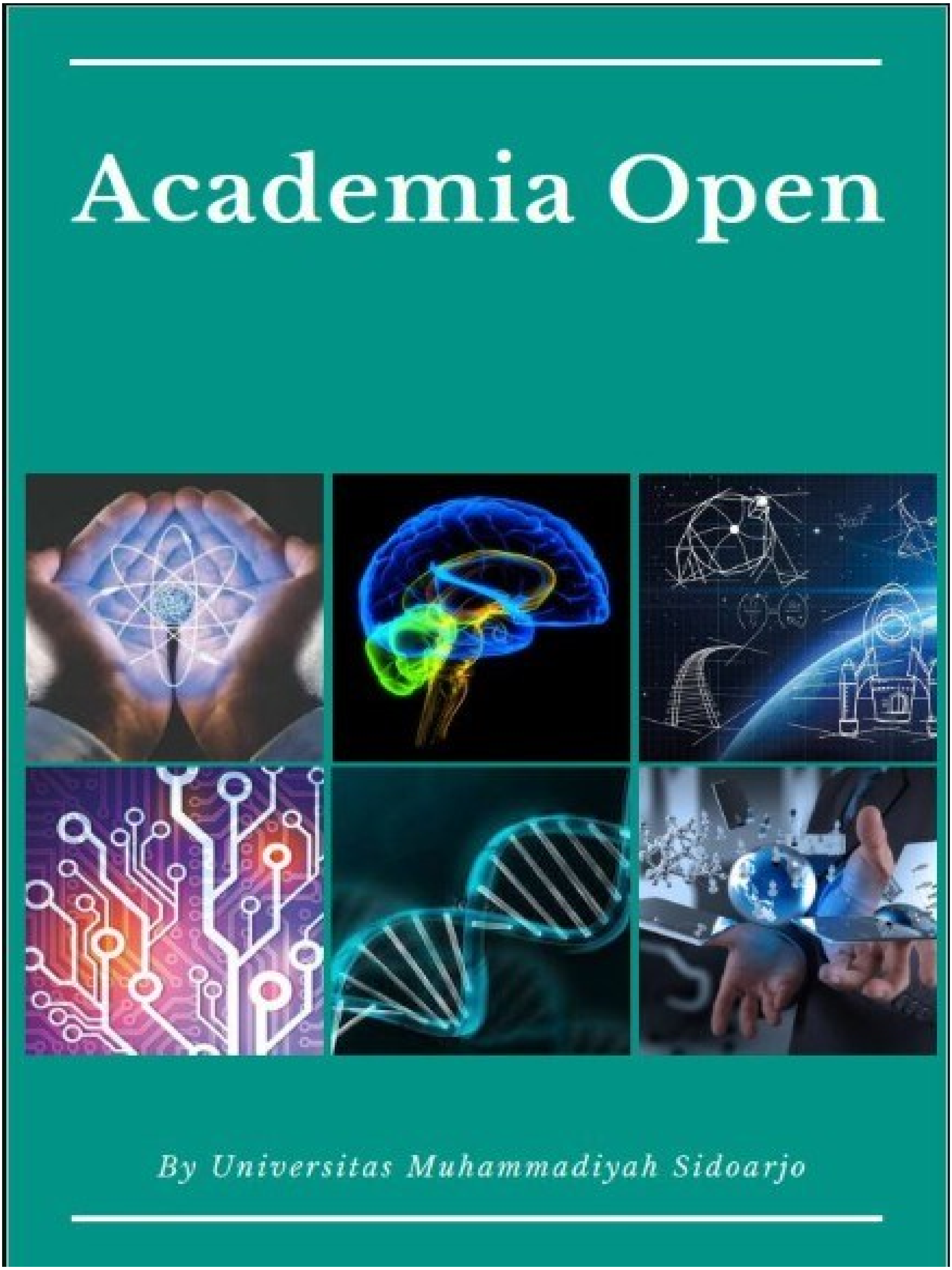
Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398



ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

Table Of Contents

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of any other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright Statement

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

Article information

Check this article update (crossmark)

Check this article impact (*)

Save this article to Mendeley

(*) Time for indexing process is various, depends on indexing database platform

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

Risk Management Analysis on Implementation Time Performance Using the House of Risk (HoR) Model in Toll Road Construction Projects

M. Iqbal Vikri Dzulfikar, iqbalvikrydz@gmail.com (*)

Program Studi Magister Teknik Sipil Fakultas Teknik Universitas Mercu Buana, Indonesia

Budi Susetyo, budi.susetyo@mercubuana.ac.id

Program Studi Magister Teknik Sipil Fakultas Teknik Universitas Mercu Buana, Indonesia

(*) Corresponding author

Abstract

General Background: Infrastructuredevelopment, particularlytoll road construction, playsacritical role in regional transformation and economic growth, yet project delays remain a persistent issue. **Specific Background:** In Indonesia, approximately 38% of toll road projects experience implementation delays, as observed in the Serang–Panimbang Toll Road Section 3 project, which underwent a significant time extension. **Knowledge Gap:** Limited knowledge and inadequate coordination in project risk management hinder effective identification and mitigation of delay-causing factors during the implementation phase. **Aims:** This study aims to analyze risk factors affecting time performance and determine priority mitigation strategies using the House of Risk (HoR) model. **Results:** The analysis identified 18 risk events and 18 risk agents categorized into technical, managerial, environmental, and external variables, with four dominant risk agents including design inconsistency with soil data, foreign loan dependency, unprepared technical-administrative data, and land acquisition issues. **Novelty:** The integration of HoR Phase 1 and Phase 2 with expert validation and N-Vivo analysis provides a structured prioritization of risk agents and corresponding preventive actions. **Implications:** The findings support the development of targeted risk management strategies, including design validation, contractual adjustments, early document preparation, and legal verification, to reduce potential delays and improve project time performance.

Highlights:

- Four dominant risk agents were prioritized based on Aggregate Risk Potential values.
- Delay causes were grouped into technical, managerial, environmental, and external categories.
- Preventive actions were ranked using effectiveness-to-difficulty evaluation.

