Eduvest – Journal of Universal Studies
Volume 6 Number 6, June, 2026
p- ISSN 2775-3735- e-ISSN 2775-3727

Analysis of Variables Affecting the Performance Quality of Contractors in the Execution of Fast-Drying Concrete Pouring on the Maintenance of the Jakarta Outer Ring Road Toll, Sections W2S, S, and E

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Keywords
quality management, rapid-setting concrete, SEM-PLS, work motivation, toll roads

Abstract

Toll road maintenance requires effective and efficient strategies to ensure that repair work can be completed quickly without reducing construction quality, particularly in projects using rapid-setting concrete. This study aims to analyze the variables affecting contractor quality performance in the implementation of fast-drying concrete pouring on the maintenance of the Jakarta Outer Ring Road (JORR) sections W2S, S, and E, as well as to identify the most dominant factors influencing project quality. The study employed a quantitative approach using Structural Equation Modeling-Partial Least Squares (SEM-PLS) combined with Importance Performance Map Analysis (IPMA). Data were collected through questionnaires distributed to 96 respondents consisting of project owners, contractors, supervising consultants, and rapid-setting concrete producers. The results revealed that material management, work motivation, work equipment, and work environment significantly influenced project quality performance. Material was identified as the most dominant factor with the highest total effect value, while communication significantly affected work motivation as a mediating variable. The model explained 67.9% of the variance in project quality performance. In conclusion, improving material management, strengthening work motivation, optimizing equipment readiness, and creating a supportive work environment are essential strategies for enhancing the quality of fast-drying concrete maintenance projects on toll roads.

INTRODUCTION

Toll roads are the backbone of the modern transportation system in Indonesia, playing an important role in supporting economic growth and facilitating the flow of human and goods mobility (Hendarto et al., 2021). Toll roads not only provide fast and efficient transportation access, but also become one of the indicators of a country's infrastructure progress (Iswandi, 2023; Mulyani et al., 2022). Along with rapid economic growth and urbanization, the volume of traffic on toll roads is increasing every year (Sidabutar et al., 2024). This requires continuous maintenance and improvement of the quality of toll roads so that the services provided to the community remain optimal and in accordance with the set standards (Hendito & Tajudin, 2021).

However, the implementation of toll road maintenance cannot be separated from various challenges. One of the biggest challenges is the limited time of execution of the work because traffic activities should not be disrupted for too long. The closure of toll road lanes for maintenance purposes can cause significant traffic congestion, especially in densely active urban areas (Azmia & Rohman, 2024). As a result, innovation is needed in the technique of implementing maintenance work so that it can be carried out in a short time but still produce high quality. One of the innovative solutions that is now widely adopted is the use of rapid setting concrete. The quick-drying concrete technology allows the casting and road repair work to be completed within a few hours, so that the lanes can be reopened immediately and the impact of congestion can be minimized (Albert, 2019; Bahr, 2016; Ferry, 2025; Wolmar, 2024).

The success of the application of quick-drying concrete in toll road maintenance is greatly influenced by various factors. Empirical experience in various projects

It shows that not all quick-drying concrete work gives optimal results. In many cases, problems were found related to the quality of work results, delays in completion, and complaints from road users related to discomfort during the work process (Bachtiar, 2012).

These problems indicate that the technical aspects alone are not enough to guarantee the success of the project. A more holistic understanding of all variables that affect the quality of the implementation of quick-drying concrete work in toll road maintenance projects is needed (Jordaan & Steyn, 2022; Lee et al., 2025; Mujiburrokhman et al., n.d.). Factors such as environmental conditions, concrete mix composition, application methods, and worker experience and skills all contribute to the quality and efficiency of the final result (Susanto et al., 2020).

One of the fundamental factors that is very decisive is Human Resources (HR). Human resources in this context not only include implementing workers in the field, but also project management, supervisory consultants, and project owner managers. Technical competence, experience, discipline, and commitment of all human resources involved are key factors in ensuring that each stage of work is carried out in accordance with the quality standards that have been set. Superior human resources are able to anticipate risks, make quick decisions, and adapt to the dynamics of work in the field. On the contrary, weak competence and lack of motivation of human resources are often the root of the problems of delays, work errors, and declining quality of work results (Ekwuno, 2022; Helmi et al., 2025; Morrison, 2015). Therefore, effective human resource management, including capacity building and minimization of the risk of work fatigue, is crucial to maintain the productivity and quality of toll road maintenance work (Arini & Dwiyanti, 2017; Sulistyarto, 2003).

The work environment is an important aspect in addition to human resources that is often overlooked, even though a safe, comfortable, and clean work environment has been proven to improve the health, safety, productivity, and morale of the project team. A conducive work environment can reduce the risk of accidents, reduce fatigue errors, and create a harmonious work atmosphere through facility support, waste management, and effective supervision. Various studies show that a good work environment contributes to increased job satisfaction and individual performance, while neglecting these aspects can have a significant impact on the decline in project quality and efficiency (Purbasari, 2020; Pitaloka et al., 2023).

In addition to the work environment, communication is a crucial factor in the success of construction projects, especially in toll road maintenance work that is dynamic and time-limited. Effective communication between job owners, supervisory consultants, and implementing contractors allows for fast and accurate information exchange, accelerates decision-making, and minimizes miscommunication and conflict. On the other hand, poor communication is often the cause of delays, technical errors, and declining quality of work results, so that effective communication is the main prerequisite for achieving quality targets and project implementation time (Abdallah et al., 2024; Gamil et al., 2019; Suleiman et al., 2023).

In addition to human and process factors, material and work equipment aspects also play a strategic role in ensuring the quality of work results. Materials must meet technical specifications and be available on time so as not to hinder the execution of the work, as delays or material quality mismatches can have a direct impact on the quality and schedule of the project. Similarly, complete, sophisticated, and well-maintained work equipment is an absolute requirement to ensure the efficiency, effectiveness, and accuracy of work execution, especially in conditions of limited working time such as in toll road maintenance projects.

