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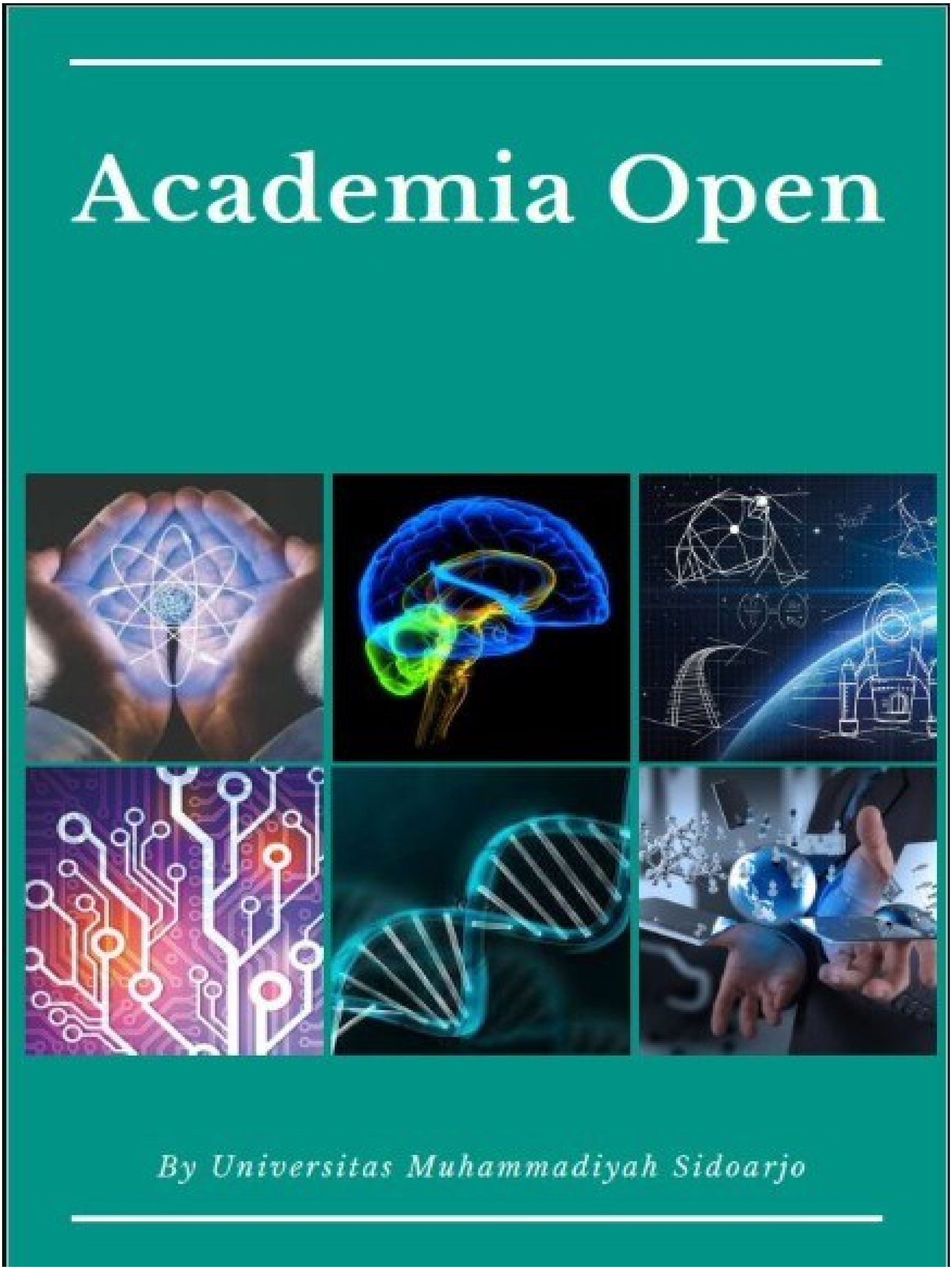

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Owner Representative Decisions and Risk Drivers of Residential Project Delays

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Abstract

General Background: Rapid population growth in Indonesia increases housing demand and pressures residential project schedules. **Specific Background:** Residential projects require coordination among stakeholders, with the owner's representative responsible for key project approvals. **Knowledge Gap:** The role of the owner's representative in project time performance remains insufficiently studied. **Aims:** This study examines owner representative decision factors related to schedule performance using SEM-PLS, risk matrix, and SWOT analysis. **Results:** The model shows strong validity and reliability, with Site, Materials, and Labor identified as the main delay risks. **Novelty:** The study links owner decision-making with schedule deviation risks through an integrated analytical framework. **Implications:** Proactive decisions, early site validation, and improved material and labor management are essential to maintain schedule stability in residential construction projects.

Highlights:

- Site conditions, material availability, and workforce factors form the dominant moderate-level delay risks.
- Measurement model demonstrates strong construct validity and reliability through high AVE and composite reliability values.
- Strategic positioning in the diversification zone supports Strength–Threats mitigation to control schedule deviation.

Keywords: Website Development, Pesantren Profile, Digital Transformation, Usability, Waterfall.

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Introduction

Population growth in Indonesia continues to show a positive trend, meaning that the total population keeps increasing over time. Similar conditions also occur in West Java Province and Bekasi City, where the population growth rate is relatively high [1]. This increase in population has a direct impact on the rising demand for housing, as housing is one of the basic needs besides clothing and food. The property sector, particularly housing, has experienced significant development compared to previous years due to the high public demand for residential houses. To meet market needs, various housing development projects by developers have increasingly emerged. Construction projects, including housing development, have distinctive characteristics because they consist of a series of activities carried out within a specific period of time using limited resources, with the aim of producing outputs in accordance with the provisions stipulated in the contract documents [2].

The construction industry plays an important role in supporting national development, particularly in the provision of residential buildings as a basic need of society [3]. Various previous studies have identified the causes of delays in construction projects. However, most of these studies focus more on factors originating from contractors, weak site management, or external factors such as weather conditions and permitting processes. Meanwhile, the role of the project owner's representative as a strategic decision-maker has often not received adequate attention, even though its influence on project performance is highly significant [4]. The owner's representative plays an important role in granting approvals related to site aspects, design aspects, labor aspects, material aspects, contract aspects, and financial aspects, as well as in controlling the contractor during project implementation. In practice, various problems are frequently found that are related to the decision-making process carried out by the owner's representative [5].

Since not all constraints can be predicted, such events can be identified as risks based on previous experience or the opinions of construction experts. Therefore, every company is expected to have effective risk management to anticipate and mitigate potential risks by applying appropriate handling strategies for each identified risk [6]. In risk management, ineffective risk handling can lead to project profit losses and cost overruns as a result of poor risk responses. In contrast, effective risk handling is expected to minimize the negative impacts of risks so that the project schedule and budget can be implemented smoothly in accordance with the planned targets [7].

