Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 06, June - 2025

Risk Assessment of the Radial Road Project in Surabaya using the Probability-Impact Matrix Approach

Ide Causaprima Pitoyo
Universitas 17 Agustus 1945 Surabaya
Master of Civil Engineering Study Program
Surabaya, Indonesia

Hanie Teki Tjendani
Universitas 17 Agustus 1945 Surabaya
Master of Civil Engineering Study Program
Surabaya, Indonesia

Jaka Purnama
Universitas 17 Agustus 1945 Surabaya
Master of Civil Engineering Study Program
Surabaya, Indonesia

Abstract — **The construction of the radial road in Surabaya is a strategic effort to alleviate traffic congestion and improve community mobility, particularly in connecting the city center with peripheral areas. This study aims to evaluate the key risks that may hinder the implementation of the radial road project and to identify the highest-priority risks requiring immediate mitigation.**

A mixed-method approach was employed, combining qualitative descriptive techniques and quantitative analysis. Risks were identified based on a review of similar infrastructure projects and analyzed through probability and impact assessments. Data were collected through questionnaires, in-depth interviews, and focus group discussions (FGDs) with stakeholders experienced in the construction sector.

The analysis revealed six dominant risks with significant influence on the project: changes in technical design, insufficient preliminary data and pre-design surveys, limited logistical access to the project site, unresolved land compensation processes, disruptions caused by public protests, and overlapping work from private sector projects in the same area. These findings serve as a basis for formulating risk mitigation strategies to ensure efficient and timely project execution.

Keywords : **radial road, risk assessment, mitigation, project implementation, Surabaya**

I. INTRODUCTION (BACKGROUND)

Surabaya, as the capital of East Java Province and one of the largest metropolitan cities in Indonesia, holds a strategic role in the development of the economy, transportation, and infrastructure across eastern Indonesia. In the western part of Surabaya, rapid economic growth has driven increased population mobility and traffic volume, in line with the expansion of residential areas, shopping centers, and business districts. The accumulation of such activities has exerted pressure on existing road capacity, further exacerbated by the lack of alternative routes and suboptimal drainage systems.

High traffic density, limited green open space, and unequal distribution of public facilities add complexity to urban governance. In response to these issues, the Surabaya City Government initiated the development of radial roads—a road network that connects the city center to suburban areas in a wheel-spoke pattern (Shi & Gao, 2020). This strategy aims to accelerate interregional connectivity and facilitate the distribution of goods and services. The road is designed with flexible pavement, considered suitable for the dynamic conditions of urban traffic.

However, infrastructure projects such as radial road development are associated with high levels of risk, particularly in technical, administrative, social, and environmental aspects. Without proper risk management, projects may face delays, cost overruns, or even quality degradation (Moi & Purnawirati, 2021; Pirogova et al., 2022). Hence, a comprehensive risk management approach is required—from risk identification and evaluation to the formulation of systematic and applicable mitigation strategies.

Beyond technical concerns, occupational safety issues are also critical. Neglecting these factors may lead to workplace accidents, increased insurance costs, and disruption of project performance (Rahmawati & Tenriajeng, 2020). In practice, project delays are often caused by unidentified early-stage risks, which result in overtime work, budget spikes, and financial losses for contractors (Winoto et al., 2023).

According to the Project Management Institute (2017), risk in a project refers to uncertainty that may impact the achievement of cost, quality, and schedule objectives. Therefore, risk management is essential to anticipate and minimize potential disruptions through continuous planning, monitoring, and control processes (Setiawan et al., 2023). The success of risk management also depends on the clarity of its scope—whether at the strategic, operational, program, or project level—so that it aligns with organizational goals and enables the establishment of relevant risk criteria (Yuli Anita et al., 2023).