In addition, traffic management and work motivation are also determining factors for the success of the project. Good traffic engineering ensures the safety of workers and road users while maintaining the smooth flow of vehicles during the work, while poor traffic management can cause congestion, accidents, and reduce public satisfaction. Work motivation acts as a mediating variable that strengthens the influence of human resources, work environment, and communication on project quality, because competence and a good work system will not be optimal without strong internal encouragement. Therefore, this study is designed to comprehensively analyze the influence of these technical and managerial factors on the quality performance of fast-drying concrete work on toll road maintenance using the SEM-PLS approach to produce applicable and sustainable improvement recommendations.

METHOD

This study used a quantitative approach with the Structural Equation Modeling analysis method based on Partial Least Squares (SEM-PLS) followed by Importance Performance Map Analysis (IPMA). This approach was chosen because it is able to analyze complex relationships between latent variables and is suitable for medium sample sizes and data that do not have to be normally distributed. The research is focused on the maintenance work of the JORR Toll Road W2S, section S, and section E which uses quick-drying concrete, with the aim of identifying factors that affect the quality performance of contractors comprehensively.

The research population included all stakeholders involved in the maintenance work of the toll road, namely project owners, supervisory consultants, implementing contractors, and quick-drying concrete manufacturers. The sampling technique used is non-probability sampling with a purposive sampling approach, where respondents are selected based on direct experience in similar projects and involvement in technical decision-making. Based on the 10-times rule in PLS-SEM, the minimum number of samples required is 70 respondents, while this study managed to collect 96 respondents so that it is considered to meet the feasibility requirements for analysis.

The research data was collected through primary data and secondary data. Primary data was obtained through the distribution of questionnaires to project stakeholders using a five-level Likert scale to measure perceptions of research variables. Meanwhile, secondary data is obtained from project documents, work duration reports, scientific publications, and relevant technical documentation. All research instruments are tested for validity and reliability before use to ensure the accuracy and reliability of the data.

Data analysis was carried out using SEM-PLS through the stages of descriptive statistical analysis, external model evaluation (construct validity and reliability), inner model evaluation (relationship between latent variables), and hypothesis testing using bootstrapping. Furthermore, IPMA analysis is used to identify variables that have a high level of importance but low performance as a basis for determining improvement priorities. This approach allows for the drawing of conclusions that are not only statistical, but also applicable to managerial decision-making in the field.

RESULT AND DISCUSSION

A. SEM-PLS Analysis

1. Evaluation of Reflective Outer Models

First of all, in the SEM-PLS analysis, a Reflective Outer Model Evaluation is carried out. One of the things that is done is to test the validity of the indicator. To measure the validity of the indicator to the construct it represents, an outer loading test is carried out as part of the measurement model test. Outer loading shows the strength of each indicator's contribution to the latent variable, which is expressed in the correlation value between the indicator and the construct. In this analysis, an outer loading value of 0.70 or more is considered to indicate an indicator that has strong convergent validity and can be maintained in the model. However, indicators with values between 0.40 and 0.70 can still be considered to be maintained if the Average Variance Extracted (AVE) value and overall construct reliability still meet the criteria. This test is important to ensure that each indicator is able to adequately represent its construct before proceeding to the structural analysis stage.

Tabel 1 Outer Loading

Leave Variable← Indicator	Outer loadings	Leave Variable← Indicator	Outer loadings
M1.1 ← Work Motivation	0.810	X4.1 ← Material	0.801
M1.2 ←- Work Motivation	0.770	X4.2 ← Material	0.849
M1.3 ← Work Motivation	0.763	X4.3 ← Material	0.815
M1.4 ← Work Motivation	0.671	X4.4 ← Material	0.768
M1.5 ← Work Motivation	0.742	X4.5 ← Material	0.854
X1.1 ← Human Resources	0.738	X5.1 ← Work Equipment	0.707
X1.2 ← Human Resources	0.652	X5.2 ← Work Equipment	0.785
X1.3 ← Human Resources	0.786	X5.3 ← Work Equipment	0.700
X1.4 ← Human Resources	0.803	X5.4 ← Work Equipment	0.792
X1.5 ← Human Resources	0.589	X5.5 ← Work Equipment	0.813
X2.1 ← Working Environment	0.754	X6.1 ← Traffic Management	0.735
X2.2 ← Work Environment	0.795	X6.2 ← Traffic Management	0.674
X2.3 ← Work Environment	0.723	X6.3 ← Traffic Management	0.823
X2.4 ← Work Environment	0.754	X6.4 ← Traffic Management	0.685
X2.5 ← Working Environment	0.796	X6.5 ← Traffic Management	0.671
X3.1 ← Communication	0.774	Y1.1 ← Quality Performance	0.746
X3.2 ← Communication	0.813	Y1.2 ← Quality Performance	0.727

Source: Research Data Processed (2025).

Table 2. Outer Loading (Advanced)

Leave Variable← Indicator	Outer loadings	Leave Variable← Indicator	Outer loadings
X3.3 ← Communication	0.791	Y1.3 ← Quality Performance	0.725
X3.4 ← Communication	0.775	Y1.4 ← Quality Performance	0.735
X3.5 ← Communication	0.768	Y1.5 ← Quality Performance	0.769

Source: Research Data Processed (2025).

The results of the outer loading test as presented in Table 4.10 show that most indicators have an outer loading value above 0.70, which means that they significantly reflect the latent variable construct they measure and meet the criteria for convergent validity. All indicators in the variables Material (X4), Communication (X3), and Project Quality Performance (Y1) have an outer loading value between 0.725 to 0.854, which indicates an excellent contribution to the construction.

In the Work Motivation (M1) variable, although four of the five indicators were above 0.70, there was one indicator (M1.4) with a value of 0.671, which was still maintainable because it was close to the threshold and the overall construct showed good reliability. The same thing also happens with the Human Resources variable (X1), where one indicator (X1.5) has a value of 0.589, lower than the ideal threshold, but can still be considered if it does not significantly reduce the value of AVE and Composite Reliability.

For the Work Environment (X2) variable, all indicators have values above 0.70, except X2.3 (0.723), X2.4 (0.754), and X2.5 (0.796) which remain within the valid limits. In the Traffic Management variable (X6), three indicators (X6.2, X6.4, and X6.5) had values below 0.70 (0.674, 0.685, and 0.671 respectively), but were still within the tolerance range (0.40–0.70) as recommended by Hair et al. (2021) if the construct remained reliable overall.

These outer loading results support that most indicators have a strong contribution to their constructs, and no indicators need to be eliminated directly without considering their effect on the overall reliability of the construct.