Keywords: Freeway, Risk Management, Risk Matrix, Risk Management Strategy

Published date: 2026-03-14

Introduction

In this modern era, governments carry out large-scale development so that areas can transform into advanced regions and be able to keep up with current developments.[1] One of the infrastructures that supports this rapid growth is the toll road construction project.[2] In the implementation of highway construction projects, many problems and obstacles are often encountered, one of which is delays, with 38% of projects in Indonesia experiencing discrepancies between the actual execution time and the planned schedule.[3]

The delay in the implementation of the highway construction project will impact the postponement of a series of other objectives that follow. This delay constraint also occurs in National Strategic Projects (PSN), one of which is the Serang – Panimbang Toll Road Section 3 (Cileles – Panimbang) Development Project in the Banten Province area. The project is intended to support accessibility to the Special Economic Zone (SEZ), mainly in the tourism sector in the Tanjung Lesung area. The project has been ongoing since August 2022 and is being carried out by three main contractors through a Joint Operation (KSO) led by Sino Roads and Bridge Group Co. Ltd. (SRBGC), with participation from PT. W., and PT. A. The respective work portions in this KSO system are sequentially as follows: SRBGC (55%) – WIKA (22.5%) – ADHI (22.5%).[4] The project was originally scheduled in the initial contract to be completed within 720 calendar days. Over time and with several contract amendments, the execution period became 1,374 calendar days. The change in the execution period, with an addition of 654 calendar days, is based on work that could not be completed at several points in the three contractor work areas. This will consequently impact the delay in project completion and increased costs.[5]

In the construction project implementation phase, it is very important to carry out planning, coordination, and management to mitigate or avoid risks that are likely to occur. The risks that often occur during the implementation phase include time overruns, which are influenced by stakeholder, material, and external factors, resulting in losses for the contractor, especially when the agreed contract is a lump sum.[6] Obstacles and challenges in the implementation of development will certainly affect productivity, so a risk management study must be conducted by performing risk analysis and addressing potential risk impacts that affect construction performance. Therefore, this study was conducted to determine the effect of limited involvement of various parties in managing risk during the implementation of highway construction projects.[7]

Method

In the preparation of this final project proposal, the research object is the Serang – Panimbang Toll Road Construction Project Section III (Cileles – Panimbang) on the STA 74+275 – STA 77+387 stretch, which is 3.1 km long. The study, with this project as its object, aims to analyze the risk management system during the implementation phase of the related project in order to identify the risks causing project delays by determining the most dominant risks. Furthermore, from these risks, appropriate mitigation measures are determined to minimize the existing risks.

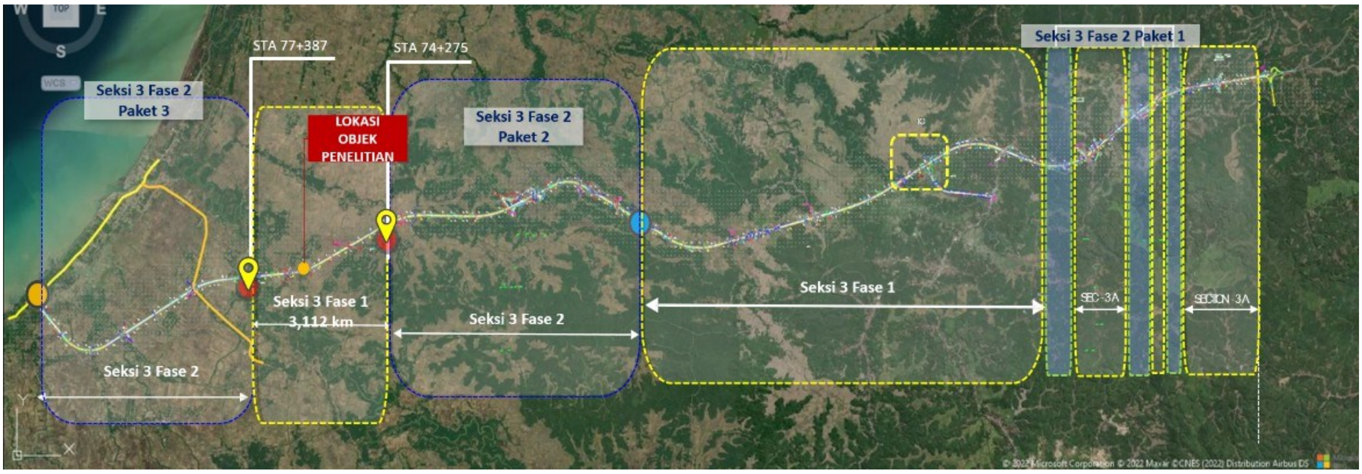


Figure 1. *Location of Research Object of Project Archive Data, 2025*

Research variables are risk factors based on several references that support the related research. In general, research variables are grouped into 2 (two) types, namely:

a. Exogenous variable / independent reliable.

b. Endogenous variable / dependent variable.

The research focused on the causes of risks that impact delays in the construction project implementation phase. It is based on literature sources, experience, and a developed list of risks. The existing data were analyzed through a qualitativedescriptive approach using interviews, observations, and literature-documentation studies. The results of the data were described to identify the severity and impact of these risk events. In this study, the following variables are included:

Table 1. Research Variables

Variables		Research Indicators	Reference Source
Technical & Operational Risks (X1)	X1.1	Design & specification changes	Noor, Agus Bambang (2024)
	X1.2	Situation data & land readiness	Lestari, Ayu (2025)
	X1.3	Limited use of technology	Moh Nur Sholeh (2023)
Project Risk Management (X2)	X2.1	Establishment of risk management guidelines	Hari Yanto, (2023)
	X2.2	Discrepancy in BOQ calculation	Lestari, Ayu (2025)
	X2.3	Communication and coordination	Hari Yanto, (2023)
	X2.4	Lack of coordination between teams	Sholihin, Rohmat Agus (2024)
	X2.5	Poor communication between stakeholders	Sholihin, Rohmat Agus (2024)
	X2.6	Delay in the contract document preparation process	Moh Nur Sholeh, (2023)
	X2.7	Changes in team personnel	Moh Nur Sholeh, (2023)
	X2.8	Conflict between parties	Sholihin, Rohmat Agus (2024)
Environmental Risk (X3)	X3.1	Extreme weather	Moh Nur Sholeh, (2023)
	X3.2	Natural disaster/force majeure	Moh Nur Sholeh, (2023)
	X3.3	Geological conditions	Moh Nur Sholeh, (2023)
External Risk (X4)	X4.1	Iinflation and price fluctuations	Moh Nur Sholeh, (203)
	X4.2	Changes in government political and economic policies	Hari Yanto, (2023)
	X4.3	Increase in base price	Noor, Agus Bambang (2024)
	X4.4	Legal and regulatory issues related to licensing and other legal matters	Moh Nur Sholeh, (2023)
Time Performance (Y1)	Y1.1	Proper planning and scheduling	Noor, Agus Bambang (2024)

Results and Discussion

At this stage, data processing is carried out using the House of Risk (HOR) method. Data processing begins by summarizing the questionnaire results on the severity scale (impact) and occurrence scale identification. The questionnaires were filled out by respondents from a population based on the location of the research object, which is the contractors implementing the Serang – Panimbang Toll Road Project Section 3A (Cileles – Panimbang), categorized by major categories such as positions/roles including project manager, deputy project manager, project engineering, project commercial, project finance, project production, and senior staff. The determination of the risk scale is based on the research by Anityasari & Wessiani (2011) as follows.

