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Research Paper

Analysis of Factors Affecting Delays in Road Reconstruction Projects in East Kalimantan Province, Indonesia

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ABSTRACT : *Road reconstruction projects in East Kalimantan are strategically important for regional connectivity and for supporting the development of Indonesia's new capital region. However, delays remain frequent and may reduce budget efficiency, disrupt public services, and increase indirect project costs. This study identifies the empirical structure and dominant determinants of delays in road reconstruction projects in East Kalimantan Province. A quantitative explanatory survey was conducted among 45 stakeholders representing government/owners, contractors, and supervising consultants. The instrument contained 26 indicators covering financial conditions, human resources, work scheduling, work execution methods, design changes, materials, and equipment. Data were evaluated through validity and reliability testing, exploratory factor analysis using principal component analysis with Varimax rotation, classical assumption tests, and multiple linear regression. The Kaiser-Meyer-Olkin value was 0.795 and Bartlett's test was significant ($\chi^2 = 1203.745$; $p < 0.001$), confirming the adequacy of factor analysis. Six empirical factors explained 84.069% of the total variance. The regression model was significant ($F = 16.226$; $p < 0.001$). Design changes ($B = 0.310$; $p = 0.009$) and the combined material-and-equipment factor ($B = 0.371$; $p = 0.015$) significantly increased project delays, with material and equipment emerging as the dominant factor. The findings emphasize the need for early procurement, reliable supplier and equipment planning, preventive maintenance, comprehensive design review, faster change approval, and stronger coordination among project stakeholders.*

KEYWORDS: *Construction management, project delay, road reconstruction, exploratory factor analysis, multiple linear regression.*

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I. INTRODUCTION

East Kalimantan has become one of Indonesia's most important infrastructure development regions following the establishment of Nusantara as the country's new capital. The expansion of administrative, residential, industrial, and logistics activities requires a reliable road network that can connect production centers, settlements, public facilities, and interregional transport corridors. Road reconstruction is therefore not only a technical maintenance activity but also a strategic investment that supports mobility, economic integration, and balanced regional development [10-12].

Despite its importance, road reconstruction is frequently exposed to delays. A construction delay occurs when an activity or the overall project cannot be completed according to the approved schedule. Delays may extend the contract period, increase indirect costs, reduce the availability of public infrastructure, create disputes, and weaken public confidence in infrastructure delivery [4-6]. For road projects, the consequences can be particularly broad because unfinished work interferes with traffic, logistics, access to services, and the operation of surrounding communities.

The causes of delay are multidimensional. Financial constraints can interrupt payments to suppliers and workers; inadequate human resources may reduce productivity and coordination; unrealistic scheduling can create unachievable work sequences; inappropriate execution methods can lower output; design changes may generate remeasurement and rework; and deficiencies in materials or equipment may stop critical activities. These factors do not operate independently. A late design revision may postpone material ordering, while unavailable equipment can make an otherwise realistic schedule impossible to implement [1-4].

Studies of Indonesian road projects have reported related patterns. Mulyadi et al. found that groups of managerial and operational factors simultaneously affected extensions of contract time in national road projects [8]. Kustamar and Putranto reported a strong relationship between project-management factors and delays on a road maintenance project in Samarinda, East Kalimantan [7]. Putra et al. identified design errors, owner-initiated changes, weak site supervision, material shortages, inappropriate methods, permit delays, nonconforming materials, and insufficient pre-design surveys as important causes of construction delays in Balikpapan [9]. These studies demonstrate the persistence of delay risk, while also indicating that the relative importance of each factor depends on project and regional conditions.

Many previous investigations rank individual delay indicators using descriptive indices. Although such rankings are useful, they may not reveal whether several indicators represent the same underlying dimension or whether a factor remains influential when other variables are controlled. An integrated procedure combining exploratory factor analysis and multiple regression provide a stronger basis for simplifying correlated indicators, testing the simultaneous model, and identifying variables with statistically significant partial effects.