The next step is to measure the overall convergent validity at the construct level using the Average Variance Extracted (AVE) value. AVE describes the proportion of indicator variance that can be explained by latent constructs compared to error variance. According to Hair et al. (2021), a good AVE value is ≥ 0.50, which indicates that more than 50% of the variance of the indicator can be explained by its construct. In other words, the higher the AVE value, the better the ability of the indicators to represent the construct consistently. Therefore, AVE analysis becomes essential to ensure that each construct in the model has an adequate degree of convergent validity before proceeding to structural testing.

Tabel 3 Average Variance Extracted

Variable Leave	Average variance extracted (AVE)
Quality Performance	0.549
Communication	0.615
Work Environment	0.585
Traffic Management	0.518
Material	0.669
Work Motivation	0.566

Work Equipment	0.579
Human Resources	0.516

Source: Research Data Processed (2025).

The results of the analysis of the Average Variance Extracted (AVE) value shown in Table 4.11 show that all constructs in the model have met the criteria of convergent validity. The entire AVE value is above the minimum threshold of 0.50, as recommended by Hair et al. (2021), which indicates that more than 50% of the indicator's variance can be explained by the respective latent constructs. Construct Materials has the highest AVE value of 0.669, followed by Communication (0.615) and Work Environment (0.585), which shows that the indicators in the construct are very representative. Meanwhile, the constructs with the lowest AVE scores are Human Resources (0.516) and Traffic Management (0.518), although they remain within acceptable limits. Overall, these results confirm that each construct in the model has sufficient convergent validity, making it feasible for use for subsequent structural model analysis.

After ascertaining the convergent validity through the AVE value, the next stage in the evaluation of the measurement model is to test the reliability of the construct using the Composite Reliability (CR) value. CR is used to assess the internal consistency between indicators in representing a latent construct. In contrast to Cronbach's Alpha which assumes the contribution of the same indicator, CR gives weight based on the actual contribution of each indicator, so it is considered more accurate in the context of Partial Least Squares Structural Equation Modeling (PLS-SEM). According to Hair et al. (2021), a good CR value is ≥ 0.70, which indicates that the construct has strong and stable internal reliability. Therefore, CR analysis is important to ensure that each construct in the model has adequate measurement consistency before interpreting the relationships between constructs in the structural model.

Tabel 4. Composite Reliability

Variable Leave	Composite reliability (rho_c)
Quality Performance	0.859
Communication	0.889
Work Environment	0.876
Traffic Management	0.842
Material	0.910
Work Motivation	0.867
Work Equipment	0.873
Human Resources	0.840

Source: Research Data Processed (2025).

The results of the Composite Reliability (CR) analysis presented in Table 4.12 show that all constructs in the model have an excellent level of reliability. All CR values are above the minimum threshold of 0.70, as recommended by Hair et al. (2021), which indicates that the indicators in each construct consistently reflect the latent variables being measured. The Material variable showed the highest reliability with a value of 0.910, followed by Communication (0.889) and Work Environment (0.876), indicating a very strong level of internal consistency. Other constructs such as Quality Performance, Work Motivation, Work

Equipment, and Human Resources also show solid reliability with CR values ranging from 0.840 to 0.867. These results confirm that all constructs in the model meet the reliability criteria and are trustworthy for use in further structural model analysis.

After testing the convergent validity and reliability of the construct, the next step in the evaluation of the measurement model is to test the discriminant validity between latent constructs. One of the recommended methods for discriminant validity testing in the context of PLS-SEM is the Heterotrait-Monotrait Ratio of Correlations (HTMT). HTMT measures the extent to which a construct is empirically different from other constructs in the model, by comparing the correlation between indicators of different constructs (heterotraits) with the correlation between indicators of the same construct (monotrait). According to Henseler et al. (2015), HTMT values lower than 0.90 (or 0.85 for more conservative models) indicate the existence of adequate discriminant validity. Therefore, HTMT testing is important to ensure that each construct in the model does measure different concepts and does not overlap with each other.

Table 5. HTMT

	Quality Performance	Communication	Work Environment	Traffic Management	Material	Work Motivation	Work Equipment	Human Resources
Quality Performance								
Communication	0.668							
Work Environment	0.707	0.506						
Traffic Management	0.597	0.525	0.468					
Material	0.727	0.440	0.442	0.397				
Work Motivation	0.718	0.555	0.371	0.511	0.382			
Work Equipment	0.713	0.521	0.502	0.538	0.394	0.379		
Human Resources	0.593	0.500	0.580	0.531	0.323	0.518	0.531	

Source: SmartPLS Output (2025).

The results of the Heterotrait-Monotrait Ratio (HTMT) test shown in Table 4.13 show that all construct pairs have HTMT values below the threshold of 0.90, even most of them well below that value. This indicates that each construct in the model has sufficient discriminant validity, meaning that each construct actually represents a different concept and there is no overlap of meanings between constructs. The highest HTMT scores were recorded in the relationship between Quality and Material Performance (0.727) and Quality Performance and Work Motivation (0.718), but remained within acceptable limits. Meanwhile, other HTMT values such as between Communication and Materials (0.440) or Work Motivation and Work Equipment (0.379) showed a lower relationship, confirming the clear differences between constructs. Thus, these results reinforce the structural validity of the measurement model used, and the constructed tested can be considered conceptually independent.

Based on the results of the evaluation of the measurement model (outer model), it can be concluded that all constructs in the model have met the required criteria for validity and reliability. The outer loading value is mostly above 0.70, indicating that the indicators have a strong contribution to the construct. The entire Average Variance Extracted (AVE) value also exceeded the threshold of 0.50, indicating that the convergent validity was met. In addition, the

Composite Reliability (CR) value of all constructs is above 0.70, indicating internal consistency between indicators in measuring latent constructs.

Finally, the HTMT results show that each construct has good discriminant validity, with the entire HTMT value below 0.90. With the fulfillment of all the criteria for evaluating the outer model, the measurement model can be declared feasible, and the analysis can be continued to the next stage, namely the evaluation of the structural model (inner model) to test the relationship between latent constructs.

