this project has an acceptable level of risk and is not too high. This shows that even though there are still deviations from the plan, the system implemented is considered quite good. However, to minimize delays or project failures, more appropriate and good handling from the people involved is needed to reduce the existing risks.

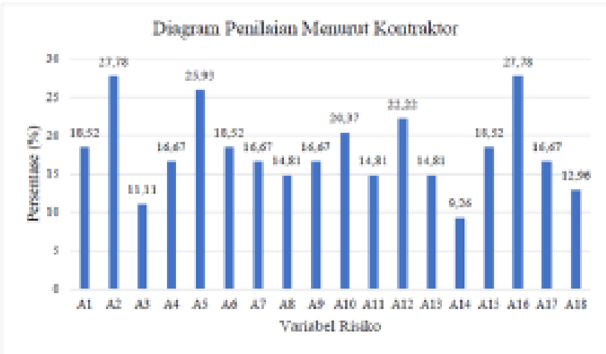

Figure 1. Diagram of Risk Assessment Results According to Contractors to Suppliers

Source: Primary data processed from contractor survey questionnaire

Risk A2 "Additional material orders due to specification changes" (27.78%), Risk A16 "Increase in material prices" (27.78%), and Risk A5 "Additional requests from owners beyond the initial design" (25.93%) were the three material supply chain risks with the highest percentage value based on contractors' perceptions of suppliers, according to the results of the questionnaire analysis. These findings suggest that risks related to specification modifications, increased material costs, and extra demands from owners are top priorities that must be addressed through more adaptive planning and robust contract negotiations, to reduce potential cost overruns and delays in civil engineering construction projects. This approach not only aids in risk mitigation but also supports integration with predictive analysis tools, such as risk simulation models, to ensure sustainability and efficiency in the execution of large-scale infrastructure projects.

Risks in the material supply chain to the Contractor may cause several negative impacts to the Contractor, such as delays in work due to under-delivery of materials, which may take time for redelivery. This can reduce contractors' profits by up to 28.9%. Cost *overrun* outside the initial budget plan, especially due to the increase in material prices. Additional costs and cash flow disruptions due to sudden additional requests from owners that require contractors to find new materials and incur unexpected costs.

Mitigation Measures that the Contractor can take to overcome these risks, the Contractor can take steps on materials that do not meet specifications, the Contractor can hold *the supplier* accountable to replace or resend the appropriate materials. Then the material price increases, the Contractor can prepare a reserve budget and make a clear contractual agreement with *the supplier*, including a price negotiation clause, from the beginning of the project.

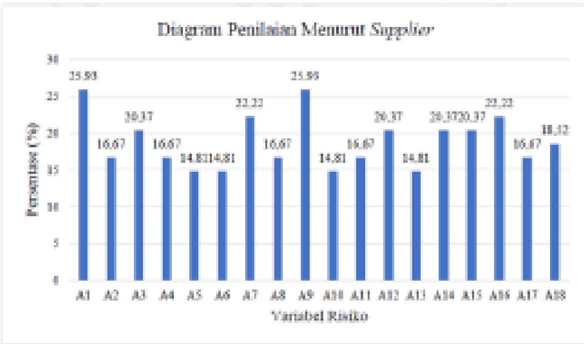

Figure 2. Diagram of Risk Assessment Results According to Suppliers to Contractors

Source: Primary data processed from contractor survey questionnaire

Based on results of the questionnaire analysis, Risk A1 "Change in material orders due to contractors' inaccuracies in preparing schedules" (25.93%) and Risk A9 "Delays in material delivery due to problems in the smooth delivery of contractor costs" (25.93%) are the material supply chain risks with the highest percentage value based on the supplier's perception of contractors. These findings suggest that issues related to planning schedules and financial flows are key factors that need to be addressed through mitigation strategies such as improved communication coordination and tighter budget management, to ensure smooth material supply in civil engineering construction projects. This approach not only helps in identifying priority risks but also supports the development of predictive models that can integrate data from various stakeholders, thereby improving the overall efficiency and success of the project.

Risks in the supply chain, particularly delays in the delivery of materials due to financial problems and inaccurate schedules from contractors, have the potential to result in delays in the implementation of projects. Suppliers are at risk of financial losses due to irregular payment flows from contractors. In order to anticipate these risks, effective communication between contractors and suppliers regarding payment procedures is required. Contractors also need to manage invoices properly to ensure smooth payments to *suppliers*. Table 6 shows the risk response or classification for each variable in the project that falls into the low category.