One commonly used tool is the Probability and Impact Matrix, which maps risks based on their likelihood of occurrence and resulting impact. This matrix serves as a guideline for prioritizing risk handling in a targeted manner (Witjaksana & Purnama, 2025). As a qualitative research approach, Focus Group Discussion (FGD) has also proven effective in capturing group perceptions and social dynamics across various fields such as construction, public policy, and community development (Nyumba et al., 2018; Guest et al., 2017).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 06, June - 2025

II. RESEARCH METHODOLOGY

A. Research Design

This study employed a descriptive quantitative approach, with a survey method as the primary technique for collecting empirical data related to risk in construction projects. The main focus was to identify and analyze critical risks that may affect the success of the Flexible Pavement Collector Road Construction Project (Radial Road) located in the western region of Surabaya. The quantitative approach was chosen because it allows for systematic, objective, and measurable analysis of the risk variables involved, thereby providing an accurate depiction of the dominant risks that require immediate mitigation.

In addition to the quantitative approach, the study also strengthened its theoretical framework through an extensive literature review. The reviewed materials included academic journals, project documentation, risk management standards, and relevant previous studies. This mixed-method approach enabled the development of an applicable and contextually relevant risk management model for medium- to large-scale construction projects.

B. Location and Duration of the Study

The study was conducted at the site of the Flexible Pavement Collector Road Construction Project (Radial Road Extension), strategically located in West Surabaya. This area was selected due to its high traffic volume, intense urban development, and complex project characteristics. The research spanned approximately six months, covering the planning phase, data collection, data analysis, and the formulation of risk mitigation recommendations. The data collection process took place over a period of three months, using field observations, questionnaires, Focus Group Discussions (FGD), and structured interviews with project stakeholders.

C. Population and Sample

The target population of this research comprised all key actors involved in the planning and execution of the project, including technical officials from the Surabaya Department of Water Resources and Highways, the construction management team from PT. Karya Nugraha Nusantara – PT. Mitra Cipta Engineering (KSO), and the main contractor PT. Media Cipta Perkasa. The sampling technique used was Proportionate Stratified Random Sampling within the Probability Sampling framework. A total of 14 respondents were selected, consisting of 12 core project personnel and 2 external experts with more than ten years of experience in construction risk management.

D. Data Collection Techniques

Three main techniques were applied:

1. Document Review

Project documentation such as the Detail Engineering Design (DED), work contracts, technical specifications, Bill of Quantities (BOQ), implementation schedules, and work methods were examined. The literature review also included scientific references from previous studies (Kartam & Kartam, 2001; Perera et al., 2009; Nguyen et al., 2014; Dang et al., 2017; Szymański, 2017) to compile an initial risk register.

2. Questionnaire

The questionnaire-based survey was carried out in two stages :

- Preliminary Questionnaire: Employed the Guttman Scale to capture early-stage potential risks based on respondent perceptions.
- Main Questionnaire: Distributed after the FGD to assess the probability and impact levels of verified risks.

3. Focus Group Discussions (FGD)

FGD were conducted to validate and explore the risks identified through the preliminary questionnaire. Participants included representatives from the Road and Bridge Technical Team of the relevant public agency, the project management team, and the contractor’s staff. The outcome of the FGD was a finalized list of research variables in the form of validated risk items.

E. Research Instruments

The primary research instrument was a closed-ended questionnaire, designed to capture respondent perceptions regarding the probability, impact, and mitigation strategies of each identified risk. The questions were developed based on validated indicators derived from the literature review and FGD outcomes.

F. Research Variables

The variables in this study refer to potential risks that may arise during the planning and execution phases of construction, which could hinder the achievement of key project success criteria (cost, time, and quality). These risks were categorized based on a combination of literature-derived classifications and specific conditions observed in the project context..

G. Data Analysis Techniques

The data were analyzed using a descriptive and inferential quantitative approach, supported by Risk Assessment as the primary analytical tool. Risks were evaluated based on the product of their probability and impact values (likelihood × consequence), using a Probability-Impact Grid model derived from the Qualitative Risk Matrix standard as outlined in AS/NZS guidelines. Risks with the highest combined scores were classified as top priorities for strategic mitigation.