2. Inner Model Evaluation

Before testing the relationship between latent constructs in the structural model (inner model), it is necessary to evaluate the potential problem of multicollinearity between predictor variables. One of the approaches used in PLS-SEM is to measure the value of the Variance Inflation Factor (VIF). VIF shows the extent to which the variance of a construct is affected by other predictive constructs in the model. A high VIF value indicates a strong correlation between predictor constructs, which can interfere with the interpretation of the model's results. According to Hair et al. (2021), a good VIF value is below 5.0, and ideally below 3.3, which indicates that there is no significant multicollinearity. Therefore, VIF evaluation is an important step before testing causal relationships in the inner model.

Tabel 6. VIF Inner Model

Relationships Between Latent Variables	LIVE
Quality Performance→ Communication	1.615
Work Motivation→ Communication	1.513
Quality Performance→ Work Environment	1.495
Work Environment → Motivation	1.494
Quality Performance→ Traffic Management	1.472
Traffic Management → Work Motivation	1.432
Quality → Performance Materials	1.308
Work Motivation→ Materials	1.290
Quality Performance→ Work Motivation	1.444
Quality Performance→ Work Equipment	1.493
Work Motivation Work Equipment →	1.493
Human Resources → Quality Performance	1.530
Human Resources → Work Motivation	1.466

Source: SmartPLS Output (2025).

The results of the analysis of the Variance Inflation Factor (VIF) in the inner model as shown in Table 6 show that the entire VIF value is well below the maximum recommended threshold, which is 5, and even ideally also below 3. This indicates that there are no significant symptoms of multicollinearity among the predictor constructs in the structural model. The highest VIF value was recorded in the relationship between Communication → Quality Performance, which was 1,615, which was still in the safe category and did not show any indication of a high correlation between predictor constructs. Followed by Human Resources → Quality Performance (1,530) and Communication → Work Motivation (1,513), which also remained within the tolerance limit. Other relationships such as Material → Quality Performance (1,308) and Material → Work Motivation (1,290) showed the lowest VIF values in the model, indicating that these variables did not experience a high correlation with other predictor constructs. Overall, these results reinforce that the inner model is free from multicollinearity problems, so that the analysis of causal relationships between latent constructs can be performed more accurately and without statistical distortion. This model is feasible to proceed to the stage of testing path coefficients, direct effects, and indirect effects.

After confirming that the measurement model (outer model) meets the criteria of validity and reliability, and that no multicollinearity problems are found in the inner model, the next step is to test the structural relationships directly between latent constructs. This test aims to determine the magnitude of the direct influence of a latent variable on other latent variables in the model. The analysis was carried out by looking at the path coefficient, t-statistical value, and p-value, which were obtained through bootstrapping. A relationship is considered significant when the p-value < 0.05 (significance level 5%). The results of this test will provide an overview of the strength and direction of the direct causal relationship between constructs, as well as become the basis for answering the research hypothesis.

Table 7. Direct Effect

Relationship Between Constructs	Path Coefficients	P values	Remarks
Quality Performance→ Communication	0.085	0.411	Not Significant Effect
Work Motivation→ Communication	0.266	0.015	Significant Impact
Quality Performance→ Work Environment	0.224	0.017	Significant Impact
Work Environment → Motivation	-0.014	0.909	Not Significant Effect
Quality Performance→ Traffic Management	0.033	0.711	Not Significant Effect
Traffic Management → Work Motivation	0.167	0.157	Not Significant Effect
Quality → Performance Materials	0.307	0.000	Significant Impact
Work Motivation→ Materials	0.112	0.355	Not Significant Effect
Quality Performance→ Work Motivation	0.279	0.000	Significant Impact
Quality Performance→ Work Equipment	0.236	0.001	Significant Impact

Source: SmartPLS Output (2025).

Table 8 Direct Effect (Advanced)

Relationship Between Constructs	Path Coefficients	P values	Remarks
Work Motivation Work Equipment →	0.002	0.984	Not Significant Effect
Human Resources → Quality Performance	0.015	0.875	Not Significant Effect
Human Resources → Work Motivation	0.211	0.099	Not Significant Effect

Source: SmartPLS Output (2025).

The results of the direct influence test showed that not all independent variables made a significant contribution to the dependent variables in the model. One of the important findings is that Communication (X3) does not have a significant direct effect on Project Quality Performance (Y), with a path coefficient value of 0.085 and a p-value of 0.411. However, Communication has been shown to have a significant influence on Work Motivation (M1) (path coefficient 0.266, p-value 0.015), which suggests that good communication can increase team motivation, even if it does not directly impact project quality. In contrast, the Work Environment (X2) showed a significant direct influence on Quality Performance (path coefficient 0.224, p-value 0.017), but did not have a significant effect on Work Motivation (path coefficient -0.014, p-value 0.909). This indicates that a safe and comfortable work environment can directly improve the quality of work results, but it is not strong enough to affect morale psychologically. The variables of Materials (X4) and Work Equipment (X5) showed the strongest direct influence on Quality Performance, with a path coefficient of 0.307 (p-value 0.000) and 0.236 (p-value 0.001), respectively. These two variables are technical aspects that greatly determine the success of a project, especially in the context of quick-drying concrete casting work that requires high precision and efficiency. However, neither Materials nor Work Equipment showed a significant effect on Work Motivation, which means their contribution is more operational than psychological. Work Motivation (M1) itself has been proven to have a significant direct influence on Quality Performance (path coefficient 0.279, p-value 0.000), strengthening its important role as an internal factor that drives project quality achievement. These findings support the theory that work motivation is a key driver in the implementation of quality projects, especially in work conditions that demand speed and precision. Meanwhile, the variables Human Resources (X1) and Traffic Management (X6) did not show a significant influence on either Quality Performance or Work Motivation, with all p-values well above the 0.05 threshold. This shows that although human resources and traffic management remain important in the context of the project, their contribution to project quality is not dominant in this model.

After testing the direct relationship between latent constructs, the next step is to analyze the indirect effect in the structural model. This test aims to find out whether an independent variable can affect the dependent variable indirectly through a mediated variable. In this context, the Work Motivation variable acts as a mediator that connects several independent variables, such as Communication, Work Environment, and Human Resources, with Project Quality Performance. The indirect influence is considered significant if the p-value < 0.05 and is supported by a positive path coefficient value. The results of these tests are important for understanding the more complex causal mechanisms in the model, as well as providing deeper insights into the pathways that may not be seen through direct relationship analysis alone.