Table 6. Impact and Risk Response of Contractors and Suppliers

Party Impacted	Risk Variable	Risk Identification	Potential	Response
Contractor	3 risk variables	- Additional material orders due to specification changes - Requests for additional items from owner outside initial design - Material price increases	- Sudden cost changes, not matching initial budget plan	Contractor should prepare extra budget as contingency, hold regular coordination meetings, involve suppliers from project start, and negotiate with suppliers to meet needs
Supplier	2 risk variables	- Change in material orders because contractor did not schedule properly - Changes in material delivery due to payment issues	- Delays and disruption in material delivery - Operational costs limited - Reduced trust toward contractor	Maintain good communication with contractor, negotiate and settle payments, follow agreed design plans, ensure payment agreements with contractor

Source: Authors' synthesis based on survey analysis and risk mitigation framework

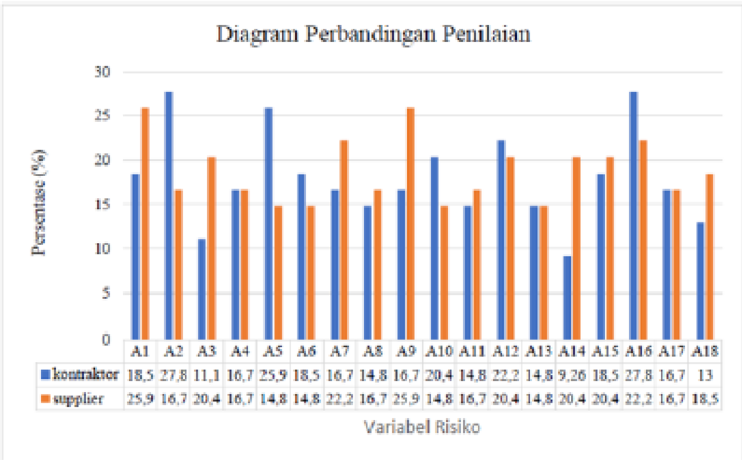

Figure 3. Comparison Diagram of Joint Risk Assessment Results between Contractor and Supplier

Source: Primary data processed from contractor survey questionnaire

The two parties have different levels of risk and percentage of risk, according to a comparison of risk assessments from the perspective of the contractor and the supplier. Risk A12, "Poor Information and Communication," and Risk A16, "Rising Material Prices," are two hazards that are evaluated at a percentage of 20% or higher and are classified as common, according to the comparison chart.

According to the findings of the comparative evaluation, there are two main hazards that are equally faced and can harm both contractors and suppliers. The first is less effective information and communication, which has the potential to damage the cooperative relationship in the material procurement process. The second is the increase in material prices, which forces contractors to revise budgets and requires suppliers to bear additional costs.

To avoid these risks, both parties need to build good and transparent communication and establish long-term cooperation. This risk not only leads to financial losses but also delays in work activities. Therefore, appropriate response and handling are required to address any risks that arise in the supply chain. Table 7 shows the author's reaction to the hazards encountered.

Table 7. Joint Impact and Risk Response between Contractors and Suppliers

Impacted Party	Risk Variable	Risk Identification	Potential	Response
Contractor & Supplier	2 risk variables	- Poor information and communication - Material price increases	- Errors in information regarding quality and cost of materials - Delays in material delivery - The work done becomes hampered or takes a long time, - Cooperative relations become less good	Contractor communicates effectively with supplier, provides notes on material orders. Supplier provides accurate info on quality and cost, calculates costs fairly, and maintains good cooperation from project start to finish.

Source: Primary data processed from contractor survey questionnaire

In the Hasna Medika Heart Clinic Building project, the contractor and *supplier* have done their job well despite some risks that are completely unavoidable. Smooth and harmonized communication between the two parties is a key element in implementing efficient supply chain management, in order to prevent losses for themselves and for the project itself. In the context of civil engineering construction management, this risk mitigation can be strengthened through the integration of digital technologies such as online collaboration platforms and predictive data analysis, which help in monitoring supply fluctuations and optimizing the allocation of resources for health projects such as clinic buildings, thereby improving the overall success of the project. This approach also supports the development of comprehensive prevention strategies, including team training and periodic audits, to minimize the impact of risks to construction schedules and budgets.

CONCLUSION

Research on Material Supply Chain Risk Analysis in the Hasna Medika Majalengka Heart Clinic Building project resulted in three main conclusions. The first conclusion is that Risk Identification was successfully identified 18 risk variables based on preliminary surveys and literature reviews. The second conclusion of Each Party's Perception, namely the

Contractor assesses the three most frequent risks, namely: changes in orders (A2 = 27.78%), additional *owner requests* (A5 = 25.93%), and increases in material prices (A16 = 27.78%). On the other hand, the *supplier* stated that there are 2 (two) different risk variables that they most often experience in practice, namely A1 (25.93%) and A9 (25.93%) Risk. The third conclusion of the Common Risk (Consensus) is that there are two risks that both parties agree to be the most frequent (percentage >20%), namely poor communication (A12) and material price increases (A16).

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