Method

The research method refers to a series of systematic steps used to investigate a case, problem, phenomenon, or symptom with the aim of obtaining rational and evidence-based answers [8]. PT SA is one of the leading property development companies in Indonesia, well known for its various residential, commercial, and industrial development projects. The property project examined in this study is located at a different site, with the first research location situated in West Java Province.

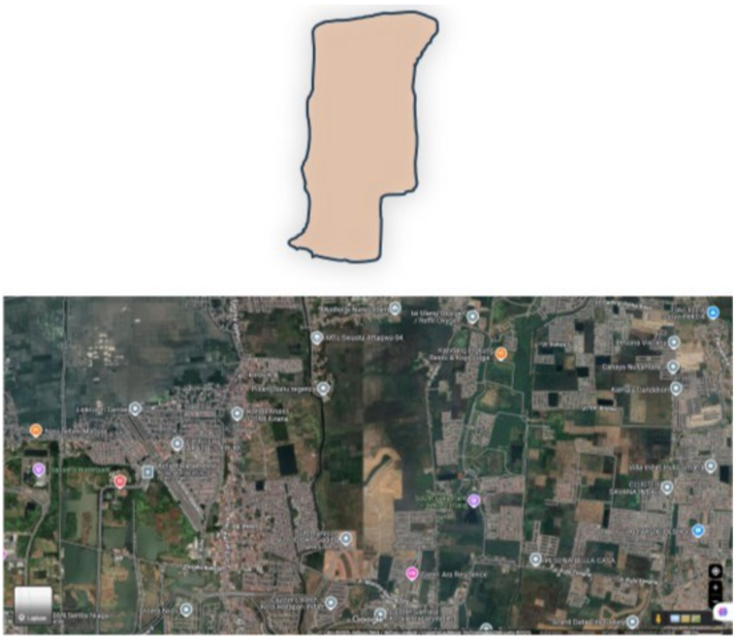

Figure 1. Research Location

The object of this research focuses on the Cluster Regia housing development project, which is part of a regional development undertaken by PT SA Tbk., Regional 1 (Bekasi), within the Summarecon Crown Gading area. The project is located in Setia Asih, Tarumajaya Subdistrict, Bekasi Regency, West Java, with postal code 17215. This project consists of 422 housing units constructed by seven different contractors.

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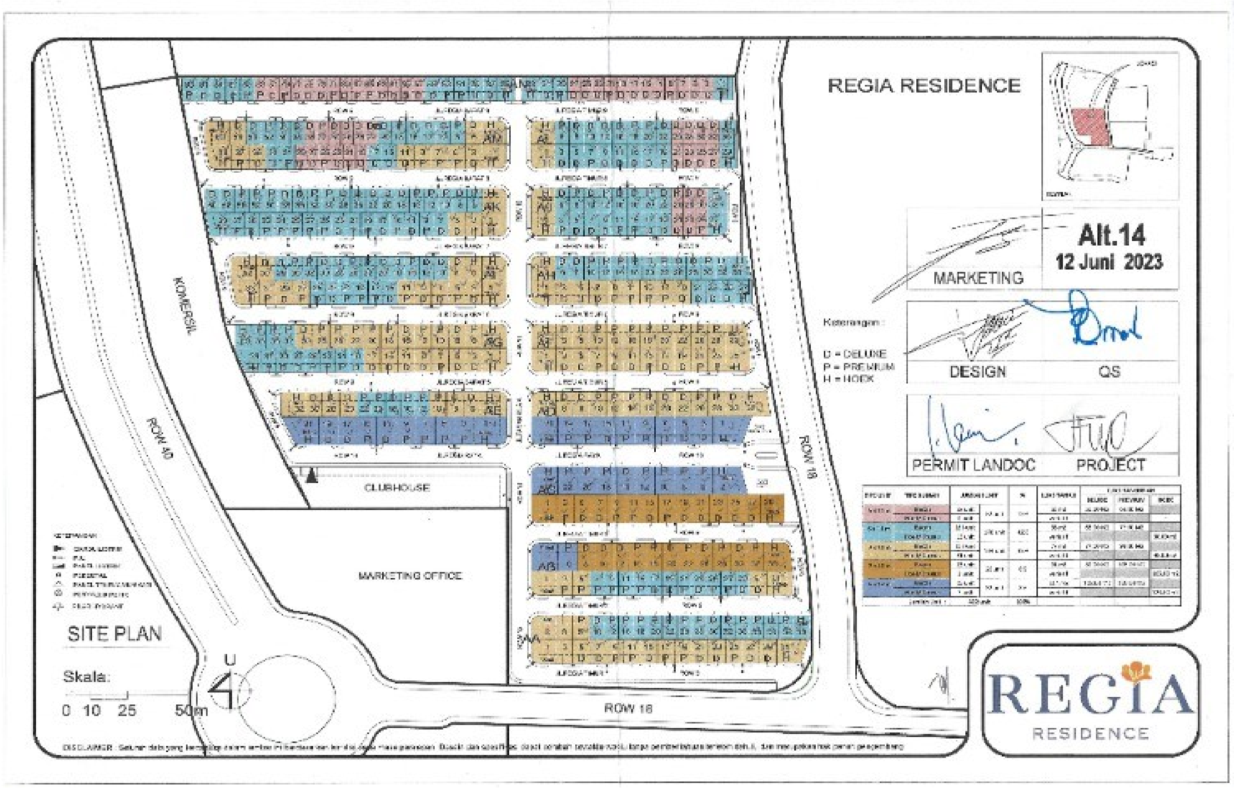

Figure 2. Research Site Plan

Results and Discussion

A. Practical Implications

The practical implications of these findings indicate that the owner's representative should prioritize risk management on factors that have been proven to exhibit dominant occurrence intensity and impact on time performance. Strict control over risks categorized as "Moderate," particularly those related to Site, Materials, and Labor aspects, should become a primary focus in daily operational strategies. Therefore, accelerating decision-making related to material approvals, conducting earlier validation of site readiness, and implementing intensive monitoring of labor availability are concrete actions that need to be taken by the owner's representative to effectively break the chain of causes of project delays [9].

In addition, the implementation of responsive mitigation strategies is a crucial step to maintain project stability amid significant external pressures. Given that the organization's strategic position lies in Quadrant II (Diversification Zone), the owner's representative must actively leverage existing internal strengths as capital to neutralize external threats [10]. Periodic evaluation of the effectiveness of these S–T (Strengths–Threats) strategies enables management to dynamically adjust risk-handling tactics, thereby ensuring that each managerial decision provides maximum protection for project completion targets and stakeholder satisfaction [11].

B. Theoretical Implications

Theoretically, the results of this study provide a significant empirical contribution to the construction management literature, particularly in the context of the role of the owner's representative in residential building projects. First, this study demonstrates the robustness of the developed measurement model, where high validity values (AVE > 0.759) and reliability values (Composite Reliability > 0.894) confirm that the instrument is highly precise in measuring the latent variables of owner decision- making [12].