Table 2. Likert Scale of Severity (Impact)

Scale	Description	Severity
1	*Insignification*	Very low
2	*Minor*	Low
3	*Moderate*	Moderate
4	*Major*	Tall
5	*Catastrophic*	Very High

Table 3. Likert Scale Occurrence (Probability)

Scale	Description	Severity
1	*Rare*	Very rare
2	*Unlikely*	Rare
3	*Possible*	It can happen
4	*Likely*	Very likely to happen
5	*Almost Certain*	Almost certain to happen

1. House of Risk (HOR) Fase 1

Phase I of the House of Risk (HOR) is a stage for conducting a risk event analysis, where the risk priorities are identified so that risk mitigation planning can be carried out in the next phase. In this study, Phase I of HOR was conducted through the identification of risk events based on a review of existing studies, and then the identification of risk agents was carried out by distributing questionnaires to respondents according to predetermined criteria.[8]

The scale measurement in the questionnaire was conducted on the risk impact scale (severity) to determine the potential impact of the risk that may arise from the risk event. In addition, a measurement of the likelihood of the risk occurrence (occurrence) was also carried out based on the risk-triggering factors (risk agents) to interpret the frequency of the risk agents emerging. Then, a scale measurement of the correlation between the severity and occurrence scores was conducted. Risk agents with the highest ARP value will become risk priorities for mitigation efforts or solutions, thereby reducing the risk level.[9]

Based on the identification results from several literature reviews of previous studies and also referring to the risk register archive documentation of the Serang – Panimbang Toll Road Project Section 3A (Cileles-Panimbang), 18 risk events were identified, which were then measured for impact scale (severity) through the distribution of questionnaires to respondents. The impact scale measurement ranges from 1-5, where a score of 1 represents a very low impact level and a score of 5 represents a very high impact level. The conclusion of the impact scale assessment for each risk event is based on the mode (the most frequently occurring number) in the severity assessment. The conclusions of the severity assessment from the respondents' questionnaires are presented in the following table.

Table 4. Severity Assessment Results

No	Risk Event (Impact)	Code	Severity
X1. Technical & Operational Risks			
1	Design & specification changes	E1	5
2	Factors related to situational data, conditions, and land readiness	E2	5
3	Limited use of technology	E3	3
X2. Project Management Risk			
1	Application of risk management context according to risk identification in the field	E4	4
2	The occurrence of BOQ calculation discrepancies	E5	3
3	Limited access to data & information and not real-time	E6	3
4	Poor communication and coordination system among project team members	E7	4
5	Poor communication and coordination systems among stakeholders and policies	E8	4
6	Delay in the contract document preparation process	E9	5
7	The occurrence of personnel changes within the team	E10	3
8	Complex conflict between parties	E11	4
X3. Environmental Risk			
1	The impact of extreme weather changes on the project	E12	4
2	The occurrence of natural disasters or emergency situations	E13	4
3	The work location cannot be carried out due to land issues	E14	5
X4. External Risk			
1	The occurrence of inflation and price fluctuations	E15	5
2	Changes in government political and economic policies	E16	4
3	The impact of an increase in base prices resulting in higher prices for strategic materials	E17	5
4	The existence of legal and regulatory issues related to licensing and other legal matters	E18	4

2. Identification of Risk Triggers (Risk Agent)

The identification of risk triggers is based on the potential risk events. The stage of identifying risk triggers is carried out by integrating risk event factors through a focus group discussion (FGD) with several experts from different backgrounds to obtain diverse perspectives. Based on the results of the focus group discussion with experts, the discussion data is then processed using N-Vivo software to determine the statements that are most frequently expressed. [10]

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

From the FGD results, 18 risk-triggering factors (risk agents) were also obtained. The next step involved measuring the likelihood of occurrence scale by distributing questionnaires to respondents. This likelihood scale measurement ranges from 1 to 5, where a score of 1 represents a very rare occurrence from now, and a score of 5 represents a near-certain chance of occurrence.[11] The conclusion of the assessment of the likelihood scale for each risk agent is based on the mode (the most frequently occurring number) in the occurrence assessment. The conclusions of the occurrence assessment from the respondent questionnaire are presented in the following table.

Table 5. Occurrence Assessment Results

No	*Risk Agent (Cause)*	Kode	*Occurance*
X1. Technical & Operational Risks			
1	The job design during planning does not match the results of the soil investigation during execution	A1	4
2	The technical aspect of unstable soil and the unclear land status	A2	5
3	The limited regulatory push for digitization policies and the inter-system configuration has not been fully connected	A3	4
X2. Project Management Risk			
1	Poor accuracy of the risk management program system	A4	5
2	Changes in the scope of work, initial design, methods, and technical specifications of the work.	A5	5
3	The lack of project operation procedures for each activity	A6	3
4	Different standards of job understanding	A7	4
5	The presence of interference or intervention from other parties	A8	4
6	Unpreparedness of technical and administrative data	A9	5
7	Personnel rotation under management instructions	A10	3
8	Differences in background and the lack of an integrated digital platform	A11	4
X3. Environmental Risk			
1	Changing local climate conditions that are prone to storms, rain, or waves	A12	5
2	The project location is in an area prone to natural disasters such as earthquakes, landslides, tsunamis, and floods	A13	5
3	There is a land ownership conflict and the land acquisition has not been completed	A14	5
X4. External Risk			
1	Some sources of funding are foreign loans	A15	5
2	Changes in the political coalition or cabinet reshuffle	A16	4
3	The high demand for construction projects (IKN) and the influence of the global economy	A17	5
4	Changes in authority and regulation in the construction sector	A18	4