This study addresses that need by examining road reconstruction projects implemented in East Kalimantan during the 2022-2024 budget periods. Seven initial determinants were investigated: financial conditions, human resources, work scheduling methods, work execution methods, design changes, materials, and equipment. The study was designed to answer three questions: whether the operational factors significantly influence delays, what empirical model is formed from the observed indicators, and what managerial strategies should be prioritized to reduce delay risk.

The contribution of the study is twofold. Academically, it demonstrates how factor reduction and regression can be integrated to analyze construction delays in a regional road-reconstruction context. Managerially, it provides evidence-based priorities for owners, contractors, and supervising consultants, particularly regarding the readiness of materials and equipment and the management of design changes.

Table 1. Initial operational factors and their expected delay mechanisms

Factor	Typical Condition	Delay Mechanism
Financial conditions	Insufficient working capital; late owner or contractor payments	Interrupted procurement, labor payment, and project cash flow
Human resources	Labor shortage; limited certification; weak coordination and responsibility	Low productivity, errors, and slow problem resolution
Work scheduling method	Unrealistic schedule; incorrect sequencing; delayed shop-drawing approval	Compressed activities, waiting time, and missed milestones
Work execution method	Noncompliant work stages; late-year mobilization; technical nonconformity	Reduced output, rework, and inefficient use of resources
Design changes	Owner changes; slow redesign; failure of initial design assumptions	Approval delays, quantity changes, and rework
Materials	Shortage; late delivery; specification changes; damage; market scarcity	Work stoppage and disruption of critical activities
Equipment	Poor condition; inappropriate use/specification; late delivery; limited quantity	Breakdown, low capacity, and idle labor

II. LITERATURE REVIEW

2.1. Project Delay in Road Reconstruction

Project management coordinates planning, organization, leadership, and control so that a temporary undertaking can achieve its scope, time, cost, and quality objectives [1]. In road reconstruction, this coordination is complicated by traffic management, existing pavement conditions, dispersed work fronts, weather exposure, material hauling distances, utility conflicts, and the need to maintain public access. A delay in one activity can therefore propagate to several downstream activities and affect the final completion date.

Callahan explains that delay can be identified by comparing actual progress with the approved schedule and by evaluating how a late activity affects succeeding work [5]. Lewis and Atherley distinguish delays associated with uncontrollable events, owner responsibility, and contractor responsibility [6]. This classification is important because the contractual consequences differ: some events justify time extensions, some justify both time and cost compensation, and others remain the contractor's responsibility. Nevertheless, the managerial objective is the same—to identify preventable constraints early and reduce their effect on the critical path.

Road reconstruction delay also reflects the interaction among time, cost, and quality. Accelerating delayed work may require overtime, additional equipment, or premium procurement, while uncontrolled acceleration can reduce quality and safety. Conversely, postponing corrective action increases overhead and exposes completed and unfinished work to further deterioration. Effective delay management must therefore emphasize prevention, reliable short-term planning, and rapid resolution of constraints rather than relying only on end-of-project acceleration [3,4].

2.2. Determinants of Project Delay

Financial capacity supports every operational input. Contractors require adequate cash flow to pay labor, purchase fuel and materials, mobilize equipment, and maintain subcontractor commitments. Delayed payment by an owner can affect the contractor’s ability to fulfill these obligations, while weak internal financial control can create the same outcome even when certified payments are available. Financial problems are therefore expected to increase the probability and duration of work interruption.

Human resources influence productivity through technical competence, experience, certification, supervision, communication, and responsibility. Road projects depend on coordinated teams operating equipment, controlling levels and dimensions, managing traffic, testing materials, and documenting progress. Shortages or competency gaps can lead to inefficient work, technical defects, and rework. However, the effect of labor may be moderated by equipment, material readiness, and the degree to which tasks are standardized.

Scheduling translates scope into a time-based sequence of activities and resource requirements. An effective schedule must reflect realistic productivity, weather allowances, resource constraints, approval lead times, and relationships among activities. A schedule developed only from assumptions or past experience may be formally complete but operationally infeasible. Late approval of shop drawings or work plans can further disconnect the schedule from field readiness.