Second, these findings deepen the understanding of project risk management theory by identifying specific causal relationships between decisions made by the owner's representative and schedule deviations. The identification of Site, Materials, and Labor aspects as dominant risk factors in the "Moderate" category confirms the theory that uncertainty in owner decision-making regarding critical resources has a direct impact on time performance. This addresses a gap in the literature by highlighting that, in residential projects, delay risks do not originate solely from contractors' technical factors but are strongly influenced by the intensity and accuracy of decisions made by the owner's representative [13].

Third, the analysis of the strategic position in Quadrant II (Diversification) confirms that the application of S–T (Strengths–Threats) strategies is a crucial mechanism for mitigating external pressures through the optimization of internal strengths. This reinforces the theoretical proposition that project success is more strongly determined by an organization's capability to orchestrate internal resources than by reliance on external market conditions alone [14].

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C. Research Limitations

First, this study focuses solely on residential building projects. Therefore, the generalization of the findings to other types of construction, such as high-rise buildings, infrastructure projects, or industrial facilities, may be limited. The specific characteristics of residential projects, including project scale, design complexity, and the communication patterns of the owner's representative, may influence the relationship between owner decision-making and time performance differently compared to larger-scale projects.

Second, the use of the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method and risk matrix analysis relies on data collected through questionnaires, which are susceptible to subjective response bias. This limitation may affect data objectivity, particularly when respondents, such as owner representatives or project team members, assess risk levels or importance weights based on personal experience rather than on measurable historical data.

Third, this study limits its primary exogenous variables to aspects of owner representative decision-making and directly related internal and external project factors. Other potentially relevant macro variables, such as global material price fluctuations, sudden changes in urban planning regulations, or extreme weather conditions, were not specifically analyzed as independent variables influencing project time performance separately.

Fourth, the sample size used in this study is limited to the number of owner representatives or residential projects willing to participate within the selected study area, which may restrict statistical power and the scope of generalization of the findings. Therefore, future research is recommended to expand the geographical coverage, consider additional moderating variables, and apply mixed-method approaches, both qualitative and quantitative, to explore more deeply the underlying reasons behind owner decision-making in order to enhance research outcomes.

Before proceeding to an in-depth analysis of the influence of owner's representative decision factors in the context of residential building projects, this study first presents the profile of respondents' characteristics. This overview is essential to map the participants' backgrounds and to strengthen the contextual validity of the collected data. The examined characteristics include the highest level of education, length of professional experience, and organizational position. These three dimensions were selected based on their relevance in reflecting individual competence and leadership typology, which theoretically may influence perceptions and response patterns toward the research variables. In addition, this demographic description serves as a verification instrument to ensure that all respondents have functional involvement relevant to the specifications of the residential building projects that constitute the focus of this study [15].

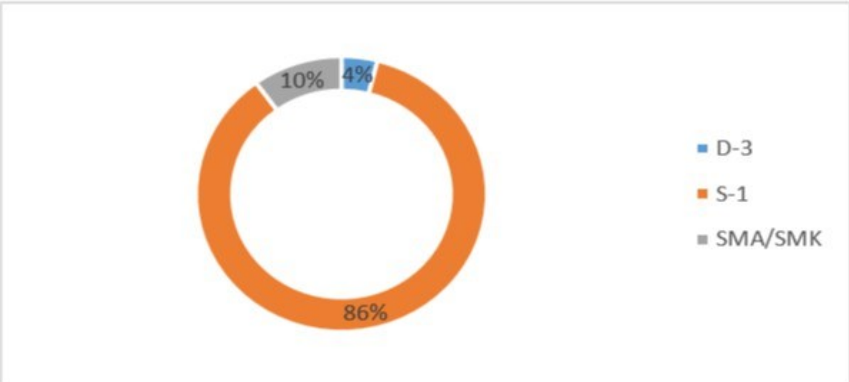

Figure 3. Donut Chart of Respondents' Highest Education Level

Based on the data presented in Figure 3, the composition of the highest educational background of the 50 research respondents shows a significant dominance of higher education levels. The majority of respondents, amounting to 86% (43 individuals), hold a Bachelor's degree (S-1). This large proportion reflects strong professional qualifications within the studied construction project environment, where strategic and managerial roles generally require an undergraduate academic foundation to support complex technical decision-making [16]. Furthermore, respondents with a senior high school or vocational high school (SMA/SMK) educational background account for 10% (5 individuals). This group represents operational personnel who play a crucial role at the technical field level or in project execution. Meanwhile, the smallest proportion consists of Diploma Three (D-3) graduates, comprising 4% (2 individuals) of the total population, who provide support through applied vocational expertise aligned with the needs of the construction industry [17]. Overall, this educational distribution constructs a narrative indicating that the study involves participants with adequate intellectual capacity. The dominance of Bachelor's degree holders provides a strong signal that the collected data possess high levels of credibility and objectivity, as they originate from respondents with relevant theoretical understanding and professional experience in the dynamics of the infrastructure development sector [18].

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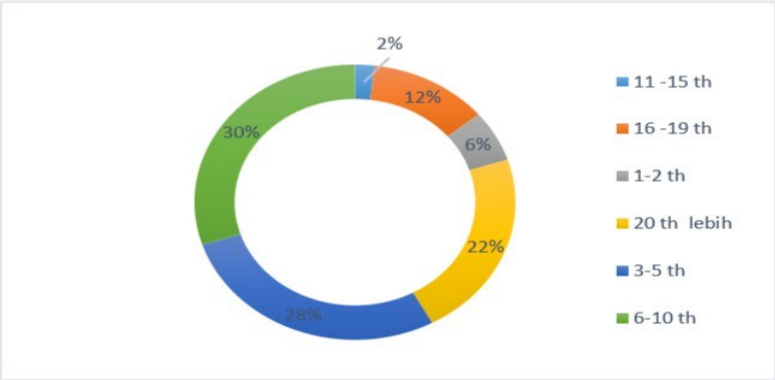

Figure 4. Donut Chart of Respondents' Work Experience

Figure 4 illustrates the distribution of work experience among the 50 respondents who participated in this study. Overall, the data show that the majority of respondents fall within the 6 to 10 years of work experience range, totaling 15 individuals or 30%. The dominance of this group indicates that the core of the research population is in a mature professional phase, where individuals have passed the initial adaptation stage and possess an in-depth technical understanding of residential building project procedures. The group with 3 to 5 years of work experience ranks second with 14 respondents (28%). Their presence represents a dynamic and operationally active workforce, capable of providing fresh perspectives on the current implementation of project management practices in the field [19]. Furthermore, a significant contribution is also provided by the senior expert group with more than 20 years of experience, comprising 11 respondents (22%). Although not the majority in terms of quantity, this group holds high strategic value because it brings extensive historical perspectives and long-standing experience in dealing with various complexities of the construction industry. Their positions, which often involve decision-making authority, add an additional layer of credibility to the responses provided in the research questionnaire. Meanwhile, respondents in the 16 to 19 years of experience category number 6 individuals (12%). This transitional group strengthens data validity by offering assessments from professionals who have long been engaged in the industry while remaining actively involved in technical supervision functions.