3. Identification of the Correlation Scale of Risk Events and Risk Agents

The relationship between risk events and risk severity based on severity and occurrence scores is then identified using a scale of 0, 1, 3, or 9 to indicate the correlation of each aspect.[12] In Edy Suyanto's (2022) research, the value of this correlation scale is based on an approach using Quality Function Deployment (QFD) with the following criteria and integrated with risk scale levels:

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

Table 6. Correlation Scale Table and Risk Scale

SKALA RISIKO				PERLAKUAN RISIKO	SKALA KORELASI	
1-5	(green)	*LOW*	RENDAH	***Accept / Monitor***	0	Tidak ada korelasi
6-11	(light green)	*LOW TO MODERATE*	RENDAH KE SEDANG	***Reduce / Mitigate* atau *Accept / Monitor***	1	Rendah
12-15	(yellow)	*MODERATE*	SEDANG	***Reduce / Mitigate***	3	Sedang
16-19	(orange)	*MODERATE TO HIGH*	SEDANG KE TINGGI	***Reduce / Mitigate* atau *Transfering / Sharing***	9	Tinggi
20-25	(red)	*HIGH*	TINGGI	***Reduce / Mitigate* atau *Avoid (Hindari)***	9	Tinggi

Based on the correlation scale table, the data in Table 6 below represents the correlation scale values of risk events and risk agents. The scale numbers were obtained after conducting interviews with the project management.

Table 7. Table of Correlation Scale between Risk Event and Risk Agent

No	*Risk Event* (Impact	Kode	*Risk Agent* (Cause)	Code	Correlation
X1. Technical & Operational Risks					
1	Design & specification changes	E1	The job design during planning does not match the results of the soil investigation during execution	A1	9
2	Factors related to situational data, conditions, and land readiness	E2	The technical aspect of unstable soil and the unclear land status	A2	9
3	Limited use of technology	E3	The limited regulatory push for digitization policies and the inter-system configuration has not been fully connected	A3	9
X2. Project Management Risk					
1	The implementation of risk management context according to the identification of risks in the field	E4	Poor accuracy of the risk management program system	A4	9
2	The occurrence of BOQ calculation discrepancies	E5	Changes in the scope of work, initial design, methods, and technical work specifications.	A5	9
3	Limited and non-real-time access to data & information	E6	The lack of project operation procedures for each activity	A6	1
4	Poor communication and coordination system among project team members	E7	Different standards of job understanding	A7	3
5	Poor communication and coordination systems among stakeholders and policies	E8	The presence of interference or intervention from other parties	A8	3
6	Delay in the contract document preparation process	E9	Unpreparedness of technical and administrative data	A9	9
7	The occurrence of personnel changes within the team	E10	Personnel rotation under management instructions	A10	9
8	Complex conflict between parties	E11	Differences in background and the lack of an integrated digital platform	A11	3
X3. Environmental Risk					
1	The impact of extreme weather changes on the project	E12	Changing local climate conditions that are prone to storms, rain, or waves	A12	9
2	The occurrence of natural disasters or emergency situations	E13	The project location is in an area prone to natural disasters such as earthquakes, landslides, tsunamis, and floods	A13	9

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

No	*Risk Event* (Impact	Kode	*Risk Agent* (Cause)	Code	Correlation
3	The work location cannot be carried out due to land issues	E14	There is a land ownership conflict and the land acquisition has not been completed	A14	9
X4. External Risk					
1	The occurrence of inflation and price fluctuations	E15	Some sources of funding are foreign loans	A15	9
2	Changes in government political and economic policies	E16	Changes in the political coalition or cabinet reshuffle	A16	1
3	The impact of an increase in base prices that affects the rise in strategic material costs	E17	The high demand for construction projects (IKN) and the influence of the global economy	A17	9
4	The existence of legal and regulatory issues related to licensing and other legal matters	E18	Changes in authority and regulation in the construction sector	A18	1

4. Phase 1 HOR Calculation

The calculation stage in HOR Phase 1 is to calculate the Aggregate Risk Potential (ARP). To facilitate this calculation, it is carried out using a table and combines data from risk events, risk agents, and the correlation scale of each risk variable. The results of the aggregate risk potential calculation are used as the basis for determining the risk priority potential factors to be mitigated in HOR Phase 2. The ARP value is calculated using the following formula:

$$ARP_j = O_j \, \Sigma \, Si \, . \, Ri \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4.1)$$

Description:
ARP_j : *Aggregate Risk Potential*
Oj : *Occurance risk agent*
Si : *Severity risk event*
Ri : Nilai korelasi
One example of calculating ARP according to the formula for risk event (Ej) E5 is:
Known : O = 5
Si = 3
Ri = 9

Solution : ARP = Oj . Σ Si . Ri
= 5 . (3.9)
= 135

Hasil perhitungan ARP tahapan *House of Risk* (HOR) Fase 1 disajikan dalam tabel 8 berikut :

Tabel 8. Hasil Perhitungan *House of Risk* (HOR) Fase 1

Kategori Risiko	Risk Event	Risk Agent (Aj)																		Severity of Risk
	(Ej)	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	Event i
Risiko Teknis & Operasional	E1	9	3						9				3			1				5
	E2	3	9		3								3							5
	E3			9				1				3								3
Risiko Manajemen Proyek	E4				9			3	9											4
	E5	3				9				9						3				3
	E6						1													3
	E7				3			3												4
	E8				3			3	3											4
	E9	9								9						3				5
	E10							3		3	9									3
	E11							3				3								4
Risiko Lingkungan	E12												9							4
	E13												3	9	3					4
	E14													3	9					5
Risiko Eksternal	E15															9	3			5
	E16																1		3	4
	E17																1	9	3	5
	E18																1		1	4
Occurance of Aggregat		4	5	4	5	5	3	4	4	5	3	4	5	5	5	5	4	5	4	
Aggregat Risk of Potent		456	300	108	375	135	9	60	379	405	132	90	287	156	381	431	103	225	124	
Priority rank of Agent		1	7	14	6	11	18	17	5	3	12	16	8	10	4	2	15	9	13	

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

5. Evaluation of House of Risk (HOR) Phase 1 Calculations

This stage is the final step in data processing using the House of Risk (HOR) Phase 1 method. This evaluation stage is carried out based on the results of the recapitulation of the aggregate risk potential (ARP) calculation. The recapitulated ARP values are sorted by the highest value to be used as cumulative percentages in the preparation of a Pareto diagram. The higher the ARP value, the higher the priority for that risk agent to be mitigated earlier. The following is a recapitulation and percentage results based on the ARP value calculations in Table 9.