Execution methods determine how work is organized and performed. Inappropriate sequencing, noncompliance with technical procedures, inadequate traffic management, or mobilization near the end of a budget year can reduce productivity and increase rework. The execution method is closely related to scheduling because an activity duration is meaningful only when it is based on a defined method, crew composition, equipment capacity, and site condition.

Design changes are among the most disruptive delay sources because they affect quantities, specifications, work sequences, procurement, and approvals. Changes may be required when field conditions differ from the design assumptions, when the owner modifies functional requirements, or when the original survey and design are incomplete. The delay effect becomes larger when the change-control process lacks clear authority, response deadlines, and documentation.

Material and equipment readiness directly determines whether planned activities can start and continue. Material risk includes shortages, late transport, specification changes, storage damage, and market scarcity. Equipment risk includes breakdown, insufficient capacity, incorrect specification, delayed mobilization, and limited quantities. These two resource groups are operationally interdependent: materials cannot be installed without suitable equipment, while equipment and crews become idle when materials are unavailable. Their interaction justifies examining whether they form a common empirical factor in road reconstruction projects.

2.3. Conceptual Framework

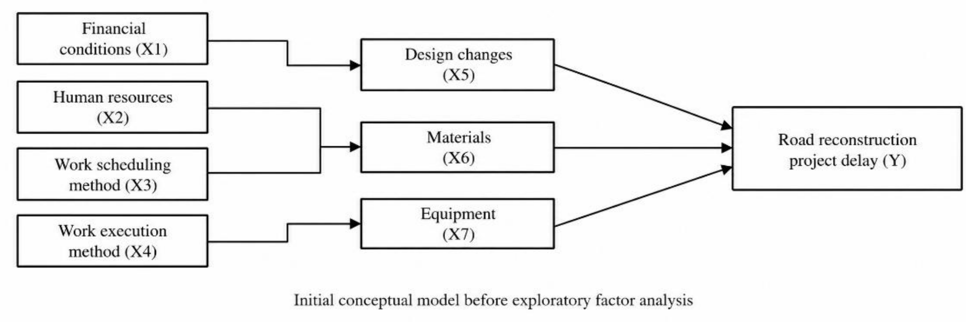

Figure 1. Initial conceptual framework of the study

The initial conceptual framework assumes that the seven operational factors affect the level of delay in road reconstruction projects. The model does not presume that the seven dimensions will remain statistically separate. Exploratory factor analysis is used to determine whether the 26 indicators form a smaller number of empirical factors, after which the resulting dimensions are entered into the regression model. The initial relationships are illustrated in Figure 1.

III. RESEARCH METHOD

3.1. Research Design and Respondents

The study used a quantitative explanatory design. Data were collected from stakeholders with direct knowledge of delayed road reconstruction projects in East Kalimantan Province. The study area covered projects implemented during the 2022-2024 budget periods. Respondents represented the principal institutional perspectives involved in project delivery, including government/owner personnel, contractors, and supervising consultants.

The accessible population consisted of 45 individuals who met the relevance criteria. Because the population was limited and all members could be reached, all 45 were included in the final survey. This census approach reduced sampling error within the defined population and ensured that the analysis incorporated perspectives from the parties responsible for planning, execution, contract administration, and field supervision.

3.2. Variables and Instrument

The questionnaire was developed from the literature review and the operational conditions reported in road projects. Seven independent variables were initially specified: financial conditions (X1), human resources (X2), work scheduling method (X3), work execution method (X4), design changes (X5), materials (X6), and equipment (X7). Project delay was treated as the dependent variable (Y). In total, 26 independent-variable indicators were evaluated using a five-point Likert scale ranging from 1 (very low influence) to 5 (very high influence).

The indicators included late payments, labor shortage and certification, unrealistic scheduling, delayed approval of shop drawings, noncompliant work stages, owner-initiated design changes, delayed redesign, material shortage and delivery, material specification changes, storage damage, equipment condition, equipment suitability, delayed mobilization, and equipment quantity. The dependent variable captured the perceived increase in project duration and the inability to meet planned completion targets.

Table 2. Measurement structure used in the survey

Code	Construct	Indicators	Main Measurement Focus
X1	Financial conditions	3	Working capital and payment delays
X2	Human resources	5	Availability, certification, coordination, responsibility
X3	Work scheduling method	3	Schedule realism, sequencing, approval readiness
X4	Work execution method	2-3	Compliance with methods, timing, specifications
X5	Design changes	3	Owner changes, redesign time, initial-design adequacy
X6	Materials	5	Availability, delivery, specification, storage, scarcity
X7	Equipment	5	Condition, use, specification, mobilization, quantity
Y	Project delay	2	Increase in duration and late completion

3.3. Data Analysis

The analysis was performed in five stages. First, item validity was examined using Pearson product-moment correlations at a 5% significance level. An item was accepted when its correlation exceeded the critical value and its p-value was below 0.05. Second, internal consistency was assessed using Cronbach's Alpha, with values above 0.70 interpreted as reliable [13-15].

Third, exploratory factor analysis was conducted using principal component analysis and Varimax rotation. Sampling adequacy was evaluated using the Kaiser-Meyer-Olkin statistic, Bartlett's test of sphericity, Measure of Sampling Adequacy values, and communalities. Components with eigenvalues greater than 1 were retained. Factor loadings were then interpreted to assign indicators to the most representative empirical dimension.

Fourth, the empirical factors were evaluated using multiple linear regression. Before estimation, the model was tested for normality, multicollinearity, heteroscedasticity, and autocorrelation. The Kolmogorov-Smirnov test was used for normality, Variance Inflation Factors for multicollinearity, Spearman correlations between predictors and absolute residuals for heteroscedasticity, and the Durbin-Watson statistic for autocorrelation [16-18].

Finally, overall model significance was assessed using the F-test, while partial effects were evaluated using t-tests and p-values. The dominant factor was defined as a statistically significant variable with the largest unstandardized regression coefficient. The analytical sequence is presented in Figure 2.

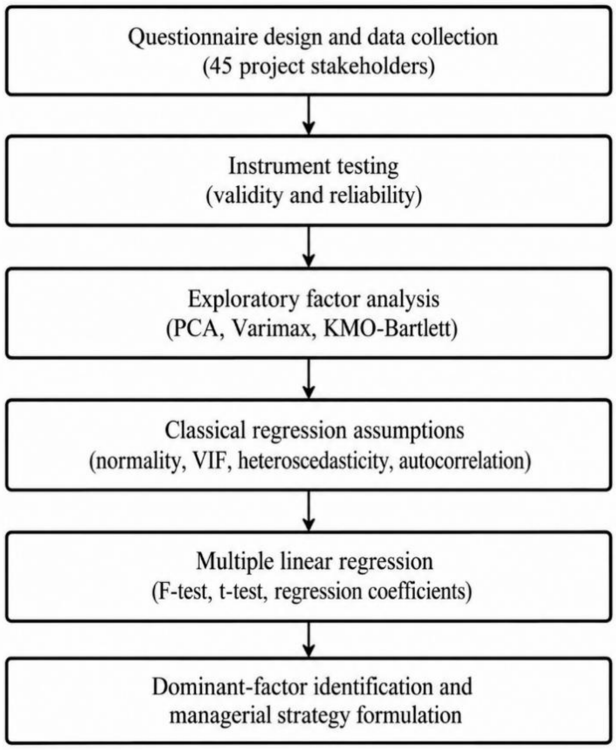

Figure 2. Research analysis procedure

IV. RESULT AND DISCUSSION

4.1. Instrument Quality

All questionnaire indicators satisfied the validity criterion. The item correlations ranged from 0.462 to 0.844 and exceeded the critical correlation value of 0.294. All reported p-values were below 0.05. The lowest valid correlation occurred within the work-execution-method construct, while the highest occurred within the equipment construct. These results indicate that the items were sufficiently associated with the concepts they were intended to represent.

The reliability analysis also showed strong consistency. Cronbach's Alpha values reported across the item-deletion diagnostics ranged from 0.957 to 0.961, substantially exceeding the minimum threshold of 0.70. The combination of valid item correlations and high reliability supports the use of the questionnaire responses in the subsequent factor and regression analyses.

Table 3. Summary of instrument and factor-analysis adequacy

Assessment	Statistic	Result	Decision
Item validity	Correlation range	0.462-0.844	All items valid
Reliability	Cronbach's Alpha range	0.957-0.961	Highly reliable
Sampling adequacy	KMO	0.795	Adequate
Sphericity	Bartlett χ^2; df; p	1203.745; 325; <0.001	Correlations suitable for EFA
Indicator adequacy	MSA range	0.602-0.915	All above 0.50
Common variance	Communality range	0.737-0.918	Strong extraction

4.2. Exploratory Factor Analysis

The KMO value of 0.795 indicates that the correlation structure was appropriate for factor analysis. Bartlett's test was significant, confirming that the correlation matrix was not an identity matrix. The individual MSA values ranged from 0.602 to 0.915 and the communalities ranged from 0.737 to 0.918, showing that every indicator had sufficient shared variance and was well represented by the extracted components.

Six components had eigenvalues greater than 1 and jointly explained 84.069% of total variance. The first component alone explained 49.047%, while the next five components added 9.903%, 8.127%, 6.664%, 5.370%, and 4.958%, respectively. This high cumulative variance indicates that the reduced structure retained most of the information contained in the 26 observed indicators.

The rotated solution produced six interpretable factors. Materials and equipment merged into a single component, indicating that respondents perceived resource supply and equipment readiness as one integrated operational constraint. Human resources, scheduling, design changes, finance, and execution methods remained separate. The merger of materials and equipment is theoretically reasonable because the utilization of each resource depends on the simultaneous readiness of the other.

Table 4. Empirical factors formed by principal component analysis

Component	Empirical Factor	Indicator Group	Interpretation
1	Materials and equipment	X61-X65; X71-X75	Resource availability, delivery, condition, capacity
2	Human resources	X21-X25	Availability, competence, coordination, responsibility
3	Work scheduling method	X31-X33	Realism, sequencing, approval readiness
4	Design changes	X51-X53	Change initiation, redesign delay, design adequacy
5	Financial conditions	X11-X13	Capital and payment continuity
6	Work execution method	X41-X42/X43	Method compliance, work timing, specifications

Table 5. Eigenvalues and explained variance of retained components

Component	Eigenvalue	Variance (%)	Cumulative (%)
1	12.752	49.047	49.047
2	2.575	9.903	58.950
3	2.113	8.127	67.077
4	1.733	6.664	73.741
5	1.396	5.370	79.111
6	1.289	4.958	84.069

4.3. Regression Assumption Tests

The residual distribution satisfied the normality requirement. The Kolmogorov-Smirnov statistic was 0.091 with a significance value of 0.200, which is greater than 0.05. Multicollinearity was also not present: VIF values ranged from 1.332 to 2.036, well below the commonly used threshold of 5. This indicates that the six empirical factors contained sufficiently distinct information for regression estimation.

The Spearman tests between predictors and the absolute residuals produced p-values from 0.083 to 0.987. Because all values exceeded 0.05, the null hypothesis of no systematic association with residual magnitude was retained, indicating homoscedastic errors. The Durbin-Watson statistic was 1.843, which fell within the reported acceptance interval of 1.8346-2.1654. The model therefore satisfied the non-autocorrelation requirement.

Table 6. Summary of classical regression assumption tests

Assumption	Statistical result	Decision
Normality	Kolmogorov-Smirnov = 0.091; p = 0.200	Satisfied
Multicollinearity	VIF = 1.332-2.036	No multicollinearity
Heteroscedasticity	Spearman p = 0.083-0.987	No heteroscedasticity
Autocorrelation	Durbin-Watson = 1.843	No autocorrelation

4.4. Multiple Regression Results

The simultaneous F-test yielded a value of 16.226 with $p < 0.001$. Thus, the six empirical factors jointly explained a statistically significant portion of variation in road reconstruction delays. Based on the reported F-statistic, sample size, and number of predictors, the model corresponds to an R^2 of approximately 0.719 and an adjusted R^2 of approximately 0.675. The model therefore has substantial explanatory power for an operational survey of project delays.

The estimated regression equation is: $Y = -0.688 + 0.201X1 + 0.055X2 + 0.219X3 + 0.073X4 + 0.310X5 + 0.371X6$, where X6 represents the empirical material-and-equipment factor. All coefficients are positive, meaning that higher exposure to each constraint is associated with a higher level of project delay when the other factors are held constant.

Only design changes and materials-and-equipment were statistically significant at the 5% level. Design changes had a coefficient of 0.310, t = 2.746, and p = 0.009. Materials and equipment had the largest coefficient, 0.371, with t = 2.545 and p = 0.015. Financial conditions, human resources, scheduling, and execution methods had positive coefficients but did not reach the 5% threshold in the multivariable model. Scheduling was the closest to significance (p = 0.088), suggesting that it remains managerially relevant even though its independent statistical contribution was weaker after controlling for the other factors.

The nonsignificant results should not be interpreted as evidence that finance, labor, scheduling, and methods are unimportant. Their effects may be indirect, may overlap with resource and design constraints, or may have shown limited variation across the surveyed projects. For example, an unrealistic schedule becomes most damaging when materials, equipment, or approved design information are not ready. The regression isolates partial effects, whereas field delays emerge from interacting constraints.

Table 7. Multiple linear regression results

Variable	B	t	p-value	Decision
Constant	-0.688	-1.693	0.099	-
Financial conditions (X1)	0.201	1.653	0.106	Not significant
Human resources (X2)	0.055	0.437	0.664	Not significant
Work scheduling method (X3)	0.219	1.753	0.088	Not significant
Work execution method (X4)	0.073	0.679	0.501	Not significant
Design changes (X5)	0.310	2.746	0.009	Significant
Materials and equipment (X6)	0.371	2.545	0.015	Significant; dominant

4.5. Discussion of Dominant Factors

The dominance of materials and equipment confirms that road reconstruction is highly dependent on the continuous readiness of physical resources. Work fronts may be geographically dispersed and located far from suppliers, while aggregates, asphalt, cement, fuel, and replacement parts must arrive according to the production sequence. A shortage or late delivery immediately reduces the utilization of crews and equipment. Conversely, equipment breakdown or insufficient capacity prevents available materials from being processed and installed. The factor-analysis result therefore reflects a field reality in which material logistics and equipment operations form one integrated production system.

The material-and-equipment coefficient was the largest in the regression model. Improvement should begin with a resource-loaded procurement and mobilization plan linked to the baseline and short-term schedules. Critical materials should be identified early, supplier lead times should be verified, and alternative sources should be prequalified. Stock monitoring should distinguish between general inventory and materials that are released, tested, and ready for a specific work package. Equipment plans should include capacity checks, preventive maintenance, spare-part availability, backup arrangements for critical machines, and daily monitoring of downtime.

Design changes were the second significant factor and had the strongest t-statistic. Road reconstruction frequently reveals field conditions that are not fully captured during preliminary surveys, including pavement-layer variability, drainage conflicts, utilities, unstable subgrade, and differences between drawings and existing geometry. When such conditions trigger design changes, the delay depends on how quickly technical clarification, cost and quantity evaluation, approval, and revised documents are completed. A technically necessary change becomes a major schedule problem when the governance process is slow or unclear.

The appropriate response is not to prohibit changes, because some are essential for safety, functionality, and constructability. Instead, the project should reduce avoidable changes through better surveys, multidisciplinary design reviews, constructability reviews, and early stakeholder consultation. During construction, a formal change-control workflow should specify submission requirements, responsible reviewers, decision authority, maximum response times, and the method for communicating approved revisions to field teams, laboratories, suppliers, and measurement personnel.

The results are consistent with local studies that identify design deficiencies, owner changes, material shortages, and unsuitable methods as recurring causes of delay [7-9]. The present study adds evidence that, after correlated indicators are reduced and competing factors are controlled, resource readiness and design-change management remain the most influential partial determinants. This distinction is important for prioritizing limited managerial attention and contingency resources.

4.6. Managerial Improvement Strategy

The recommended strategy integrates prevention, readiness verification, and rapid response. Before each major work package is authorized, the project team should confirm that the latest approved design is available, required materials have been delivered and accepted, equipment is serviceable and appropriately sized, competent crews are assigned, access and traffic arrangements are ready, and inspection points are agreed. Activities that fail this readiness test should be resolved before they are placed on the short-term schedule.

Weekly coordination meetings should focus on constraints rather than only reporting percentage progress. Each constraint should have an owner, due date, and escalation route. A simple digital dashboard can track material delivery, equipment availability and downtime, pending design decisions, shop-drawing status, test results, and critical-path effects. Owners, contractors, and supervising consultants should use the same updated information so that decisions are not delayed by inconsistent records.

The priority actions derived from the model are summarized in Table 8. The first two priorities directly address the significant variables. Scheduling, finance, human resources, and execution methods remain supporting priorities because they strengthen the project's capacity to implement the principal controls.

Table 8. Managerial priorities for reducing road reconstruction delays

Priority Area	Recommended Actions
1. Materials and equipment	Prepare early procurement and mobilization plans; prequalify alternative suppliers; monitor critical stock; implement preventive maintenance; provide backup equipment for critical-path work.
2. Design changes	Improve field surveys and constructability review; establish change-control deadlines and authority; accelerate technical review and revised-document distribution.
3. Scheduling and methods	Develop resource-loaded schedules; use rolling look-ahead planning; verify work-package readiness; align durations with approved methods and realistic productivity.
4. Coordination and information	Conduct constraint-focused meetings; maintain a shared dashboard for drawings, materials, equipment, tests, and approvals; escalate overdue decisions.
5. Finance and workforce	Protect cash flow for suppliers and labor; improve technical training, certification, supervision, and responsibility for corrective actions.

V. CONCLUSION

This study analyzed 26 indicators associated with delays in road reconstruction projects in East Kalimantan Province. The survey involved 45 respondents from owner/government, contractor, and supervising-consultant organizations. The instrument was valid and highly reliable, and the data were suitable for exploratory factor analysis. Six empirical factors were extracted and explained 84.069% of total variance: materials and equipment, human resources, work scheduling methods, design changes, financial conditions, and work execution methods.

The regression model was significant at $p < 0.001$. Design changes and materials-and-equipment had significant positive effects on project delay. Materials and equipment constituted the dominant factor, with the largest regression coefficient ($B = 0.371$), followed by design changes ($B = 0.310$). The findings demonstrate that road reconstruction delays are most strongly affected by whether physical resources are continuously ready for planned work and whether design changes are prevented, evaluated, approved, and communicated without prolonged waiting time.

Owners and project teams should prioritize early procurement, alternative suppliers, stock and delivery monitoring, preventive equipment maintenance, backup plans for critical equipment, improved field investigation, constructability review, and time-bound change-control procedures. These controls should be supported by realistic resource-loaded schedules, shared information systems, stable cash flow, qualified personnel, and constraint-focused coordination.

The study is limited to a defined set of projects and perception-based survey data in one province. Future research should combine questionnaire evidence with objective records such as planned-versus-actual durations, material delivery logs, equipment downtime, change-order processing time, weather interruptions, and critical-path impacts. Comparative research across provinces and project types would also help determine whether the dominant delay structure changes under different geographic, contractual, and market conditions.

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