Other categories include younger personnel with 1 to 2 years of work experience, totaling 3 respondents (6%). Although small in proportion, their inclusion remains essential to capture the perceptions of the new generation regarding the effectiveness of existing management systems. Finally, the smallest category consists of respondents with 11 to 15 years of work experience, represented by 1 individual (2%). Overall, the integration of these six experience categories creates a highly comprehensive data spectrum. The combination of practical and technical foundations from the majority group with the strategic insight of senior professionals ensures that the analysis of the influence of owner's representative decision-making is grounded in credible, multi-layered perspectives that represent all levels of the professional hierarchy within the studied project.

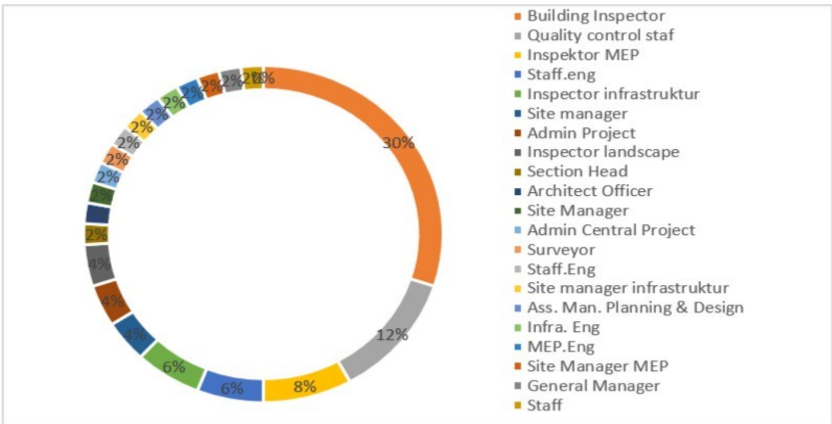

Figure 5. Donut Chart of Respondents' Job Positions

Figure 5. presents the job position profile of the respondents, showing the functional distribution within the project organizational structure. The Building Inspector position constitutes the largest group at 30% (15 individuals), followed by Quality Control Staff at 12% (6 individuals) and MEP Inspectors at 8% (4 individuals). In addition, there is representation from other managerial and technical levels, such as Engineering Staff at 6% (3 individuals), Infrastructure Inspectors at 6% (3 individuals), as well as various managerial positions including Site Manager, General Manager, and Section Head, each contributing unique perspectives. The presence of diverse positions ranging from administrative staff and surveyors to project managers indicates that the research data are inclusive and comprehensive. This ensures that the phenomenon of owner's representative decision-making is examined from multiple viewpoints of authority and functional responsibility within the residential building project environment.

1. Descriptive Statistics

The application of descriptive statistics in this study is intended to comprehensively map the distribution of participants' responses to each variable indicator. Through this approach, trends in respondents' perceptions regarding the influence of owner's representative decision factors in residential building projects can be systematically identified. The data are presented through percentage analysis of agreement levels and the calculation of mean values based on Likert scale scores. These descriptive statistical results serve as initial indicators to evaluate the degree of respondent consensus, where higher mean values reflect stronger levels of agreement or satisfaction with a given indicator, while lower values signal the urgency for performance strengthening or improvement, particularly in aspects of project time performance.

2. Project Management Aspect

Table 1. Descriptive Statistics of the Project Management Aspect

Variabel	Kode	Indikator Pernyataan	P1	P2	P3	P4	P5	P6	P7	P8	MEAN
Aspek Tempat	X1.1	Menyusun jadwal kerja fleksibel dan membuat *contingency plan*	5	4	5	4	2	5	5	5	**4,375**
	X1.3	Koordinasi dengan dinas perhubungan untuk rekayasa lalu lintas	5	4	5	5	2	5	4	5	**4,375**
	X1.4	Menetapkan vendor/material supplier alternatif dan *buffer stock*	5	5	4	4	3	5	5	4	**4,375**
	X1.5	Memastikan jadwal serah-terima lahan jelas sejak awal kontrak	4	4	5	4	2	5	5	5	**4,25**
Aspek Desain	X2.1	Melakukan *design review* bersama konsultan dan kontraktor	5	4	5	5	2	5	5	5	**4,5**
	X2.2	Menetapkan *deadline approval* desain dan menugaskan PIC khusus	5	5	5	4	2	5	4	5	**4,375**
	X2.3	Mengadakan koordinasi rutin gambar kerja di lapangan	5	4	4	4	3	5	5	5	**4,375**
	X2.4	Menentukan *lead time* persetujuan material di awal proyek	4	4	5	5	2	5	5	5	**4,375**
	X2.5	Mengadakan *technical coordination meeting* secara berkala	5	4	5	4	2	5	5	4	**4,25**
Aspek Tenaga Kerja	X3.1	Menyederhanakan dan mempercepat prosedur perijinan internal	5	4	5	4	2	5	4	5	**4,25**
	X3.2	Mewajibkan kontraktor menyiapkan tenaga kerja kompeten	5	4	5	5	2	5	5	5	**4,5**
	X3.3	Pelatihan dan evaluasi kinerja personel owner secara berkala	5	5	4	4	2	5	5	5	**4,375**
	X3.4	Mengadakan *technical briefing* sebelum pekerjaan dimulai	4	4	5	4	3	5	5	4	**4,25**
	X3.5	(Indikator Pernyataan X3.5)	5	4	5	4	2	5	5	5	**4,375**
Aspek Bahan	X4.1	Menentukan jadwal pengadaan & *buffer material* penting	5	5	5	4	2	5	5	5	**4,5**
	X4.2	Menyediakan opsi material substitusi setara di awal kontrak	5	4	5	5	2	5	4	5	**4,375**
	X4.3	Mewajibkan kontraktor membuat *procurement schedule* detail	5	4	5	4	2	5	5	5	**4,375**
	X4.4	Mengatur waktu pemesanan lebih awal & kontrol *progress*	5	4	4	4	3	5	5	5	**4,375**
	X4.5	Menetapkan prosedur persetujuan perubahan material cepat	4	4	5	5	2	5	5	5	**4,375**
Aspek Kontrak	X5.1	Menetapkan prosedur VO (*Variation Order*) yang jelas dan ketat	5	4	5	4	2	5	5	5	**4,375**
	X5.2	Melakukan *design review* dan *crosscheck* dokumen gambar	5	4	5	5	2	5	4	5	**4,375**
	X5.3	Melakukan kajian risiko dan persetujuan VO sebelum pelaksanaan	5	5	5	4	2	5	5	5	**4,5**
	X5.4	Membatasi pekerjaan tambah hanya yang benar-benar *urgent*	5	4	5	4	2	5	4	5	**4,25**
	X5.5	Melakukan *review* desain dan *scope* sebelum kontrak dimulai	4	4	5	5	3	5	5	5	**4,5**
Aspek Keuangan	X6.1	Menyusun *contingency budget* dan negosiasi ulang harga	5	5	5	4	2	5	5	5	**4,5**
	X6.2	Menetapkan sistem pembayaran *progress* berkala yang jelas	5	4	5	4	2	5	4	5	**4,25**
	X6.3	Melakukan estimasi ulang biaya oleh estimator independen	5	3	5	5	2	5	5	5	**4,375**
	X6.4	Memberikan bonus/percepatan bagi kontraktor	4	4	5	4	2	5	5	5	**4,25**
	X6.5	Mewajibkan kontraktor membuat *cash flow schedule*	5	4	5	4	2	5	5	5	**4,375**

The descriptive results for the Site Aspect (X1) show that indicators related to work schedule flexibility, traffic coordination, and the availability of alternative vendors achieved the highest mean value of 4.375. This indicates that respondents perceive logistics risk management and external relationship management as top priorities. Meanwhile, the indicator of land handover certainty (X1.5) recorded a slightly lower mean value of 4.25. This finding suggests that although location-related factors are highly critical, there are administrative challenges at the early contract stage that are considered to have a distinct level of complexity compared to operational coordination in the field. In the Design Aspect (X2), the indicator stating the implementation of design reviews involving consultants and contractors (X2.1) achieved the highest mean value of 4.5. This high score reflects a collective awareness that the integration of perspectives between planners and implementers is highly effective in minimizing technical errors. Other indicators, such as the establishment of approval deadlines and coordination of working drawings, consistently recorded a mean value of 4.375. This illustrates that design document management has been carried out systematically, although its effectiveness is highly dependent on the speed of the approval process at the initial stage of the project.

The analysis of the Labor Aspect (X3) reveals that the requirement for contractors to provide competent labor (X3.2) attained the highest mean value of 4.5. This result emphasizes that human resource quality is regarded as the most fundamental asset for project success. On the other hand, indicators related to routine training (X3.3) and technical briefings (X3.4) recorded mean values ranging from 4.25 to 4.375. Although these values remain high, the slight differences signal that companies need to further strengthen capacity development and technical communication to ensure that workforce competencies in the field are well standardized.

In the Materials Aspect (X4), the indicator related to procurement scheduling and buffer material management (X4.1) recorded the highest mean value of 4.5. This indicates that respondents place strong emphasis on material availability to maintain work continuity. Other indicators, such as the use of substitute materials and detailed procurement scheduling, achieved a mean value of 4.375. These data reflect that supply chain management strategies are relatively mature, with contractors tending to prepare contingency plans to anticipate delivery delays that could disrupt the project's critical schedule. The Contract Aspect (X5) demonstrates very strong perceptions regarding the importance of controlling work changes, where the indicators of risk assessment (X5.3) and scope review prior to contract signing (X5.5) each attained a mean value of 4.5. This finding indicates that contract clarity from the early stages is considered crucial to avoiding disputes in the future. Meanwhile, the indicator related to limiting additional work (X5.4) recorded a mean value of 4.25. This suggests that although restricting changes is important, it still requires careful consideration in practical implementation.

In the Financial Aspect (X6), the indicator concerning the preparation of contingency budgets and price negotiations (X6.1) achieved the highest mean value of 4.5. This shows that the management of reserve funds is regarded as the most effective financial protection instrument by experts. On the other hand, indicators related to the progress payment system (X6.2) and the provision of acceleration bonuses (X6.4) recorded the lowest mean values within this aspect, at 4.25. These relatively lower scores compared to other indicators indicate room for improvement in incentive systems and payment mechanisms to better motivate partners in accelerating the physical progress of the project.

3. External Aspect

Descriptive analysis of the External Conditions Aspect (Z) provides an overview of the extent to which the company responds to environmental and regulatory factors that lie beyond the internal control of the project.

Table 2. Descriptive Statistics of the External Aspect

Variabel	Kode	Indikator Pernyataan	P1	P2	P3	P4	P5	P6	P7	P8	MEAN
Aspek Kondisi Eksternal	Z.1	Perusahaan secara rutin melakukan monitoring terhadap regulasi dan perizinan proyek.	4	3	4	3	3	4	4	4	3,625
	Z.2	Perusahaan melengkapi proyek dengan asuransi untuk memitigasi risiko kerugian akibat kejadian tidak terduga.	5	4	5	4	2	5	4	4	4,125
	Z.3	Perusahaan menyusun perjanjian yang jelas mengenai tanggung jawab lingkungan dengan pihak terkait.	4	3	5	4	2	5	5	4	4
	Z.5	Perusahaan menugaskan PIC khusus untuk menangani perizinan dan koordinasi dengan dinas terkait.	4	3	4	3	3	4	4	5	3,75
	Z.6	Perusahaan menyiapkan langkah antisipasi terhadap kebijakan baru yang dapat berdampak pada proyek.	5	4	5	4	2	5	4	4	4,125

Based on the data, the indicators related to the use of insurance for risk mitigation (Z.2) and the readiness to anticipate new policies (Z.6) recorded the highest mean values of 4.125. The value of indicator Z.2 confirms that experts perceive financial protection through insurance instruments as a crucial strategy for transferring risk associated with unforeseen events in the field. In line with this, the high value of Z.6 indicates that the company demonstrates strong proactivity in monitoring government regulatory dynamics, where policy changes are often the most difficult external variables to predict yet have significant impacts on project cost structures and schedules.

Meanwhile, the indicator related to the formulation of clear environmental responsibility agreements (Z.3) achieved a mean value of 4.0. This reflects a strong level of legal and environmental awareness, where contractual clarity regarding environmental impacts is regarded as an operational standard to safeguard the company's reputation while avoiding legal disputes with third parties or surrounding communities. On the other hand, the indicators concerning the assignment of a dedicated Person in Charge (PIC) for permitting coordination (Z.5) and the routine monitoring of regulations (Z.1) recorded mean values of 3.75 and 3.625, respectively. Although these values still fall within a good category, their relatively lower scores compared to other indicators indicate room for improvement in internal bureaucratic processes and the consistency of regulatory oversight. These findings signal that while the company has established strong mitigation measures, such as insurance coverage, administrative aspects and daily coordination with relevant authorities remain areas that present particular challenges.

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4. Owner's Representative Decision Aspect

Table 3. Descriptive Statistics of the Owner's Representative Decision Aspect

Variabel	Kode	Indikator Pernyataan	P1	P2	P3	P4	P5	P6	P7	P8	MEAN
Keputusan Represnetatif Pemilik	Y.1	Sejauh mana Keputusan Representatif Pemilik dirasa memberikan solusi pada saat terjadi masalah.	4	4	5	4	2	4	5	5	**4,125**
	Y.2	Sejauh mana Keputusan Representatif Pemilik dirasa konsisten dengan tujuan proyek.	5	3	5	4	2	5	4	4	**4**
	Y.3	Sejauh mana Keputusan Representatif Pemilik dirasa dilakukan secara transparan dan akuntabel.	4	3	5	3	3	4	4	4	**3,75**
	Y.4	Sejauh mana Keputusan Representatif Pemilik dirasa adil pada saat terdapat ambiguitas gambar pelaksanaan.	5	3	5	4	2	4	5	5	**4,125**
	Y.5	Sejauh mana Keputusan Representatif Pemilik dirasa adil dalam membagi risiko antara Owner dan Kontraktor.	4	4	5	3	3	5	4	4	**4**

The Owner's Representative Decision Aspect (Y) provides an overview of the effectiveness of leadership and policy decision-making by the project owner in responding to field dynamics. The data collection results show that the indicators related to decision-making ability in providing solutions when problems occur (Y.1) and fairness of decisions when facing ambiguity in construction drawings (Y.4) recorded the highest mean value of 4.125. This high score indicates that experts agree on the role of the owner's representative as a central figure in resolving technical conflicts, where decisiveness and fairness in interpreting design documents are key to ensuring that work progress continues without prolonged interpretative obstacles.

Meanwhile, the indicators concerning the consistency of decisions with project objectives (Y.2) and fairness in risk sharing between the owner and the contractor (Y.5) achieved mean values of 4.0. Although these results already reflect solid performance, the indicator related to transparency and accountability in decision-making (Y.3) recorded the lowest mean value at 3.75. This finding signals room for improvement in communication systems and the openness of decision-making processes so that each decision taken is not only operationally effective but also administratively accountable. This slight difference suggests that while the owner's representative is perceived as solution-oriented and fair, strengthening information transparency is necessary to build stronger trust among project stakeholders.

a. SEM-PLS Analysis Indicator Reliability Test

In the analysis of the measurement model based on Partial Least Squares Structural Equation Modeling (PLS-SEM), the indicator reliability test is conducted by evaluating outer loading values. This coefficient represents the degree of consistency of each indicator in reflecting its latent construct. The standard applied in this study requires an outer loading value of ≥ 0.70 for an indicator to be considered reliable. Nevertheless, indicators with loading values between 0.40 and 0.70 may still be considered for retention in the model, provided that they meet certain retention criteria. Such indicators may be retained if their contribution to content validity or construct validity is considered theoretically significant. This test serves as an initial step to ensure that each indicator used is appropriate for further analysis within the structural model [20].

Table 4. Indicator Reliability Test Table

	Outer loadings
X1.1 ← Y	0,981
X1.3 ← Y	0,949
X1.4 ← Y	0,885
X1.5 ← Y	0,911
X2.1 ← Y	0,982
X2.2 ← Y	0,963
X2.3 ← Y	0,921
X2.4 ← Y	0,931
X2.5 ← Y	0,913
X3.1 ← Y	0,978
X3.2 ← Y	0,97
X3.3 ← Y	0,938
X3.4 ← Y	0,894
X3.5 ← Y	0,937
X4.1 ← Y	0,981
X4.2 ← Y	0,97
X4.3 ← Y	0,941
X4.4 ← Y	0,841
X4.5 ← Y	0,972
X5.1 ← Y	0,987
X5.2 ← Y	0,964
X5.3 ← Y	0,946
X5.4 ← Y	0,866
X5.5 ← Y	0,961

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	Outer loadings
X6.1 ← Y	0,982
X6.2 ← Y	0,965
X6.3 ← Y	0,951
X6.4 ← Y	0,977
X6.5 ← Y	0,984
Y1 ← A	0.880
Y2 ← A	0.873
Y3 ← A	0.894
Y4 ← A	0.905
Y5 ← A	0.877
Z1 ← A	0.865
Z2 ← A	0.884
Z3 ← A	0.864
Z4 ← A	0.826
Z5 ← A	0.914
A1 ← A	0.929
A2 ← A	0.886
A3 ← A	0.910

The results of the measurement model testing indicate that all indicators used in this study demonstrate good and strong individual reliability. For the Site Aspect variable (X1.1–X1.5), the outer loading values range from 0.885 to 0.981. The highest value is achieved by indicator X1.1 (0.981), which confirms that the preparation of flexible work schedules and contingency plans is the most dominant element in representing the Site Aspect. All indicators for this variable exceed the minimum threshold of 0.70 and are therefore declared highly valid in forming the construct.

Furthermore, the indicators for the Design Aspect variable (X2.1–X2.5) show high consistency, with values ranging from 0.913 to 0.982. Indicator X2.1, which refers to the implementation of design reviews involving consultants and contractors, serves as the main contributor with a value of 0.982. This result indicates that technical coordination during the design phase has a very strong correlation with the formation of the latent Design Aspect variable.

For the Labor Aspect variable (X3.1–X3.5), the outer loading values range between 0.894 and 0.978. Indicator X3.1, which relates to the simplification of internal permitting procedures, records the highest value at 0.978. This finding indicates that internal bureaucratic efficiency is perceived as the most representative indicator of labor quality in this context. Although indicator X3.4 has the lowest value within this group at 0.894, it is still categorized as very strong and appropriate to be retained in the model.

For the Materials Aspect variable (X4.1–X4.5), all indicators contribute significantly, with loading values ranging from 0.841 to 0.981. Dominance is shown by X4.1, which relates to procurement scheduling and buffer material management, with a value of 0.981. This emphasizes the importance of logistics management in achieving project success. Meanwhile, the Contract Aspect (X5.1–X5.5) demonstrates solid reliability with values ranging from 0.866 to 0.987, where strict Variation Order (VO) procedures (X5.1) emerge as a key element in forming the construct.

The Financial Aspect variable (X6.1–X6.5) also shows highly reliable results, with loading values between 0.951 and 0.984. Indicator X6.5, which concerns the obligation to prepare a cash flow schedule, is recorded as the strongest indicator with a value of 0.984. This reflects a consistent perception that cash flow management constitutes the core of project financial stability.

Finally, for the External Conditions Aspect (Z.1–Z.6) and the Owner's Representative Decision variable (Y.1–Y.5), all loading values exceed 0.80. Within the External Conditions Aspect, indicator Z.5, which relates to the assignment of a dedicated PIC for permitting, stands out with the highest value of 0.914. In the Owner's Representative Decision variable, indicator Y.4, which addresses fairness when ambiguity arises in construction drawings, shows the highest value at 0.905. The absence of indicators with values below 0.70 across all research variables confirms that the model is constructed from solid items, internally consistent, and possesses very adequate reliability to explain their respective latent variables.

b. Internal Consistency Test

The internal consistency test is conducted to evaluate the extent to which indicators within a latent construct are able to measure the same concept in a cohesive and stable manner. As a vital element of reliability assessment, this analysis describes the level of cohesion among measurement items. Within the Partial Least Squares Structural Equation Modeling (PLS-SEM) framework, the main parameters used for this test include Composite Reliability (CR) and Cronbach's Alpha. Referring to Hair et al. [20], CR values exceeding the threshold of 0.70 indicate that the indicators possess adequate reliability in reflecting their constructs. Therefore, meeting the internal consistency criteria serves as a crucial foundation to ensure that the research instrument is reliable before proceeding to subsequent stages of analysis.

Table 5. Internal Consistency Test Table

Variabel	Composite Reliability
Kinerja Waktu (A)	0.934
Aspek Eksternal (Z)	0.940
Keputusan Representatif Pemilik (Y)	0.948
Aspek tempat(X1)	0.964
Aspek desain (X2)	0.975
Aspek tenaga kerja (X3)	0.976
Aspek Kontrak (X5)	0.977
Aspek bahan (X4)	0.975
Aspek Keuangan (X6)	0.988

The results of the internal consistency test indicate that the composite reliability (CR) values for all latent variables exceed 0.70. Project Time Performance (A) records a value of 0.934, the External Aspect (Z) reaches 0.940, the Owner's Representative Decision variable (Y) attains 0.948, and the group of Aspect variables (X1 to X6) shows very high values ranging from 0.964 to 0.988. Composite reliability values greater than 0.70 confirm that the indicators within each construct demonstrate high internal consistency. With all variable values exceeding 0.90, the Financial Aspect (X6), which reaches 0.988, along with the other variables, exhibits excellent internal consistency. Even Project Time Performance (A), which has the lowest value at 0.934, still reflects a strong level of consistency. Therefore, all variables in this study meet the requirements of internal consistency and are considered reliable for use in subsequent structural model testing.

c. Convergent Validity Test

The evaluation of convergent validity is conducted to verify that the indicators forming a construct are strongly correlated and consistently represent the same concept. This test constitutes a fundamental component of construct validity, aiming to ensure that the indicators effectively reflect their latent variables. Within the Partial Least Squares Structural Equation Modeling (PLS-SEM) framework, the primary parameter used for this assessment is the Average Variance Extracted (AVE), which represents the proportion of indicator variance captured by the latent construct. Referring to the standard proposed by Hair et al. [20]. a construct is considered to have adequate convergent validity when its AVE value is at least 0.50. This threshold indicates that the construct explains more than half of the variance of its indicators, thereby ensuring the accuracy and robustness of the measurement model applied in the study.

Table 6. Convergent Validity Test Results

Variabel	Jumlah Indikator	Total Kuadrat Loading (∑λ2)	Nilai AVE
X1	4	3.476	**0.869**
X2	5	4.440	**0.888**
X3	5	4.454	**0.891**
X4	5	4.441	**0.888**
X5	5	4.472	**0.894**
X6	5	4.723	**0.945**
Y	5	3.924	**0.785**
Z	5	3.794	**0.759**
A	3	2.476	**0.825**

Convergent validity in this study was evaluated using the Average Variance Extracted (AVE) values for each latent construct. A construct is considered to have good convergent validity if the AVE value exceeds 0.50, indicating that the construct is able to explain more than 50% of the variance of its indicators. Based on the test results presented in the table, all constructs in this model meet this criterion with highly satisfactory values [21]. The AVE values for the exogenous variables X1 to X6 range from 0.869 to 0.945, while variables Y, Z, and A have values of 0.785, 0.759, and 0.825, respectively. With all values exceeding the 0.50 threshold, all constructs are proven to have adequate convergent validity and are appropriate for further structural analysis. Specifically, construct X6 exhibits the highest AVE value of 0.945, indicating that 94.5% of the variance of its indicators can be explained by the latent construct. This finding suggests that the five indicators forming X6 are highly correlated and collectively provide a comprehensive representation of the concept measured by the variable. Even the construct with the lowest value in the model, namely Z (0.759), is still able to explain nearly 76% of the variance of its indicators. Therefore, all constructs in this study can be declared convergently valid and demonstrate very strong internal consistency in representing the variables under investigation [22].

d. Risk Matrix Analysis

1) Probability (Likelihood)

The risk probability analysis in this study is structured based on the ranking of Risk Scores to identify which variables require the highest level of urgency in mitigation efforts. The determination of this priority scale is critical to ensure the effective allocation of managerial resources in responding to potential disruptions to project performance.

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Table 7. Probability Analysis Table

No	Kode	P (Mean)	I (Mean)	Nilai (P x I)
1	P1/I1	3,9	2,74	10,7
2	P2/I2	3,94	3,02	11,9
3	P3/I3	3,9	2,72	10,6
4	P4/I4	3,92	2,98	11,7
5	P5/I5	3,94	3,44	13,6
6	P6/I6	3,92	2,96	11,6
7	P7/I7	3,98	3,08	12,3
8	P8/I8	3,96	3,12	12,4
9	P9/I9	3,8	3,28	12,5
10	P10/I10	3,92	2,64	10,3
11	P11/I11	3,92	2,98	11,7
12	P12/I12	3,92	2,86	11,2
13	P13/I13	3,98	3,1	12,3
14	P14/I14	3,88	3,36	13
15	P15/I15	3,94	2,96	11,7
16	P16/I16	3,92	3,42	13,4
17	P17/I17	3,92	2,64	10,3
18	P18/I18	3,96	2,94	11,6
19	P19/I19	3,86	2,92	11,3
20	P20/I20	3,92	2,96	11,6
21	P21/I21	3,92	3,04	11,9
22	P22/I22	3,94	3,04	12
23	P23/I23	3,94	3,1	12,2
24	P24/I24	3,92	3,14	12,3
25	P25/I25	3,94	3,04	12
26	P26/I26	3,82	2,98	11,4
27	P27/I27	3,94	2,64	10,4
28	P28/I28	3,92	3,12	12,2
29	P29/I29	3,9	2,92	11,4
30	P30/I30	3,9	3,26	12,7
31	P31/I31	3,7	3	11,1
32	P32/I32	3,82	3,18	12,1
33	P33/I33	3,66	3,06	11,2
34	P34/I34	3,66	2,74	10
35	P35/I35	3,84	3,02	11,6

Based on the mapping results presented in the table, the highest priority for risk management is assigned to the variable coded P5/I5, which records the highest risk score of 13.6. This elevated score is driven by a combination of a high probability of occurrence (3.94) and a significant impact level (3.44), placing it in the “Medium” risk category with a prescribed risk response strategy of Mitigation. In addition, variables P16/I16 and P14/I14 also rank among the top priorities, with risk scores of 13.4 and 13.0, respectively. This cluster of risks with scores above 13.0 indicates the presence of critical areas that require proactive and well-planned mitigation strategies rather than passive monitoring alone.

Conversely, the lowest priority within the matrix is represented by variable P34/I34, which has a risk score of 10.0. Although this variable shows a relatively high probability of occurrence at 3.66, the associated impact is comparatively lower at 2.74. As a result, its handling approach is more flexible and falls under the “Mitigate or Monitor” category. Overall, this prioritization analysis provides clear guidance that the focus of risk management strategies should be directed toward indicators with the highest scores, namely P5, P16, and P14, to prevent substantial deviations in project performance.

2) Impact (Consequences)

The analysis of the impact dimension in this study was conducted to evaluate the magnitude of negative consequences

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generated by each risk variable on project performance if the risk were to occur. This measurement is crucial for mapping how destructive the influence of a given indicator can be on cost, quality, and construction schedule performance.

Table 8. Impact Analysis Table

No	Kode	P (Mean)	I (Mean)	Nilai (P x I)
1	P1/I1	3,9	2,74	10,7
2	P2/I2	3,94	3,02	11,9
3	P3/I3	3,9	2,72	10,6
4	P4/I4	3,92	2,98	11,7
5	P5/I5	3,94	3,44	13,6
6	P6/I6	3,92	2,96	11,6
7	P7/I7	3,98	3,08	12,3
8	P8/I8	3,96	3,12	12,4
9	P9/I9	3,8	3,28	12,5
10	P10/I10	3,92	2,64	10,3
11	P11/I11	3,92	2,98	11,7
12	P12/I12	3,92	2,86	11,2
13	P13/I13	3,98	3,1	12,3
14	P14/I14	3,88	3,36	13
15	P15/I15	3,94	2,96	11,7
16	P16/I16	3,92	3,42	13,4
17	P17/I17	3,92	2,64	10,3
18	P18/I18	3,96	2,94	11,6
19	P19/I19	3,86	2,92	11,3
20	P20/I20	3,92	2,96	11,6
21	P21/I21	3,92	3,04	11,9
22	P22/I22	3,94	3,04	12
23	P23/I23	3,94	3,1	12,2
24	P24/I24	3,92	3,14	12,3
25	P25/I25	3,94	3,04	12
26	P26/I26	3,82	2,98	11,4
27	P27/I27	3,94	2,64	10,4
28	P28/I28	3,92	3,12	12,2
29	P29/I29	3,9	2,92	11,4
30	P30/I30	3,9	3,26	12,7
31	P31/I31	3,7	3	11,1
32	P32/I32	3,82	3,18	12,1
33	P33/I33	3,66	3,06	11,2
34	P34/I34	3,66	2,74	10
35	P35/I35	3,84	3,02	11,6

Based on the distribution of the mean impact values presented in the table, the range of risk impacts spans from 2.64 to 3.44. The variable coded P5/I5 is identified as having the highest severity level, with an impact value of 3.44. This high score indicates that if this risk materializes, it has the potential to cause the most substantial disruption to project stability compared to other factors. In addition, variables P16/I16 and P14/I14 also demonstrate high criticality, with impact values of 3.42 and 3.36, respectively. The concentration of high impact values in these variables necessitates the implementation of more stringent contingency strategies. Conversely, the lowest impact value of 2.64 is recorded for several indicators, including P10/I10, P17/I17, and P27/I27. Although these risks have relatively lower impacts, their presence should not be entirely disregarded. However, their management can be assigned a secondary priority compared to high impact risks. Overall, the results of this analysis provide clear guidance for project management to focus the allocation of mitigation resources on risks with impact magnitudes above 3.30 in order to minimize significant deviations in project performance.

3) Risk Scale

The evaluation of the risk scale in this study aims to classify each risk variable into specific strata or levels based on its Risk Score. This classification serves as a strategic guideline for determining the required intensity of response, distinguishing between risks that are tolerable and those that demand active intervention. Based on the mapping presented in the data table, the project risk profile is distributed into two main scale categories, namely “Moderate” and “Low to Moderate.” The “Moderate” scale category dominates variables with risk scores above the threshold of 12.0, such as items P5/I5 (13.6), P16/I16 (13.4), and P14/I14 (13.0). This grouping indicates that these variables have a relatively high level of urgency and are consistently associated with mitigation-oriented risk behavior. This confirms that risks within this scale are considered significant and cannot be addressed solely through monitoring, but instead require concrete preventive or corrective actions.

In contrast, the “Low to Moderate” scale category includes variables with more moderate risk score ranges, such as P34/I34 (10.0) and P10/I10 (10.3). The characteristics of this scale indicate greater flexibility in managerial response, where the recommended risk behavior varies between “Mitigation” and “Mitigation or Monitor.” The presence of this scale suggests that although potential disruptions exist, their impacts remain within more controllable limits compared to the “Moderate” category. Overall, the absence of a “High” risk category in this matrix illustrates that the project environment under study is relatively conducive, yet it still requires focused vigilance on the potential escalation of risks from the intermediate level.

4) Risk Behavior

The analysis of risk behavior in this study focuses on determining the most appropriate managerial response to address each identified potential risk. The determination of risk behavior is based on the classification of risk severity levels, where each category requires a specific handling approach, ranging from passive monitoring to active intervention in the form of mitigation. Based on the presented data, the recommended risk behaviors are divided into two main spectrums: “Mitigation” and “Mitigation or Monitor.” The “Mitigation” behavior is predominantly required for variables that fall within the “Moderate” scale category with significant risk scores, such as items P5/I5 (13.6) and P16/I16 (13.4). This instruction indicates that for these risks, project management cannot adopt a wait-and-see approach, but must instead design concrete preventive actions to reduce the probability of occurrence or minimize the resulting impact. Meanwhile, the “Mitigation or Monitor” behavior is applied to risks with more moderate scores, such as P1/I1 (10.7) and P10/I10 (10.3). This dual option provides flexibility for decision makers to adjust their response based on resource availability; if mitigation is feasible, it should be implemented, but if resources are limited, periodic monitoring is considered sufficient to keep the risk under control. Overall, the dominance of “Mitigation” instructions for key risks underscores that this project requires a proactive risk management approach to ensure the successful achievement of project objectives.

Conclusion

First, the results of the study indicate that all measurement instruments used have met the criteria of validity and reliability in representing the research variables. This is evidenced by the Average Variance Extracted (AVE) values ranging from 0.759 to 0.945 and the high level of internal consistency, with Composite Reliability (ρA) values ranging from 0.894 to 0.933. These findings confirm that the research model demonstrates a high degree of reliability, thereby ensuring that the analytical results are scientifically accountable. Second, the risk profile analysis indicates that the factor of the owner’s representative decision-making exhibits a relatively high probability of occurrence and has a significant impact on project time performance. Three dominant factors classified within the moderate risk category were identified as the main causes of delay, namely the Site aspect as the highest risk, followed by the Material aspect and the Labor aspect. This condition demonstrates that effective control over these three aspects is a critical factor in efforts to minimize deviations in project schedule performance. Third, based on the SWOT analysis results, the position of the owner’s representative lies in Quadrant II (Diversification Zone) with coordinates (X = +0.87; Y = −0.57). This position reflects the dominance of internal strengths confronted by fairly significant external threats. Accordingly, the most appropriate strategy to be applied is the ST (Strength–Threats) Strategy, which involves optimally leveraging internal strengths to anticipate and mitigate the impact of external threats on project completion.

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