Table 9. Recapitulation of Aggregate Risk Potential (ARP) Values

Rank	***Risk Agent* Kode**	**ARP**	**Presentase**	**Presentase Kumulatif**
1	A1	456	10.97%	10.97%
2	A15	431	10.37%	21.34%
3	A9	405	9.74%	31.09%
4	A14	381	9.17%	40.26%
5	A8	379	9.12%	49.37%
6	A4	375	9.02%	58.40%
7	A2	300	7.22%	65.62%
8	A12	287	6.91%	72.52%
9	A17	225	5.41%	77.94%
10	A13	156	3.75%	81.69%
11	A5	135	3.25%	84.94%
12	A10	132	3.18%	88.11%
13	A18	124	2.98%	91.10%
14	A3	108	2.60%	93.70%
15	A16	103	2.48%	96.17%
16	A11	90	2.17%	98.34%
17	A7	60	1.44%	99.78%
18	A6	9	0.22%	100.00%

According to Grosfeld-Nir, Ronen, & Kozlovsky (2016), a good Pareto chart is one in which about 20% of the attribute components carry 80% of the weight. It can thus be concluded that 80% of the risk of loss is caused by 20% of these essential factors.[13] By prioritizing the 20% risk factors, the impact of the 80% risk can be managed and mitigated early. In this study, a Pareto diagram is used to identify the main risk agents that will become a priority in the management and mitigation of risks. The formulation of risk management, handling, and mitigation efforts as a form of preventive action will be carried out in the HOR Phase 2 stage.

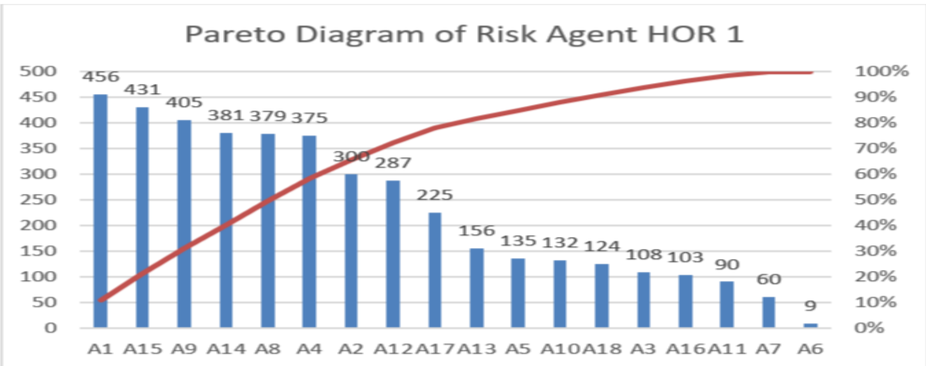


Figure 2. Pareto Diagram of Risk Agents

From the Pareto diagram, the results for the selected risk agents show that there are 3 risk factors. Since there are 4 main variable factors in this study, 4 risk agent factors were taken based on the Pareto diagram. Thus, the order of the risk agents is as follows:

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

DOI: 10.21070/acopen.11.2026.13398

Table 10. Selected Risk Agent

Order	Code	*Risk Agent*
1	A1	Changes in design & specifications due to the work design during planning not matching the results of the soil investigation during the implementation phase
2	A15	Some sources of funding are foreign loans
3	A9	Unpreparedness of technical and administrative data
4	A14	The occurrence of land ownership conflicts and the unfinished land acquisition.

Based on the results of the selected risk agent in the HOR Phase 1 stage, processing was then carried out with HOR Phase 2 to plan risk management and mitigation so that potential risks and their impacts can be minimized.

a. House of Risk (HOR) Phase 2 In this stage of House of Risk (HOR) Phase 2, mitigation management efforts (PAk) will be carried out as the most effective and efficient preventive action to be implemented in the field according to actual conditions. [14] To determine the most effective and efficient mitigation efforts, a Focus Group Discussion (FGD) was conducted with selected experts from various fields and experiences in civil engineering.

b. Identification of Mitigation Preventive Action Identification of risk mitigation actions as preventive steps is carried out based on the results of risk dominance analysis in the HOR Phase 1 stage. The identification of preventive action (PAk) steps is conducted through discussions (FGD) with experts. The results of the FGD are processed using N-Vivo software to determine the statements most frequently expressed as forms of preventive action.[15] The results of the word frequency recap from the N-Vivo software for each dominant risk factor in each variable can be visually seen in the following diagram:

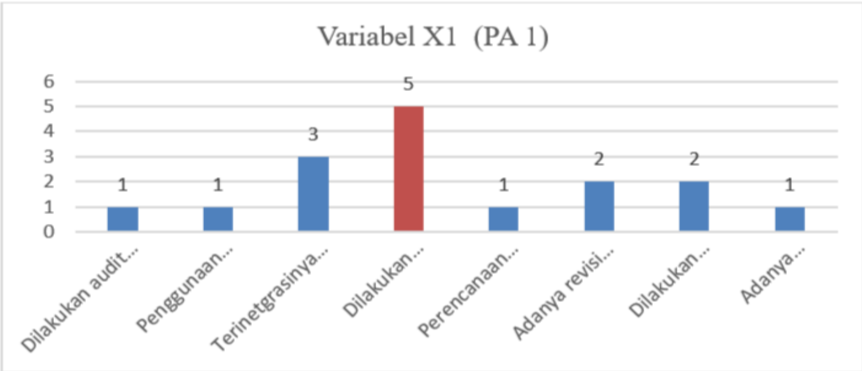


Figure 3. Word Frequency Recap for PA 1

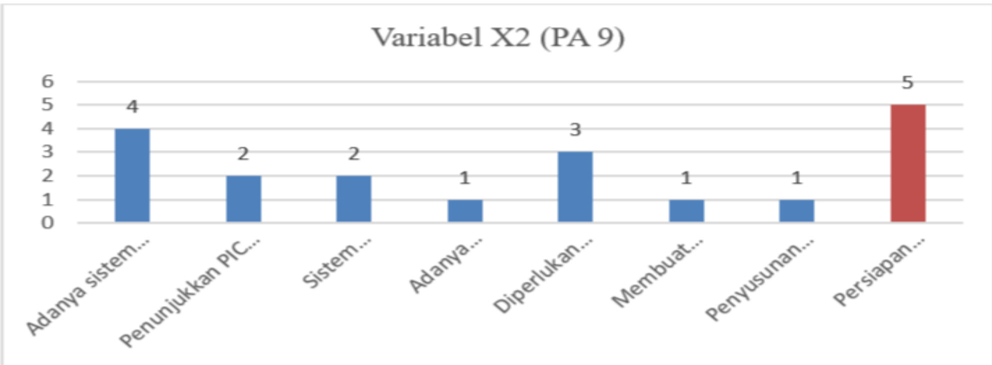


Figure 4. Word Frequency Recap for PA 9

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

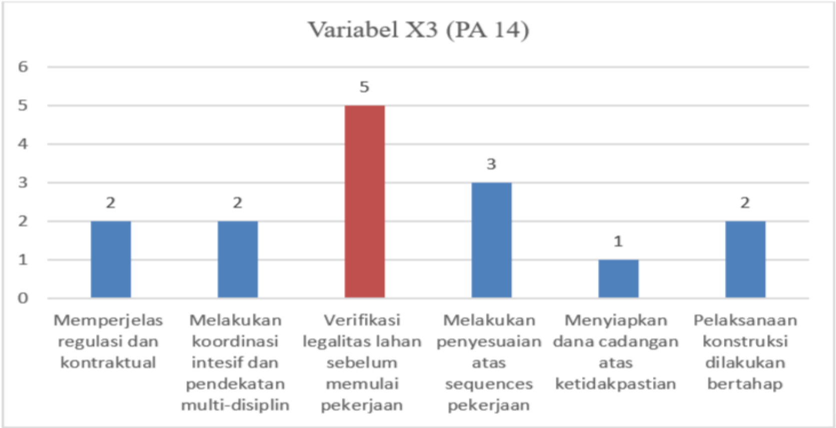


Figure 5. Word Frequency Recap for PA 14

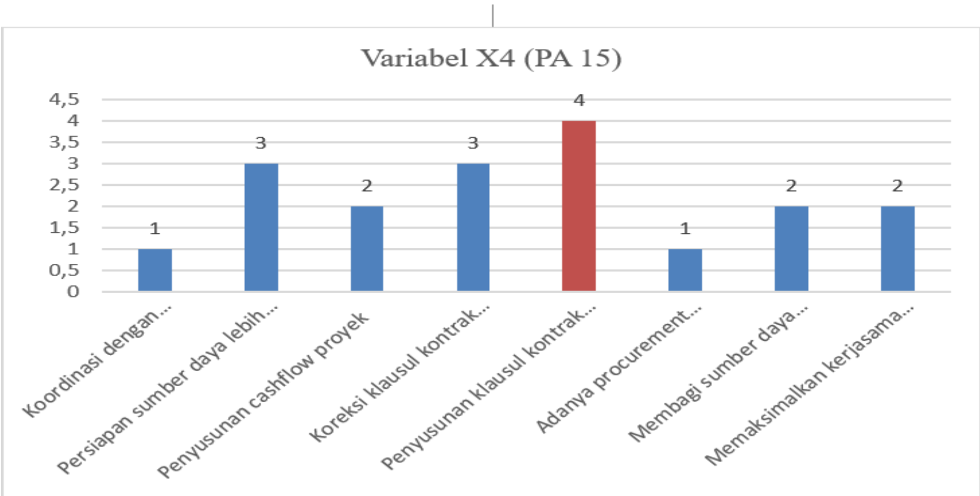


Figure 6. Word Frequency Recap for PA 15

Thus, based on the results of the Focus Group Discussion (FGD) and the processing of HOR Phase 2 data using N-Vivo software to determine risk mitigation steps in managing and minimizing risk-triggering factors (risk agents), the following results were obtained:

Table 11. Mitigation Efforts Preventive Action

Rank	Code	*Risk Agent*	*Preventive Action* (PAk)
1	PA1	The job design during planning does not match the results of the soil investigation during execution.	Initial design validation with soil investigation data from an independent geotechnical consultant.
2	PA15	Part of the funding comes from foreign loans.	Drafting contract clauses due to exchange rate differences.
3	PA9	The unpreparedness of the technical and administrative data.	Preparing pre-contract, technical, and administrative documents earlier.
4	PA14	The work location cannot be carried out due to land issues.	Carry out legality verification before starting work, integrate force majeure clauses and time adjustments in the contract, and ensure there are regulations on compensation transparency.

6. Identification of Risk Agent Correlation and Preventive Action

The identification of the correlation scale values between risk agents and preventive actions is used to determine how strong the relationship is between each risk trigger factor and its corresponding preventive action. The correlation scale provisions used are as shown in Table 12below:

Table 12. Correlation Scale of Risk Agent and Preventive Action

Scala	Interconnection	Description
0	No relationship	Cannot be used as a mitigation measure
1	weak	Has a small role in minimizing risk
3	Busy	Has a moderate role in minimizing risk
9	Strong	Plays a major role in minimizing risk

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

After determining the correlation scale between each risk trigger factor and the preventive action steps, the determination of the difficulty degree scale (Dk) in its implementation in the field was also carried out. This scale determination was done together with the project management, who act as the highest decision-makers in the project, using direct interview methods. Measurement of the difficulty degree scale value is conducted after the correlation scale between risk agents and preventive actions for each variable is known. The measurement of the difficulty degree scale value is applied according to the provisions in Table 13 below:

Table 13. Difficulty Degree Scale Values (Dk)

Scala	Description
1	Preventive measures are very easy to carry out
2	Preventive measures are easy to take
3	The preventive measures are quite easy to carry out
4	Preventive measures are difficult to implement
5	Preventive measures are very difficult to implement

Based on the provisions for determining the correlation scale and difficulty level value, the results of the correlation scale and difficulty level scale are obtained as shown in Table 14 below.