III. ANALYSIS

A. Risk Identification

This study carried out an identification process of various potential risks that may affect the successful implementation of the Radial Road Development Project. Based on a recap of data obtained from the preliminary survey, it was found that out of 53 initial risk variables compiled in the risk register, 48 were deemed relevant to the actual conditions of the project. The level of relevance was determined through respondents’ evaluations regarding the extent to which each risk variable was directly associated with real challenges encountered during the planning and construction phases.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 06, June - 2025

B. Validation and Selection of Risk Variables

Although the preliminary survey indicated that 48 risk variables were significantly related to the project, not all were immediately designated as core variables for further analysis. A subsequent validation process was conducted to ensure that only those risks which truly represented the technical complexities and specific context of the project would be retained as primary variables in the study.

A critical step in this validation phase involved conducting an in-person Focus Group Discussion (FGD) with key stakeholders of the project, including the construction management team, implementing contractors, and representatives from the project owner. The primary objective of this activity was to gain deeper practical insights from field professionals, review the initially identified risks, and refine the classification system to make it more adaptive and applicable to the specific project characteristics.

The outcome of the FGD resulted in a consensus to streamline the risk classification structure into two major categories: Planning Phase Risks and Implementation Phase Risks. This simplification was made to enhance the efficiency of the risk analysis process and facilitate the implementation of mitigation strategies according to the project's life cycle stages. Nonetheless, six sub-categories from the original classification were maintained under each major group to preserve the analytical comprehensiveness.

Through a process of re-mapping and filtering based on the empirical experiences of the respondents—taking into account the frequency of occurrence, potential impact on project objectives, and the complexity of mitigation—the final number of risk variables was narrowed down to 32 key risks considered most significant.

C. Probability and Impact Assessment

After establishing the final list of 32 core risks, the next step involved measuring the likelihood of occurrence (probability) and the severity of consequences (impact) associated with each risk in relation to project success. This assessment was conducted through the distribution of structured questionnaires to a diverse group of key respondents, each with professional experience relevant to the construction field, to ensure objectivity and representativeness in risk perception.

The data were analyzed using the Severity Index method, which calculates a combined score based on the probability and impact values for each risk. The scores obtained from respondents were then averaged and rounded to the nearest value according to the predefined classification scale. This approach provides a strong quantitative basis for determining the risk severity level and supports more informed decision-making in setting mitigation priorities.

The average scores derived from the assessment of both the probability and impact of each identified risk were subsequently rounded to the nearest whole number. This rounding process adheres to the classification guidelines established in Table 1. The objective of this step is to streamline the categorization of risks, thereby facilitating the prioritization of mitigation actions in the subsequent phases of risk analysis.

TABLE I. RISK EVALUATION LEVEL CLASSIFICATION BASED ON AVERAGE RISK INDEX VALUES

Average Index (x)	***1 ≤ x ≤ 1.5***	***1.5 ≤ x ≤ 2.5***	***2.5 ≤ x ≤ 3.5***	***3.5 ≤ x ≤ 4.5***	***4.5 ≤ x ≤ 5***
Rounded Value	***1***	***2***	***3***	***4***	***5***

Source : Majid & McCaffer, (1998)

The final results of the overall calculation of probability and impact values are systematically presented in Table 2, which provides an initial mapping of the severity level of each identified risk within the context of project implementation.

TABLE II. SUMMARY OF RISK PROBABILITY AND IMPACT ASSESSMENT RESULTS

Risk Code	***Probability***		***Impact***	
	Average	***Rounded***	***Average***	***Rounded***
R-1	4.57	5	2.50	3
R-2	3.43	3	2.71	3
R-3	3.36	3	3.50	4
R-4	3.21	3	3.29	3
R-5	2.14	2	2.36	2
R-6	2.93	3	2.86	3
R-7	2.50	3	2.07	2
R-8	1.57	2	1.86	2
R-9	1.79	2	2.00	2
R-10	1.43	1	1.43	1
R-11	2.00	2	2.43	2
R-12	1.86	2	2.43	2
R-13	1.50	2	2.36	2
R-14	2.21	2	2.43	2
R-15	3.29	3	3.21	3
R-16	3.21	3	2.93	3
R-17	2.71	3	1.57	2
R-18	2.14	2	2.79	3
R-19	2.43	2	2.36	2
R-20	3.93	4	3.36	3
R-21	3.36	3	3.29	3
R-22	1.14	1	1.57	2
R-23	3.29	3	3.07	3
R-24	2.71	3	3.43	3
R-25	1.43	1	1.21	1
R-26	1.79	2	1.50	2
R-27	3.36	3	3.50	4
R-28	2.86	3	3.50	4
R-29	2.79	3	2.93	3
R-30	3.64	4	3.50	4
R-31	3.14	3	2.79	3
R-32	3.00	3	1.93	2

Source: Processed by the Authors, 2025

D. Risk Level Classification

Based on the results of the main survey analysis, each of the 32 risk variables was categorized into three levels of severity:

- Low (L)
- Medium (M)
- High (H)

This classification was carried out using a Risk Assessment Matrix, which integrates the two key parameters: probability and impact. The purpose of this classification is to facilitate effective risk mapping and to guide the prioritization of follow-up actions according to the level of urgency.

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 06, June - 2025

The final classification results are systematically presented in Table 1, which also serves as the basis for developing mitigation strategies in the subsequent stage of analysis.

TABLE III. RISK CLASSIFICATION BASED ON PROBABILITY AND IMPACT SCORES

Risk Code	*Probability*	*Impact*	*Risk Score*	*Risk Level*
R-1	5.00	3.00	15.00	High
R-2	3.00	3.00	9.00	Medium
R-3	3.00	4.00	12.00	High
R-4	3.00	3.00	9.00	Medium
R-5	2.00	2.00	4.00	Low
R-6	3.00	3.00	9.00	Medium
R-7	3.00	2.00	6.00	Medium
R-8	2.00	2.00	4.00	Low
R-9	2.00	2.00	4.00	Low
R-10	1.00	1.00	1.00	Low
R-11	2.00	2.00	4.00	Low
R-12	2.00	2.00	4.00	Low
R-13	2.00	2.00	4.00	Low
R-14	2.00	2.00	4.00	Low
R-15	3.00	3.00	9.00	Medium
R-16	3.00	3.00	9.00	Medium
R-17	3.00	2.00	6.00	Medium
R-18	2.00	3.00	6.00	Medium
R-19	2.00	2.00	4.00	Low
R-20	4.00	3.00	12.00	High
R-21	3.00	3.00	9.00	Medium
R-22	1.00	2.00	2.00	Low
R-23	3.00	3.00	9.00	Medium
R-24	3.00	3.00	9.00	Medium
R-25	1.00	1.00	1.00	Low
R-26	2.00	2.00	4.00	Low
R-27	3.00	4.00	12.00	High
R-28	3.00	4.00	12.00	High
R-29	3.00	3.00	9.00	Medium
R-30	4.00	4.00	16.00	High
R-31	3.00	3.00	9.00	Medium
R-32	3.00	2.00	6.00	Medium

Source: Processed by the Authors, 2025

Referring to Table 1, the data on risk probability and impact levels were subsequently mapped into a Probability-Impact Matrix based on the AS/NZS 4360:2004 standard, as illustrated in Fig. 1.

Kemungkinan (*Likelihood*)	Dampak (*Consequences*)				
	Sangat Rendah (*Insignificant*)	Rendah (*Minor*)	Medium (*Moderate*)	Tinggi (*Major*)	Sangat Tinggi (*Catastrophic*)
Hampir Pasti (*Almost Certain*)			R1		
Kemungkinan Besar (*Likely*)			R20	R30	
Kemungkinan Kecil (*Moderate*)		R7,R17,R32	R2,R4,R6,R15, R16,R21,R23,R24, R29,R31	R3,R27,R28	
Tidak Mungkin (*Unlike*)		R5,R8,R9,R11,R12, R13,R14,R19,R26	R18		
Sangat Tidak Mungkin (*Rare*)	R10,R25	R22			

Fig. 1. Risk Mapping in the Probability-Impact Grid (AS/NZS 4360:2004)

Based on the visualization presented in Figure 1, all identified risk variables associated with the Radial Road construction project are classified into three main categories. This classification considers two key parameters: risk severity and risk acceptability, both of which jointly determine the urgency of response and the allocation of mitigation resources.

The First Category consists of six risk variables classified as high-risk (intolerable risk). Risks in this group are deemed unacceptable under any circumstances due to their significant potential to hinder the achievement of project objectives. Consequently, immediate and strategic mitigation actions are mandatory. The primary goal of such mitigation is to reduce the risk level to a more acceptable zone, ideally to the ALARP (As Low As Reasonably Practicable) threshold—wherein the risk cannot be entirely eliminated but has been minimized to the lowest reasonable level in terms of cost and resource considerations.

The Second Category comprises 14 risk variables identified as moderate risks. Although still within acceptable limits, these risks require proactive managerial intervention to reduce the likelihood of occurrence or mitigate their potential impacts. Risk management strategies at this level are preventive and adaptive, aiming for operational efficiency and accurate decision-making to avoid escalation into higher risk levels.

The Third Category includes 12 risk variables considered low-risk (acceptable risk). Risks in this category pose minimal impact on the project's continuity and, in general, are acceptable without the need for additional mitigation measures. Therefore, allocating specific resources to address these risks is not prioritized within the overall risk management strategy.

Nevertheless, for risks within the ALARP zone, even though they are not classified as high risk, mitigation is still recommended if the associated cost and effort are proportionate to or outweighed by the benefits of risk reduction. This approach reflects a prudent risk management principle—balancing resource efficiency with adequate protection against potential hazards.

In summary, the risk classification structure illustrated in Fig. 1 provides a systematic foundation for establishing mitigation priorities. This risk mapping not only supports the development of targeted risk management strategies but also enhances data-driven decision-making capacity, especially in scenarios requiring prompt and well-informed responses to threats that may compromise project success.

IV. CONCLUSION

This study successfully identified and analyzed 32 key risk variables from a total of 53 initial risks listed in the project's risk register. Furthermore, the research revealed six primary risks with the highest index values that have the potential to significantly hinder the successful implementation of the Flexible Pavement Road Construction Project on Radial Road. The highest-ranked risk is "Simultaneous work by private parties within the project area" (index 16), which poses a critical threat due to potential schedule disruptions and coordination issues. The second-highest risk is "Changes to the design drawings" (index 15), which can lead to technical adjustments and project delays. Meanwhile, four other risks—each with an index value of 12—include: "Suboptimal or insufficient data collection and pre-design survey stages," "Limited access to required materials and equipment at the project site," "Incomplete compensation process for privately or individually owned land," and "Temporary suspension of construction activities due to community protests."

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 06, June - 2025

ACKNOWLEDGMENT

The author expresses deepest gratitude to all respondents who generously dedicated their time and provided invaluable data for this research. Sincere thanks are also extended to the beloved family for their unwavering support and motivation throughout the research process. In addition, special appreciation is given to the entire academic community of the Faculty of Engineering, Master of Civil Engineering Program, Universitas 17 Agustus 1945 Surabaya, for their collaboration, insightful discussions, and continuous support during the course of study

REFERENCES

[1] AS/NZS 4360:2004. (2004). Australian/New Zealand Standard Risk MAnagement. In Australian Standards / New Zeland Standards 4360:2004.

[2] Dang, C. N., Le-Hoai, L., Kim, S. Y., Nguyen, C. Van, Lee, Y. D., & Lee, S. H. (2017). Identification of risk patterns in Vietnamese road and bridge construction: Contractor's perspective. Built Environment Project and Asset Management, 7(1). https://doi.org/10.1108/BEPAM-11-2015-0065

[3] Guest, G., Namey, E.E., & McKenna, K. (2017). How many focus groups are enough? Building an evidence base for nonprobability sample sizes. Field Methods, 29(1), 3–22. https://doi.org/10.1177/1525822X16639015

[4] Majid, M. Z. A., & McCaffer, R. (1998). Factors of non-excusable delays that influence contractors' performance. Journal of Management in Engineering. https://doi.org/10.1061/(ASCE)0742-597X(1998)14:3(42)

[5] Moi, F., & Purnawirati, I. (2021). Analisis Manajemen Risiko Pada Proyek Pembangunan Ruas Jalan Baru Waebetu–Tarawaja. Jurnal Talenta Sipil. http://talentasipil.unbari.ac.id/index.php/talenta/article/view/52

[6] Nguyen, T. H., Bhagavatulya, G., & Jacobs, F. (2014). Risk Assessment : A Case Study for Transportation Projects in India. International Journal of Application or Innovation in Engineering & Management, 3(9).

[7] Nyumba, T. O., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods in Ecology and Evolution, 9(1), 20–32. https://doi.org/10.1111/2041-210X.12860

[8] Perera, B. A. K. S., Dhanasinghe, I., & Rameezdeen, R. (2009). Rizikos valdymas tiesiant kelius: Šri lankos atvejis. International Journal of Strategic Property Management, 13(2). https://doi.org/10.3846/1648-715X.2009.13.87-102

[9] Pirogova, O., Plotnikov, V., & Uvarov, S. (2022). Risk-based approach in the assessment of infrastructure transport projects. Transportation Research Procedia, 63, 129–139. https://doi.org/10.1016/j.trpro.2022.05.015

[10] ProjectManagementInstitute, A. (2017). Guide to the Project Management Body of Knowledge (PMBOK Guide), Newtown Square, PA, USA: Project Management Institute. Inc.

[11] Rahmawati, N., & Tenriajeng, A. T. (2020). Analisis Manajemen Risiko Pelaksanaan Pembangunan Jalan Tol (Studi Kasus: Proyek Pembangunan Jalan Tol Bekasi-Cawang-Kampung Melayu). Rekayasa Sipil. https://rekayasasipil.ub.ac.id/index.php/rs/article/view/592

[12] Setiawan, E., Witjaksana, B., & Tjendani, H. T. (2023). Analysis Of Risk Management In Building Workers Of Sman 5 Brawijaya Building Kediri. International Journal On Advanced Technology, 2(4). https://ojs.transpublika.com/index.php/IJATEIS/

[13] Shi, H., & Gao, M. (2020). Analysis of a Flexible Transit Network in a Radial Street Pattern. Journal of Advanced Transportation, 2020(1), 5379218. https://doi.org/https://doi.org/10.1155/2020/5379218

[14] Szymański, P. (2017). Risk management in construction projects. Procedia Engineering, 208. https://doi.org/10.1016/j.proeng.2017.11.036

[15] Winoto, M. C., Guwinarto, K., & ... (2023). Faktor Penyebab dan Dampak Keterlambatan Pelaksanaan Proyek Konstruksi Menurut Kontraktor Terhadap Indikator Performa Proyek. Jurnal Dimensi Pratama https://publication.petra.ac.id/index.php/tekniksipil/article/view/13435

[16] Witjaksana, B., & Purnama, J. (2025). High-Level Risk Analysis in the Construction Project of RSUD Dr. H. Slamet Martodirdjo in Pamekasan. In Pamekasan Asian Journal of Social and Humanities (Vol. 3). https://ajosh.org/

[17] Yuli Anita, S., Tanti Kustina, K., Wiratikusuma, Y., Sudirjo, F., Sari, D., Rupiwardani, I., Nugroho, L., Rakhmawati, I., Kesumawati Harahap, A., Anwar, S., Apriani, E., & Luh Ketut Ayu Sudha Sucandrawati, N. (2023). MANAJEMEN RISIKO (M. E. Diana Purnama Sari, Ed.; 1st ed.). www.globaleksekutifteknologi.co.id