Table 9 Indirect Effect

Relationship Between Constructs	Path Coefficients	P values	Remarks
Communication → Work Motivation → Performance Quality	0.074	0.028	Significant Impact
Work Environment → Work Motivation → Performance Quality	-0.004	0.908	Not Significant Effect
Traffic Management → Work Motivation → Performance Quality	0.047	0.191	Not Significant Effect
Materials → Work Motivation → Quality Performance	0.031	0.376	Not Significant Effect
Work Equipment → Work Motivation → Performance Quality	0.001	0.984	Not Significant Effect
Human Resources → Work Motivation → Performance Quality	0.059	0.149	Not Significant Effect

Source: SmartPLS Output (2025).

The results of the indirect influence test as shown in Table 4.16 indicate that only one mediation pathway makes a significant contribution to Project Quality Performance, namely the Communication → Work Motivation → Quality Performance pathway, with a path coefficient value of 0.074 and a p-value of 0.028. These findings indicate that although

Communication does not have a direct effect on Quality Performance, it still plays an important role indirectly through increasing Work Motivation. This means that effective communication in projects can increase teamwork, which ultimately has a positive impact on the quality of work results. In contrast, the mediation pathway of Work Environment, Traffic Management, Materials, Work Equipment, and Human Resources through Work Motivation did not show a significant influence on Project Quality Performance. All p-values in these pathways are well above the threshold of 0.05, with relatively small path coefficient values, and some are even negative such as in the Work Environment → Work Motivation → Quality Performance (path coefficient -0.004, p-value 0.908). This suggests that work motivation is not an effective mediation channel for most of the technical and managerial variables in this model. These findings reinforce the conclusion that Work Motivation is only an effective mediator in the context of Communication, which is interpersonal and psychological. Meanwhile, other variables that are more technical or structural do not sufficiently affect work motivation to then have an impact on the quality of the project. Therefore, the strategy to improve project quality through work motivation should be focused on the aspects of communication and relationships between individuals in the project team.

After testing the direct and indirect effects between constructs, the next stage is to analyze the total effect. Total influence is the sum of the direct and indirect influences of an independent variable on the dependent variable. This analysis provides a comprehensive overview of how much a total construct contributes to other constructs in the model, either through direct channels or through the role of mediators. Thus, total influence is crucial to identify which variables have the most dominant influence on Project Quality Performance, and can be the basis for prioritizing the overall project performance improvement strategy.

Table 10 Total Effect

Relationship Between Constructs	Path Coefficients	P values	Remarks
Communication - > Quality Performance	0.159	0.131	Not Significant Effect
Communication - > Work Motivation	0.266	0.015	Significant Impact
Work Environment - > Quality Performance	0.220	0.035	Significant Impact
Work Environment - > Work Motivation	-0.014	0.909	Not Significant Effect
Traffic Management - > Quality Performance	0.080	0.399	Not Significant Effect
Traffic Management -> Work Motivation	0.167	0.157	Not Significant Effect
Material -> Quality Performance	0.339	0.000	Significant Impact
Material-> Work Motivation	0.112	0.355	Not Significant Effect
Work Motivation - > Quality Performance	0.279	0.000	Significant Impact
Work Equipment -> Quality Performance	0.236	0.001	Significant Impact
Work Equipment -> Work Motivation	0.002	0.984	Not Significant Effect
Human Resources - > Quality Performance	0.074	0.488	Not Significant Effect
Human Resources - > Work Motivation	0.211	0.099	Not Significant Effect

Source: SmartPLS Output (2025).

The results of the total influence analysis show that not all constructs in the model make a significant contribution to the dependent variables, either directly or through mediation. Of the overall relationships tested, only a few constructs were shown to have a significant total influence on Project Quality Performance and Work Motivation. Construct Material (X4) occupies the highest position in terms of total influence on Quality Performance, with a path coefficient of 0.339 and a p-value of 0.000, showing that quality and material management greatly determine the success of the quality of fast-drying concrete casting work. Followed by Work Equipment (X5) with a total influence of 0.236 (p-value 0.001) and Work Environment (X2) of 0.220 (p-value 0.035), which also contributed significantly to the quality of the project. Meanwhile, Work Motivation (M1) itself showed a total influence of 0.279 (p-value 0.000) on Quality Performance, strengthening its important role as an internal factor that drives project quality achievement. This confirms that the psychological aspects and teamwork spirit have a real impact on work results, especially in projects with high time pressure. On the other hand, constructs such as Communication (X3), Human Resources (X1), and Traffic Management (X6) showed no significant total influence on Quality Performance, with a p-value above 0.05 each. However, Communication still has a significant effect on Work Motivation (path coefficient 0.266, p-value 0.015), which means that the role of communication is more effective as a motivational driver than as a direct determinant of project quality. Overall, these results show that project quality improvement strategies will be more effective if they focus on strengthening material management, work motivation, equipment optimization, and improving the work environment. Meanwhile, aspects such as communication and human resources are more relevant in the context of increasing motivation, rather than directly on the quality of work results.

After testing the relationship between constructs, the next step in the evaluation of the inner model is to look at the value of the determination coefficient (R Square or R^2). R^2 is used to assess the ability of independent constructs to explain the variance of dependent constructs. The higher the R^2 value, the greater the proportion of variance that the model can explain. According to Chin (1998) and Hair et al. (2021), the R^2 value of 0.75 is categorized as substantial (strong), 0.50 is categorized as moderate (moderate), and 0.25 is categorized as weak (weak). Thus, R^2 analysis provides an overview of the predictive power of the structural model, as well as shows how well the constructs in the model explain the phenomenon under study.

Table 11 R2

Variable Leave	**R-square**
Quality Performance	0.679
Work Motivation	0.308

Source: SmartPLS Output (2025).

The results of the analysis of the determination coefficient (R Square) presented in Table 11 show that the model has predictive capabilities that vary from dependent constructs. The R^2 value for the Quality Performance construct is 0.679, which according to Chin's (1998) criteria falls into the moderate to close to substantial category, meaning that about 67.9% of the variance of Quality Performance can be explained by independent variables in the model (i.e. Material, Work Equipment, Work Environment, Work Motivation, etc.). This shows that the model is quite powerful in explaining the factors that affect the quality of project performance. Meanwhile, the R^2 value for Work Motivation of 0.308 is included in the weak category, which means that only 30.8% of the variance of Work Motivation can be explained by variables such as Communication, Work Environment, and Human Resources. These results indicate that although the model can explain Quality Performance quite well, there are still other variables outside the model that may contribute to the formation of Work Motivation and need to be explored further in future research.

In addition to the determination coefficient (R^2) which measures the predictive ability of the model internally, the evaluation of the predictive relevance of the model also needs to be carried out using the Q Square (Q^2) value. Q^2 was obtained through a blindfolding procedure and used to assess the extent to which the model was able to accurately predict observational data. According to Hair et al. (2021), a Q^2 value greater than 0 indicates that the model has good predictive relevance for related endogenous constructs. The greater the value of Q^2, the stronger the model's ability to predict dependent variables. Therefore, Q^2 testing is an important complement to R^2 in assessing the quality of the overall structural model.

Table 12 Q2

Variable Leave	SSO	SSE	Q^2 (=1-SSE/SSO)
Quality Performance	480	330.673	0.311
Work Motivation	480	415.782	0.146

Source: SmartPLS Output (2025).

The results of the Q Square (Q^2) test shown in Table 4.19 show that the model has adequate predictive relevance to both endogenous constructs analyzed. The Q^2 value for the Quality Performance construct of 0.311, which is in the moderate category according to the criteria of Hair et al. (2021), shows that the model has a fairly good predictive ability for these variables. Meanwhile, the Q^2 value for Work Motivation of 0.146, although lower, remains above zero, meaning the model still has weak but statistically valid predictive relevance to the construct. Thus, it can be concluded that the structural model used in this study is able to predict endogenous variables, especially Quality Performance, adequately and can be continued at the decision-making stage and practical implications.

B. IPMA Analysis

1. Work Motivation

After evaluating the structural model through the analysis of direct, indirect, R Square, and Q Square influences, the next step is to conduct an Importance-Performance Map Analysis (IPMA) on the target variable, in this case Work Motivation. The IPMA analysis aims to provide additional insights by mapping the importance and performance of each predictor construct to endogenous variables. This approach not only considers the magnitude of the influence of a construct (total effect value), but also the average level of performance of that construct on a scale of 0–100. Thus, IPMA helps identify strategic priorities: constructs that have a great impact but are still underperforming can be the main focus for improvement. In this section, IPMA is focused on evaluating the factors that affect Work Motivation, in order to provide more applicable and data-driven recommendations in the context of project management.

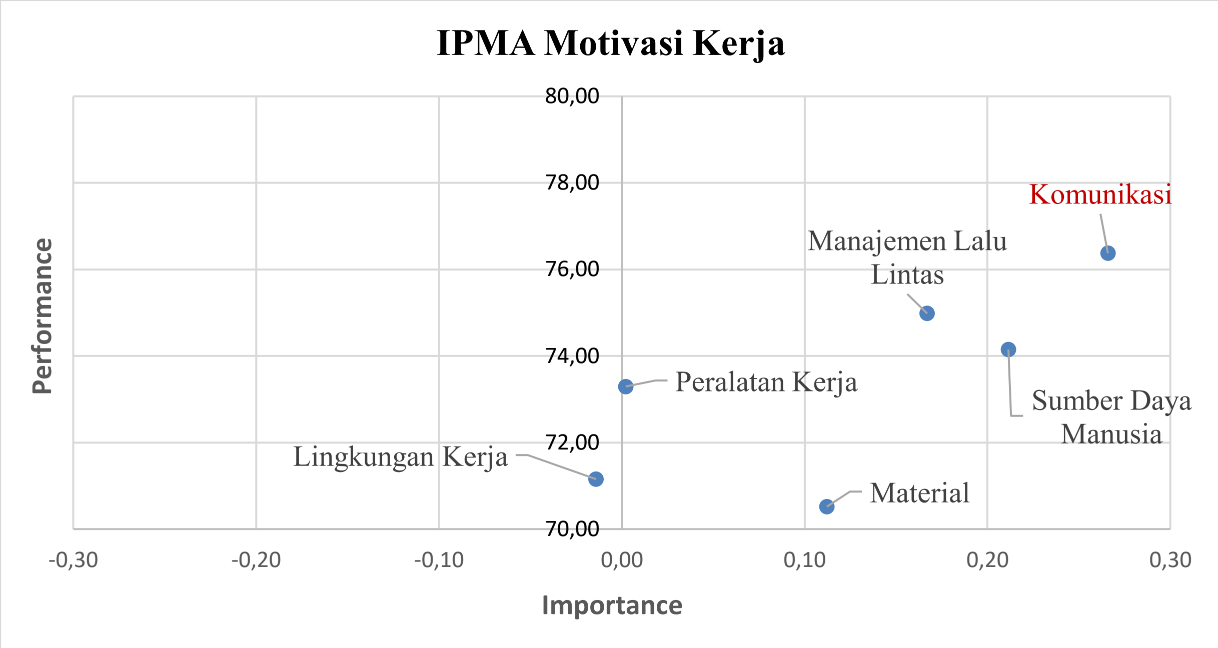

Figure 1 IPMA for Performance Motivation

The Importance-Performance Map Analysis (IPMA) of the Work Motivation construct aims to identify the most influential factors (importance) and evaluate the extent of their current performance (performance). These results are very useful for determining repair priorities in the context of toll road maintenance projects with quick-drying concrete.

1) Communication

Importance: 0,27 | Performance: 76,38

Communication occupies the most strategic position because it has the greatest influence on work motivation as well as the highest performance. This shows that the project communication system has been running very effectively and is the main force in building teamwork. Future strategies need to be focused on maintaining information transparency, cross-functional coordination, and meeting effectiveness.

2) Human Resources (HR)

Importance: 0,21 | Performance: 74,15

HR has a considerable influence on work motivation, but its performance is still below communication. This shows that there is still room for improvement through technical training, competency development, as well as a more structured reward and career development system.

3) Traffic Management

Importance: 0,17 | Performance: 74,98

Traffic management makes a moderate contribution to work motivation, especially in supporting the comfort and safety of work in the field. The relatively high performance shows that the system is running well, but it can still be improved through more effective socialization and strengthening the security of the work area.

4) Material

Importance: 0,11 | Performance: 70,52

Materials have a relatively small influence on work motivation, but show the lowest performance. This indicates that suboptimal material management can be a source of technical obstacles and work pressure, so improvements are needed in the procurement, storage, and distribution systems.

5) Work Equipment

Importance: 0,00 | Performance: 73,30

Work equipment showed very little effect on work motivation with moderate performance. Even though it does not have a direct impact on work morale, the condition and availability of tools must still be maintained so as not to interfere with the smooth running of work.

6) Work Environment

Importance: -0,01 | Performance: 71,15

The work environment is the factor with the lowest and negative importance values, indicating that its contribution to work motivation is considered very small. However, its low performance shows that this aspect still needs to be considered because in the long term it can affect productivity and job satisfaction.

Based on the results of this IPMA, Communication is the most important factor in shaping work motivation. An increased focus on this area can have a considerable additional impact on overall work motivation, especially in projects with high time pressures such as highway maintenance.

2. Quality Performance

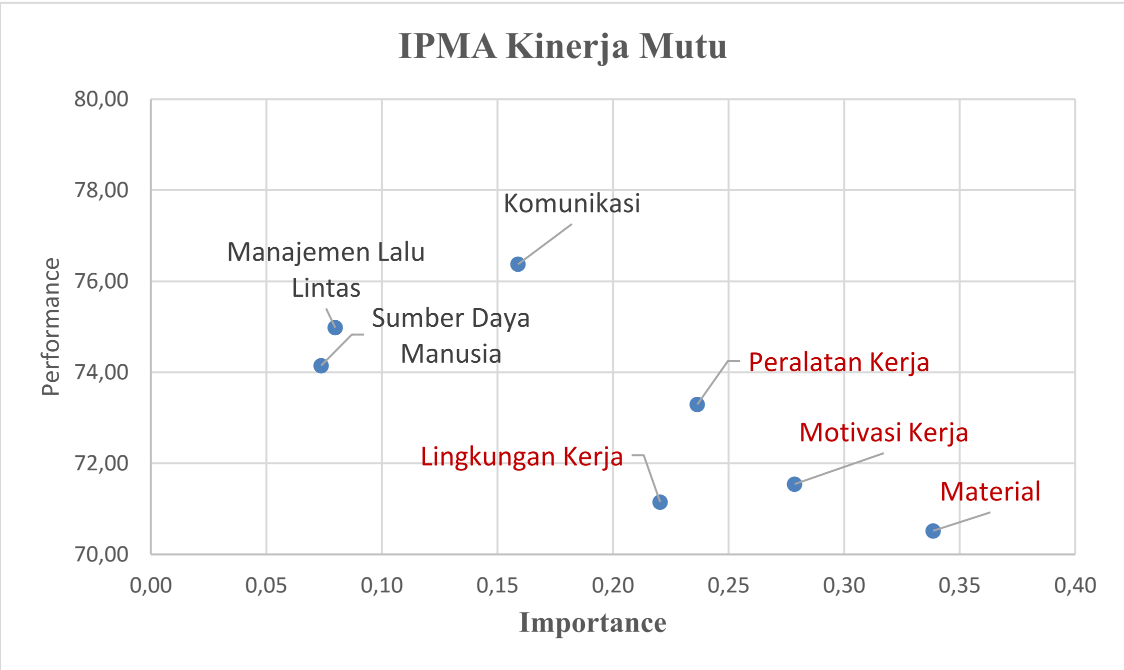

Figure 2. IPMA for Quality Performance

The IPMA analysis aims to identify the factors that have the most influence on Project Quality Performance (importance) and evaluate how well it is currently performing (performance). These results are very important for determining the priority of repairs in the context of toll road maintenance projects with quick-drying concrete.

1) Material

Importance: 0,34 | Performance: 70,52

Materials are the most crucial factor in determining the quality of a project, but it currently has the lowest performance. This shows that there is a large gap between the level of importance and implementation in the field. Therefore, it is necessary to improve the selection of quick-drying concrete, quality testing, procurement timeliness, and material storage and distribution systems so that the quality of work results can be significantly improved.

2) Work Motivation

Importance: 0,28 | Performance: 71,55

Work motivation has a big influence on the quality of the project, but the performance is still relatively low. This condition shows that the spirit and commitment of the workforce have not been fully optimal, so an improvement strategy is needed through incentive systems, training, strengthening internal communication, and creating a work environment that supports collaboration and productivity.

3) Work Equipment

Importance: 0,24 | Performance: 73,30

Work equipment has a significant effect on the quality of the project, but its performance is still below several other factors. This shows the need to increase tool readiness, routine maintenance, technological sophistication, and operator competence so that the implementation of work can run more efficiently and produce better casting quality.

4) Work Environment

Importance: 0,22 | Performance: 71,15

The work environment has a considerable influence on the quality of the project, but the performance is still low. Aspects of safety, cleanliness, comfort, and waste management need to be improved because an unconducive work environment can reduce productivity and increase the risk of technical errors in the field.

5) Comparison with Other Factors

Communication (importance: 0.16; performance: 76.38), Human Resources (importance: 0.07; performance: 74.15), and Traffic Management (importance: 0.08; performance: 74.98) showed relatively higher performance, but their influence on project quality was smaller than the four main factors above, so the improvement in these aspects would not have an impact as much as improvements in materials, work motivation, work equipment, and work environment.

Based on the results of this IPMA, the project quality improvement strategy should be focused on:

1) Strengthening material management – because the impact is greatest and the performance is the lowest.
2) Increased work motivation – as a key driver of productivity and work quality.
3) Optimization of work equipment – to support efficiency and technical precision.
4) Improving the working environment – to create safe, comfortable, and productive working conditions.

These four factors are the main priorities which, if improved simultaneously, will have a significant impact on the quality of the fast-drying concrete casting project.

C. Key Findings

In the inner model, no indication of multicollinearity was found, and most of the relationships between latent constructs were proven to be significant. Factors such as Materials, Work Motivation, Work Equipment, and Work Environment have a strong direct influence on Project Quality Performance, with an R^2 value of 0.679, indicating high predictive ability. A Q^2 value of 0.311 also indicates good predictive relevance. Indirect pathway analysis revealed that Work Motivation plays a significant mediator between Communication and Quality Performance, even though communication has no direct effect on quality. The IPMA results reinforce these findings by showing that Materials, Work Motivation, and Work Equipment are the factors that most affect the quality of the project, but performance can still be improved. Overall, this study suggests that project quality improvement strategies should be focused on:

1. Strengthening material management,
2. Increased work motivation through an incentive system and effective communication,
3. Optimization of work equipment,
4. Improved work environment that supports productivity.

Communication factors remain important as motivational drivers, while HR and traffic management do not show a significant influence on project quality in this context.

D. Comparison with Previous Research

The results of this study show that some of the findings are in line with previous studies, but also make new contributions that enrich the understanding of construction project quality management, particularly in fast-drying concrete casting work. First, the finding that Materials is the most dominant factor in influencing Project Quality Performance is in line with research by Limbong et al. (2013) and Rudnicki & Stałowski (2023), which emphasizes the importance of quality and accuracy of material procurement in high-speed construction projects. This research reinforces that poor material management can be a major source of delays and quality defects. Second, Work Motivation has been proven to have a direct influence on project quality and also acts as a mediator between Communication and Quality Performance. These findings are consistent with the studies of Mudayana & Suryoko (2016), Feriandy (2024), and Sarini et al. (2020), which show that work motivation can bridge the influence of organizational factors on performance. This study adds evidence that in projects with high time pressure, work motivation is the main driver of success. Third, Communication does not have a direct effect on the quality of the project, but has a significant influence on work motivation. This is in line with the findings of Hapsari et al. (2019) and Santalla (2022), who stated that effective communication improves team motivation and coordination, even though the impact on the final project outcome is indirect. Fourth, Work Equipment also shows a significant influence on project quality, supporting the results of Tuwo & Mustamin's (2024) research which emphasizes the importance of tool readiness and maintenance in construction projects. However, unlike some previous studies, in this study work equipment had no effect on work motivation, showing that the technical aspect does not always have a psychological impact on the workforce. In contrast, Human Resources and Traffic Management, which in some studies such as Hermawan (2016) and Mudayana & Suryoko (2016) are considered important, did not show a significant influence on the quality of projects in this model. This shows that in the context of fast-drying concrete casting work with a narrow window time, technical and motivational factors are more dominant than structural or administrative aspects. Overall, the study confirms most of the previous findings, but also provides an important update: that in fast-paced and high-risk toll road maintenance projects, Materials, Work Motivation, and Work Equipment are the most determinants of quality success, while Communication acts as a motivation booster, not as a direct determinant of project quality.

The results of this study offer a novelty in the form of a comprehensive contextual understanding of the factors that determine the quality of fast-drying concrete casting work in the JORR Toll Road maintenance project under very limited window time conditions and high traffic pressure, by showing that the success of quality is not only determined by technical aspects, but also by dynamic interaction between materials, work motivation, equipment, work environment, and communication. Materials proved to be the most dominant yet underperforming factor, thus confirming the importance of systematically improving material management, while work motivation has a dual role as a direct factor and mediator between communication and project quality, suggesting that psychological and managerial approaches are just as important as technical approaches. Work equipment and work environment also contribute significantly to quality through increased efficiency, precision, and work comfort, while communication plays an indirect role through increasing team motivation. These findings enrich the literature with empirical models that integrate technical and behavioral factors simultaneously in the context of fast-drying concrete-based toll road maintenance projects, thus providing a new basis for the formulation of more holistic, adaptive, and sustainable quality improvement strategies.

E. Implications for the Construction Industry and the Development of Construction Management Science

An in-depth understanding of the results of this study emphasizes the importance of a holistic approach in improving the quality of quick-drying concrete casting work in the maintenance project of the JORR Toll Road W2S, Section S, and Section E. The findings that materials, work motivation, and work equipment are the main determinants of quality show that the success of the project cannot rely on one aspect alone, but requires synergy between technical factors, managerial, and human resources. In working conditions with limited window time and high traffic pressure, material quality, tool readiness, and team spirit and coordination are the keys to achieving optimal quality.

Based on the results of SEM-PLS and IPMA, the quality improvement strategy needs to be focused on factors that have a big influence but are still underperforming, namely materials, work motivation, work equipment, and work environment. Strengthening material management needs to be carried out through the selection of quick-drying concrete that meets standards, periodic quality testing, scheduled procurement, and an efficient distribution system. On the other hand, increased work motivation can be achieved through performance-based incentive systems, technical and soft skills training, as well as open internal communication and participatory leadership, while the optimization of work equipment should be supported by regular maintenance and improvement of operator competencies.

Overall, the results of this study provide important implications for the practice and development of construction management science by strengthening the integrative approach between technical aspects and human behavior. The integration of material management, increased work motivation, equipment readiness, conducive work environment, and effective communication have proven to be the main foundation in improving the quality of fast-drying concrete casting work in a sustainable manner in accordance with the demands of national toll road service standards.

CONCLUSION

Based on the results of hypothesis testing and SEM-PLS analysis, the variables of Materials, Work Equipment, and Work Environment were proven to have a direct positive and significant influence on the Quality Performance of toll road maintenance projects, while HR, Communication, and Traffic Management did not have a significant direct effect, which showed that in fast-drying concrete work with limited window time, technical aspects and physical conditions of the field were more decisive in the final quality than in the final quality compared to administrative aspect. Work Motivation has been proven to play a role as a mediating variable only in the relationship between Communication and Quality Performance, so that effective communication is able to increase team motivation which further has an impact on improving the quality of work. Based on the total effect value, Materials were the most dominant factor (0.339), followed by Work Motivation (0.279), Work Equipment (0.236), and Work Environment (0.220), which emphasized that the success of quality is highly dependent on the quality and management of quick-drying concrete materials. The IPMA results show that Materials are the main priority for improvement because they have a high level of importance but the lowest actual performance, followed by Work Motivation and Work Environment, while Communication even though it has high performance still needs to be maintained because it plays a role in increasing motivation. Therefore, the recommended managerial strategies include strengthening material management, increasing work motivation through incentives and effective communication, optimizing equipment through maintenance and operator training, and improving a safe and comfortable working environment, so that the integration of technical and humanist aspects is expected to be able to improve the quality of quick-drying concrete casting work in the maintenance project of the JORR Toll Road W2S section, S, and E continuously.

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