Table 14. Correlation Results of Risk Agent and Preventive Action

Code	*Risk Agent*	Code	*Preventive Action*	Correlation	Degree of Difficulty
A1	The job design during planning does not match the results of the soil investigation during execution.	PA1	Preliminary validation of the design against soil investigation data by an independent geotechnical consultant is carried out to ensure consistency between the design assumptions and the actual soil conditions.	9	3
A15	Part of the funding comes from foreign loans.	PA15	Regulating contractual clauses regarding exchange rate fluctuations as a mechanism for mitigating financial risk through measurable and auditable price adjustments.	9	5
A9	The unpreparedness of the technical and administrative data.	PA9	Preparing pre-contract documents, both technical and administrative, from the initial stage to minimize the risk of non-compliance, delays, and potential claims during the project execution phase.	3	4
A14	The work location cannot be carried out due to land issues.	PA14	Carry out verification of legal and administrative aspects before the work is carried out, and explicitly regulate force majeure clauses, time adjustments, and compensation in the contract to mitigate the risks of delays, disputes, and legal uncertainties.	9	3

7. Calculation House of Risk (HOR) Fase 2

After the correlation scale value and the degree of difficulty are known, the Total Effectiveness (Tek) for each mitigation step is then calculated. The results of the Total Effectiveness (Tek) calculation are used to calculate the Effectiveness to Difficulty Ratio (ETD). The determination of the ETD value will be used to identify the priority ranking of each variable from preventive actions to be implemented earlier while still considering the degree of difficulty and effectiveness. The calculation of the Total Effectiveness (Tek) value uses the following formula:

T_ek = Σ j · ARP_j x Ejk (2)

Description = Tek = *Total Effectiveness*
ARPj = *Aggregate Risk Potential – Agent j*
Ejk = *Risk Agent j*

One example of calculating Tek according to the formula for risk agent (Ai) A15 is: Known = ARP = 431
Ejk = 9
Asked = Tek ..?
Answer = $T_{ek} = \Sigma j \,.\, ARP_j \; x \; Ejk$
$T_{ek} = 431 \; x \; 9$
$T_{ek} = 3879$

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

After obtaining the Total Effectiveness (Tek) value, the Effectiveness to Difficulty Ratio (ETD) is calculated using the following formula:

$$ETD_k = \frac{T_{ek}}{Dk} \quad (3)$$

Description =
ETDk = *Effectiveness to Difficulty Ratio*
Tek = *Total Effectiveness*
Dk = Degree of Difficulty

One example of ETDk calculation according to the formula for risk agent (Ai) A15 is:
Given = Tek = 3879
Dk= 5
Asked = ETDk ..?
Answer = $ETD_k = \frac{T_{ek}}{Dk}$

$$ETD_k = \frac{3879}{5}$$

$$ETD_k = 775{,}8$$

In more detail, the calculation of the ETDk value in House of Risk (HOR) Phase 2 can be seen in the following Table 15:

Table 15. Results of House of Risk (HOR) Phase 2 Calculation

Risk Agent (Ai)		Validasi awal desain terhadap data soil investigation oleh konsultan geoteknik independen dilakukan untuk memastikan konsistensi antara asumsi desain dan kondisi tanah aktual.	Mengatur klausul kontraktual mengenai fluktuasi nilai tukar sebagai mekanisme mitigasi risiko finansial melalui penyesuaian harga yang terukur dan dapat diaudit.	Melakukan kesiapan dokumen pra-kontrak, baik teknis maupun administratif, sejak tahap awal guna meminimalkan risiko ketidaksesuaian, keterlambatan, dan potensi klaim pada fase pelaksanaan proyek.	Melaksanakan verifikasi aspek legal dan administratif sebelum pelaksanaan pekerjaan, serta mengatur secara eksplisit klausul force majeure, penyesuaian waktu, dan kompensasi dalam kontrak untuk memitigasi risiko keterlambatan, sengketa, dan ketidakpastian hukum.	Agregate Risk Potential (ARP)
		PA1	PA15	PA9	PA14	
A1	Desain pekerjaan saat perencanaan tidak sesuai dengan hasil soil investigation saat masa pelaksanaan	9			3	456
A15	Sebagian sumber pendanaan adalah pinjaman luar negeri		9			431
A9	Ketidaksiapan data teknis dan administratifnya	3		9		405
A14	Lokasi pekerjaan tidak dapat dikerjakan akibat permasalahan lahan	3			9	381
Total effective (Tek)		6462	3879	3645	4797	
Degree of Difficulty (Dk)		3	5	4	3	
Effectiveness to Difficultry ratio ((ETDk)		2154	775.8	911.25	1599	
Rank of Priority		1	4	3	2	

8. Evaluation of House of Risk (HOR) Phase 2 Calculations

Based on the results of the House of Risk (HOR) Phase 2 calculations and the ranking results from the Effectiveness to Difficulty Ratio (ETDk) calculations, the priority preventive actions are identified as steps for managing and controlling risk mitigation to reduce both the triggers and the impact of the risk.

Table 16. Recapitulation of Preventive Action (PAk) Ranking

Rank	Kode	Preventive Action	ETDk
1	PA1	Initial validation of the design against soil investigation data by an independent geotechnical consultant is carried out to ensure consistency between the design assumptions and the actual soil conditions.	2154
2	PA14	Carry out verification of legal and administrative aspects before the work is carried out, and explicitly arrange force majeure clauses, time adjustments, and compensation in the contract to mitigate the risks of delays, disputes, and legal uncertainties.	1599
3	PA9	Preparing pre-contract documents, both technical and administrative, from the early stages to minimize the risk of non-compliance, delays, and potential claims during the project execution phase.	911,25
4	PA15	Regulating contractual clauses regarding exchange rate fluctuations as a mechanism for mitigating financial risk through measurable and auditable price adjustments.	775,8

Conclusion

Based on the results of research conducted using the House of Risk method and data processing with N-Vivo software, several final results and conclusions were obtained as follows: Identification of delays in the implementation time across all work areas of the Serang – Panimbang Toll Road Construction Project Section 3 (Cileles – Panimbang) indicated a work time extension of up to 654 calendar days. After the initial risk identification stage was carried out and correlated with the project risk register data for the three work areas and validated with experts and respondents, several factors causing delays in the implementation of the toll road construction project were identified, totaling 18 risk-triggering factors and 18 risk-causing factors. From these 18 factors, they were then categorized into 4 variable categories, namely (X1) Technical & Operational Risk, (X2) Project Management Risk, (X3) Environmental Risk, and (X4) External Risk. Based on the results of the research using the HOR Phase 1 method, the main factors causing delays that impact the execution time of highway

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13398

construction projects were identified. In the HOR Phase 1 method, four main risk-triggering factors (top risk agents) were identified in order: (A1) The design of the work during planning does not align with the results of the soil investigation during the implementation phase, (A15) Part of the funding comes from foreign loans, (A9) Uncertainty of technical and administrative data, and (A14) The work location cannot be executed due to land issues.

The strategy steps for risk management against probabilities/opportunities that could reduce the risk of project schedule delays are planned using the Phase 2 HOR method based on the results of Phase 1 HOR. At the Phase 2 HOR stage, planning efforts are carried out to manage and mitigate risks by correlating them based on the correlation scale and the degree of difficulty in field implementation. From the determination of this correlation scale through interviews with representatives from the project management team, the highest priority as a risk mitigation strategy was obtained, namely (PA 1) Conducting validation of the initial design using soil investigation data from an independent geotechnical consultant to achieve accurate and realistic results, with monitoring and controlling efforts including setting minimum geotechnical data standards in accordance with SNI 8460:2017, SNI 1726:2019 and specifications, and using a design validation checklist against soil parameters (SPT, CPT, shear strength, settlement). and conduct cross-reviews with the internal team and independent consultants before the final design; (PA 14) Verify legality before starting work, integrate force majeure clauses and time adjustments into the contract, and ensure transparency regulations related to compensation with monitoring and controlling efforts; coordinate intensively with the project owner regarding land acquisition updates, as well as periodically monitor and control work that cannot be carried out due to land issues; (PA 9) Prepare pre-contract, technical, and administrative documents earlier with monitoring and controlling measures; assign PICs for each type of document and internal deadlines before the tender schedule; and (PA 15) Synchronizing the cash flow disbursement schedule and reviewing loan clauses and exchange rate risks by periodically monitoring and controlling the rupiah exchange rate, and assigning a team appropriate to the contract field.

References

1. N. K. S. K. A. Seputra, “Peran Sistem Informasi Pemerintahan Daerah Dalam Menunjang Peningkatan Kualitas Perencanaan Pembangunan Daerah,” Locus Majalah Ilmiah FISIP, 2020, doi: 10.24127/att.v6i1.2144.
2. S. Apriliyaningsih, E. A. Saepudin, R. A. Putri, et al., “Kebijakan Pembangunan Infrastruktur Jalan Tol: Evaluasi Dampak Pembangunan Jalan Tol Terhadap Peningkatan Konektivitas Antar Daerah Dan Pertumbuhan Ekonomi,” Ekopedia Journal, 2025, doi: 10.24853/jk.13.2.65-80.
3. T. O. L. Simpang and I. Prabumulih, “Analisis Proyek Jalan Tol,” Jurnal Konstruksi, vol. 9, no. 3, 2024, doi: 10.24853/jk.13.2.65-82.
4. M. L. Dewa, A. Syafrudi, and K. Andayani, “Kajian Etika Profesi Insinyur Teknik Sipil Pada Pembangunan Jalan Tol,” Innovation Journal of Social Science Research, 2023, doi: 10.24127/att.v6i1.2144.
5. A. Najah and D. Pontan, “Identifikasi Peringkat Faktor Penyebab Keterlambatan Konstruksi Pada Pelaksanaan Pembangunan Jalan Tol,” in Seminar Nasional Cendekiawan, 2018, doi: 10.24853/jk.13.2.65-80.
6. W. Soviana, E. Herlina, S. Soviati, and A. Musrian, “Identifikasi Faktor-Faktor Penyebab Cost Overrun Dan Time Overrun Pada Proyek Konstruksi Gedung,” Tameh Journal of Civil Engineering, vol. 11, no. 1, pp. 11–20, 2022, doi: 10.24127/att.v6i1.2144.
7. N. Hidayat, M. Nazly, H. A. Xanichal, et al., “Pengaruh Dampak Sosial Terhadap Proyek Pembangunan Jalan Tol Di Medan–Binjai,” Jurnal Pengabdian Masyarakat, 2023, doi: 10.23960/jrsdd.v4i4.521.
8. M. A. Hamid, A. K. Hadi, and R. Musa, “Manajemen Risiko Terhadap Aspek Legal Dan Bisnis Dalam Pekerjaan Konstruksi Jembatan Penyeberangan Di Jalan Tol,” Jurnal Flyover, 2021, doi: 10.52103/jfo.v1i1.657.
9. E. Walujodjati and S. P. Rahadian, “Analisis Manajemen Risiko K3 Pekerjaan Jalan Tol Cisumdawu Phase III,” Jurnal Konstruksi, 2021, doi: 10.33364/konstruksi/v.19-1.874.
10. W. Wardhana, P. A. Wiguna, and S. H. Diputro, “Analisa Risiko Untuk Menentukan Biaya Kontinjensi Pada Pelaksanaan Konstruksi Proyek Jalan Tol Surabaya–Mojokerto Seksi IB,” in Prosiding Seminar Nasional Manajemen Teknologi XXI, 2014, doi: 10.24127/att.v6i1.2144.
11. Sonhadji, “Manajemen Risiko Dalam Proyek Jalan Tol,” Diskusi Panel Manajemen Risiko Jalan Tol, Universitas Diponegoro, 2011, doi: 10.24853/jk.13.2.65-80.
12. P. A. P. Suwandi, “Kajian Manajemen Risiko Pada Proyek Dengan Sistem Kontrak Lump Sum Dan Unit Price (Studi Kasus Proyek Jalan, Jembatan, Gedung, Dan Bangunan Air),” Tesis, Universitas, 2010.
13. M. N. Karunia, I. Kustiani, and A. M. Siregar, “Analisis Risiko Keterlambatan Waktu Pada Proyek (Studi Kasus Pembangunan Jalan Tol Trans Sumatera Bakauheni–Terbanggi Besar),” Jurnal Rekayasa Sipil Dan Desain, 2018, doi: 10.23960/jrsdd.v4i4.521.
14. G. G. Yunistra, H. H. Purba, and H. Dwiatmoko, “Biaya, Penyebab Dan Manajemen Risiko Lokasi Blackspot Di Ruas Tol Jatiluhur–Padalarang Barat Km 84–Km 120+500,” Konstruksia, 2022, doi: 10.24853/jk.13.2.65-80.
15. N. Herawati, “Analisis Risiko Lingkungan Aliran Air Lumpur Lapindo Ke Badan Air (Studi Kasus Sungai Porong Dan Sungai Aloo, Kabupaten Sidoarjo),” Tesis, Universitas Diponegoro, 2007, doi: 10.23960/jrsdd.v4i4.521.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo