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Original Article

A Comprehensive Analysis of Principal Contributing Factors to Construction Project Delays: A Multi-stakeholders Perspective on Financial Bottlenecks, Design Revisions, and Coordination Failures in High-rise Development

[1]ADE ASMI, [2]ANGGA PRABOWO, [3]AURINO DJAMARIS
[1,2]Department of Civil Engineering, Universitas Bakrie, Jakarta, Indonesia.
[3]Department of Management, Universitas Bakrie, Jakarta, Indonesia.

ABSTRACT: *This study investigates the primary factors contributing to schedule deviations in high-rise construction projects, focusing on the interconnected dynamics of financial bottlenecks, technical revisions, and coordination failures. Employing a mixed-methods approach, data are collected from fifty-four industry professionals representing contractors, owners, and consultants through structured questionnaires evaluating thirty-three delay variables. Reliability analysis yields a Cronbach's Alpha of 0.949, confirming robust instrument consistency. Progress tracking via S-curve analysis identifies a critical deviation of -4.43 between March and May 2021. Spearman Rank correlation reveals a strong positive relationship (r = 0.861) between delayed worker payments and diminished labor productivity. Results indicate that stakeholders perceive delay drivers differently: contractors emphasize coordination gaps, owners highlight financial constraints, and consultants prioritize technical rework. The research transcends traditional risk identification by proposing a role-based mitigation framework that integrates proactive cash flow management, formal change order protocols, and digital communication infrastructure. These findings provide actionable strategies for optimizing time control, enhancing stakeholder alignment, and minimizing schedule deviations in complex residential developments.*

KEYWORDS: *Construction Project Delays, Multi-Stakeholder Perception, Cash Flow Management, Spearman Rank Correlation, Project Risk Mitigation, Building Information Modeling.*

1. INTRODUCTION

Rapid urbanization in Indonesia has intensified the demand for high-density residential solutions, prompting construction providers to adopt vertical apartment concepts to optimize metropolitan land use [3]. Despite rigorous planning protocols, high-rise developments frequently experience substantial execution delays that extend completion timelines beyond contractual deadlines [1], [4]. Such deviations not only generate significant financial losses for project owners but also severely damage the professional reputation and operational capacity of contractors and consultants [8]. In the Indonesian construction context, regional market dynamics, fragmented supply chains, and varying stakeholder priorities frequently complicate project timelines [9]. Traditional delay analyses often remain superficial, relying on generic risk catalogs without addressing the systemic interdependencies between financial liquidity, technical accuracy, and communication infrastructure [6], [10]. This research investigates the Apartment X development project, a high-rise construction that experiences critical schedule deviations. By evaluating thirty-three distinct variables across financial, technical, and coordination domains, this study aims to rank the most dominant risk factors, quantify stakeholder perception discrepancies, and establish empirical correlations between payment delays and field productivity [15], [17]. The research further transitions from mere risk identification to the development of a prescriptive, role-based mitigation framework that integrates proactive financial management, formalized change control, and structured communication protocols [26]. The findings contribute to contemporary project management practices by demonstrating how integrated stakeholder responsibilities and strategic cash flow monitoring transform reactive delay management into proactive schedule optimization [1], [2].

2. LITERATURE REVIEW

Modern project management frameworks, as articulated in the PMBOK Guide Seventh Edition, shift emphasis from rigid procedural compliance to performance-based domains, particularly the Schedule Performance Domain, which addresses uncertainty and workflow optimization [1]. Contemporary construction management literature underscores that successful project delivery requires minimizing non-value-adding activities through lean principles and robust cross-functional stakeholder coordination [2]. Prior empirical studies categorize delay causes into internal factors, such as owner-related financial constraints and contractor-related resource shortages, and external factors, including regulatory changes and environmental disruptions [3], [4], [9]. However, many existing classifications treat these variables as isolated events rather than interconnected systemic failures [6], [8]. Recent scholarship highlights that delayed payments frequently trigger cascading effects, including labor demotivation, procurement stagnation, and forced work stoppages, which directly compromise field productivity [11], [13], [14]. Similarly, design changes are increasingly recognized not as isolated technical adjustments but as intersections of cost, time, and risk management that require formal change order documentation and early contractor involvement [7], [21]. Communication breakdowns further exacerbate these challenges by fostering adversarial relationships, distorting technical specifications, and delaying critical approvals [15], [16], [19]. Building Information Modeling (BIM) and standardized contractual frameworks like FIDIC emerge as vital tools for preemptively identifying design clashes, formalizing payment certificates, and establishing transparent communication channels [21], [26]. This study builds upon these theoretical foundations by integrating multi-stakeholder perception analysis, quantitative correlation testing, and financial management strategies to construct a comprehensive delay mitigation framework that addresses root causes rather than symptoms [10], [12], [22].

3. MATERIALS AND METHODS

This research employs a descriptive-qualitative and quantitative mixed-methods approach to systematically identify, rank, and analyze delay factors in high-rise construction [28]. Data collection involves fifty-four industry professionals representing three primary stakeholder groups: forty-six contractors, six consultants, and two owners. Participants complete structured questionnaires evaluating thirty-three delay variables using a modified Likert scale, which eliminates the neutral category to mitigate central tendency bias and force definitive responses [29]. Instrument reliability is confirmed through Cronbach's Alpha testing, yielding a coefficient of 0.949, indicating exceptionally high internal consistency [27]. All thirty-three variables demonstrate validity, with corrected item-total correlations exceeding the threshold value of 0.2681 at a five percent significance level [28] (see Appendix 1, Table A2). Progress tracking is conducted using S-curve analysis, comparing planned versus actual cumulative work percentages from November 2020 to May 2021 (see Appendix 1, Figure 2). Statistical analysis incorporates Mean Score ranking to prioritize delay factors and Spearman Rank correlation to quantify relationships between critical variables, particularly between payment delays and labor productivity [29]. Additionally, a Fishbone diagram is utilized to categorize root causes into management, contractual, design-technology, manpower, and force majeure domains. Findings are further mapped against PMBOK Project Management Knowledge Areas to validate alignment with established performance domains and to contextualize recommendations within recognized industry standards [1]. The sequential research design, integrating quantitative ranking with qualitative root-cause analysis, is summarized in the methodology flow diagram (see Appendix B, Figure 1)

4. RESULTS AND DISCUSSION

4.1. PROGRESS DEVIATION AND CRITICAL DELAY PERIODS

S-curve analysis reveals that the Apartment X project maintains alignment with scheduled benchmarks from November 2020 through February 2021. However, a pronounced downward deviation emerges in March 2021, culminating in a cumulative progress deficit of -4.43 by May 2021. This critical period coincides with documented financial bottlenecks and coordination failures, indicating that schedule deviations are not isolated incidents but systemic outcomes of misaligned resource allocation and delayed decision-making [3], [11]. The sharp divergence between planned and actual progress underscores the necessity of continuous schedule monitoring and proactive intervention mechanisms [22].

4.2. STAKEHOLDER PERCEPTION DIVERGENCE AND DOMINANT DELAY FACTORS

Mean Score ranking identifies delayed worker payments as the most critical delay variable, achieving a mean score of 15.50 (see Appendix 1, Table A3). Rework due to design changes and poor inter-stakeholder communication rank second and third, with mean scores of 14.25 and 13.80, respectively [27]. Notably, stakeholder perceptions diverge significantly: contractors predominantly attribute delays to coordination failures, emphasizing communication gaps and approval bottlenecks [15], [17]. Owners primarily identify financial constraints, citing cash flow limitations and budget reallocation across concurrent projects [11], [13], [14]. Consultants emphasize technical deficiencies, particularly frequent design revisions and documentation ambiguities [7], [21] (see Appendix 1, Table A4), [24]. This perceptual fragmentation highlights the absence of a unified risk assessment framework and underscores the need for role-specific mitigation strategies [16], [18].

4.3. SYSTEMIC IMPACT OF PAYMENT DELAYS ON LABOR PRODUCTIVITY

Spearman Rank correlation analysis establishes a strong positive relationship ($r = 0.861$) between delayed worker payments and diminished labor productivity [27], [29] (see Appendix 1, Table A5). This empirical finding confirms that financial health directly dictates field efficiency [13], [14]. Delayed compensation triggers workforce demotivation, procurement stagnation, and reduced equipment utilization, which collectively decelerate construction progress [11], [22]. The correlation further reveals that payment delays are not merely administrative inconveniences but critical schedule risk indicators that require immediate financial intervention [5], [6]. Implementing escrow accounts, advance payment guarantees, and retention bonds significantly enhances contractor liquidity and sustains consistent field productivity [14], [26].

4.4. DESIGN CHANGES AS INTERSECTIONS OF COST, TIME, AND RISK

Rework resulting from design changes or documentation errors accounts for a substantial portion of schedule deviations [7], [24]. Technical revisions frequently occur due to premature owner approvals, incomplete initial specifications, or inadequate clash detection during pre-construction phases [21]. Each modification generates cascading impacts, including material re-procurement, labor reassignment, and extended approval cycles [6], [10]. Formalizing change management through standardized Change Order protocols ensures that all modifications are documented, cost-impacted, and schedule-adjusted prior to implementation [26]. Additionally, integrating Building Information Modeling (BIM) enables proactive conflict resolution, significantly reducing post-approval design revisions and associated rework costs [21], [23].

4.5. COMMUNICATION BREAKDOWN AS A SYSTEMIC ROOT CAUSE

Poor communication functions as a systemic catalyst that amplifies financial and technical vulnerabilities [15], [19]. Ambiguous technical instructions, delayed approval responses, and fragmented information sharing between owners, contractors, and consultants frequently result in misaligned expectations and adversarial project environments [16], [17]. Standardizing communication through contractual frameworks like FIDIC, conducting routine coordination meetings, and deploying cloud-based collaboration platforms ensure transparent information flow and accountability [26]. These measures transform communication from a reactive liability into a proactive schedule stabilization mechanism [1], [2]. Root causes of project delays were categorized using a Fishbone (cause-effect) framework, revealing management and contractual factors as primary systemic drivers (see Appendix 2, Figure 3)

4.6. ROLE-BASED MITIGATION FRAMEWORK

Effective delay mitigation requires differentiated responsibilities across stakeholder groups [15], [18] The conceptual framework synthesizing these role-specific strategies is presented in Appendix 2, Figure 4. Owners establish transparent payment mechanisms, conduct rigorous pre-construction design reviews, and adopt collaborative delivery models [11], [14]. Contractors implement aggressive cash flow forecasting, enforce formal change order documentation, and leverage predictive analytics for risk anticipation [13], [22]. Consultants facilitate cross-functional communication, conduct comprehensive design validation, and mediate claim resolutions with impartial technical assessments [18], [21]. This structured allocation of responsibilities ensures that each stakeholder addresses vulnerabilities within their operational domain while contributing to collective schedule stability [1], [26].

4.7. FINANCIAL MANAGEMENT AS STRATEGIC SCHEDULE OPTIMIZATION

Integrating financial management into project scheduling transforms payment delays from administrative issues into strategic risk indicators [13], [14]. Proactive cash flow modeling, shortened payment cycles, and alternative liquidity instruments such as retention guarantees enable contractors to maintain consistent field operations without financial interruption [5], [6]. Owners benefit from comprehensive financial feasibility studies that prevent rigid budget constraints and ensure adequate contingency allocation [11], [14]. By treating financial liquidity as a foundational schedule enabler rather than a peripheral accounting function, projects achieve enhanced resilience against cash-flow-induced delays [1], [2]. The alignment of identified delay factors with PMBOK Project Management Knowledge Areas further validates the strategic focus on cost and schedule management domains (see Appendix 1, Table A6).

5. CONCLUSION

This study demonstrates that construction project delays stem from interconnected financial, technical, and coordination failures rather than isolated operational shortcomings [3], [8]. Empirical analysis confirms that delayed worker payments exert the most significant impact on schedule deviations, strongly correlating with diminished labor productivity ($r = 0.861$) [27], [29]. Stakeholder perception analysis reveals divergent risk prioritizations: contractors emphasize coordination gaps, owners highlight financial constraints, and consultants focus on technical rework [15], [17], [21]. The research advances beyond traditional delay identification by proposing a role-based mitigation framework that integrates proactive cash flow management, formalized change control, and structured communication infrastructure [1], [26]. Implementing escrow payment mechanisms, retention guarantees, and digital collaboration platforms significantly enhances project liquidity and schedule adherence [14], [21]. Limitations include the localized context of a single high-rise development and reliance on self-reported stakeholder perceptions [9], [10]. Future research expands the analytical scope to multi-project portfolios, incorporates longitudinal financial tracking, and evaluates the quantitative impact of BIM and AI-driven scheduling tools on delay mitigation [21], [23]. The findings provide actionable insights for construction managers, owners, and consultants seeking to optimize time control, enhance stakeholder alignment, and minimize schedule deviations in complex residential developments [1], [2], [22].

CONFLICTS OF INTEREST

The author(s) declare(s) that there is no conflict of interest concerning the publishing of this paper.

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APPENDIX 1

TABLE 1 Respondent Demographics by Stakeholder Group and Work Experience

Stakeholder Group	n	%	Position Distribution	Experience (Years)
Contractor	46	85.2	Site Manager (4), Engineer (8), QC/QS (6), Field Staff (28)	0–5: 30; 6–10: 14; >10: 2
Consultant	6	11.1	Design Engineer (3), Project Consultant (3)	0–5: 2; 6–10: 3; >10: 1
Owner	2	3.7	Project Director (2)	>10: 2
Total	54	100		

(Source: Authors' analysis, 2025)

Note: Data collected via structured questionnaire; Likert scale 1–4 (no neutral option) to reduce central tendency bias [28], [29].

TABLE 2 Instrument Reliability and Validity Test Results

Test Type	Metric	Threshold	Result	Interpretation
Reliability	Cronbach's Alpha	> 0.60 [29]	**0.949**	Excellent internal consistency
Validity	Corrected Item-Total Correlation	> 0.2681 (α=0.05) [28]	All 33 items > 0.2681	All variables valid
Sample Adequacy	Respondents per Variable	≥ 5:1 recommended	54:33 (1.64:1)	Acceptable for exploratory analysis [27]

(Source: Authors' analysis, 2025)

Note: Validity threshold calculated using r-table for n=54 at 5% significance level [28].

TABLE 3 Top 10 Delay Factors by Mean Score Ranking (N=54)

Rank	Code	Variable Description	Category	Mean Score	Std. Dev.
1	D7	Delay in payment/salaries to workers	Finance	15.50	4.40
2	D4	Rework due to design changes or errors	Technical	14.25	3.85
3	C2	Poor communication between stakeholders	Coordination	13.80	4.12
4	E5	Slow evaluation process for work progress	Coordination	13.45	3.90
5	E4	Work requiring correction due to defects	Technical	13.20	4.05
6	A1	An overly tight schedule was imposed by the owner	Management	12.95	3.75
7	F3	Labor strikes or workforce unavailability	Manpower	12.70	4.20
8	D2	Shortage of construction materials/equipment	Technical	12.55	3.65
9	E3	Delayed approval of permits or drawings	Coordination	12.40	3.95
10	C6	Subcontractor performance delays	Coordination	12.15	4.00

(Source: Authors' analysis, 2025)

Note: Mean scores derived from 4-point Likert scale (1=Strongly Disagree to 4=Strongly Agree); higher scores indicate greater perceived impact [27]. Categories aligned with PMBOK Schedule Performance Domain [1].

TABLE 4 Stakeholder Perception Divergence on Top Delay Factors

Delay Factor	Contractor Rank (n=46)	Owner Rank (n=2)	Consultant Rank (n=6)	Perception Gap
Payment delays (D7)	2	1	3	High – Owners prioritize financial constraints
Design rework (D4)	3	4	1	High – Consultants emphasize technical quality
Communication gaps (C2)	1	3	2	Moderate – Contractors feel coordination burden
Slow approvals (E3)	5	2	4	Moderate – Owners control decision timelines
Labor productivity (D5)	4	5	2	Low – All groups recognize workforce impact

(Source: Authors' analysis, 2025)

Note: Ranks based on mean scores within each stakeholder subgroup; perception gaps indicate need for role-specific mitigation strategies [15], [17].

TABLE 5 Spearman Rank Correlation: Payment Delays vs. Labor Productivity

Variable Pair	Spearman's ρ	p-value	Interpretation	Practical Implication
D7 (Payment delay) ↔ D5 (Low productivity)	0.861	<0.001	Very strong positive correlation [29]	Delayed wages directly reduce field efficiency
D7 ↔ E4 (Rework due to defects)	0.742	<0.001	Strong correlation	Financial stress compromises quality control
C2 (Poor communication) ↔ E3 (Slow approvals)	0.698	<0.001	Moderate-strong correlation	Coordination failures cascade into approval bottlenecks
D4 (Design changes) ↔ E4 (Rework)	0.815	<0.001	Very strong correlation	Technical revisions drive rework cycles

(*Source: Authors' analysis, 2025)*

Note: Correlation strength guidelines: 0.00–0.19 (very weak), 0.20–0.39 (weak), 0.40–0.59 (moderate), 0.60–0.79 (strong), 0.80–1.00 (very strong) [29].

TABLE 6 Delay Factors Mapped to PMBOK Project Management Knowledge Areas

PMBOK Knowledge Area	Relevant Delay Variables	Mean Score (Area)	Strategic Mitigation Focus
Project Cost Management	D7, D2, F3	**9.01**	Escrow accounts, advance payment guarantees, retention bonds [14], [26]
Project Schedule Management	A1, E3, E5, C6	8.75	Critical path monitoring, buffer allocation, digital scheduling tools
Project Communications Management	C2, E3, C6	8.40	FIDIC-certified communication protocols, BIM collaboration platforms [21], [26]
Project Quality Management	D4, E4	7.95	Early contractor involvement, BIM clash detection, formal change orders
Project Risk Management	F5, D7, C2	7.60	Proactive risk registers, contingency budgeting, stakeholder alignment workshops
Project Procurement Management	D2, C6	7.20	Pre-qualified supplier lists, performance-based subcontracting

(*Source: Adapted from PMI [1]; Authors' analysis, 2025)*

Note: Area mean scores calculated as average of constituent variable means; highest priority area = Project Cost Management, confirming financial bottlenecks as root cause [11], [13].

APPENDIX 2

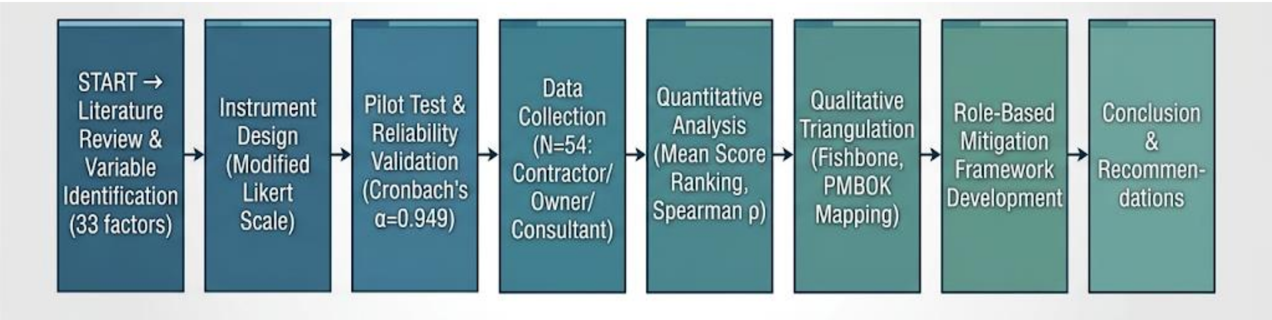

FIGURE 1 Research Methodology Flow Diagram

(Source: Authors, 2025)

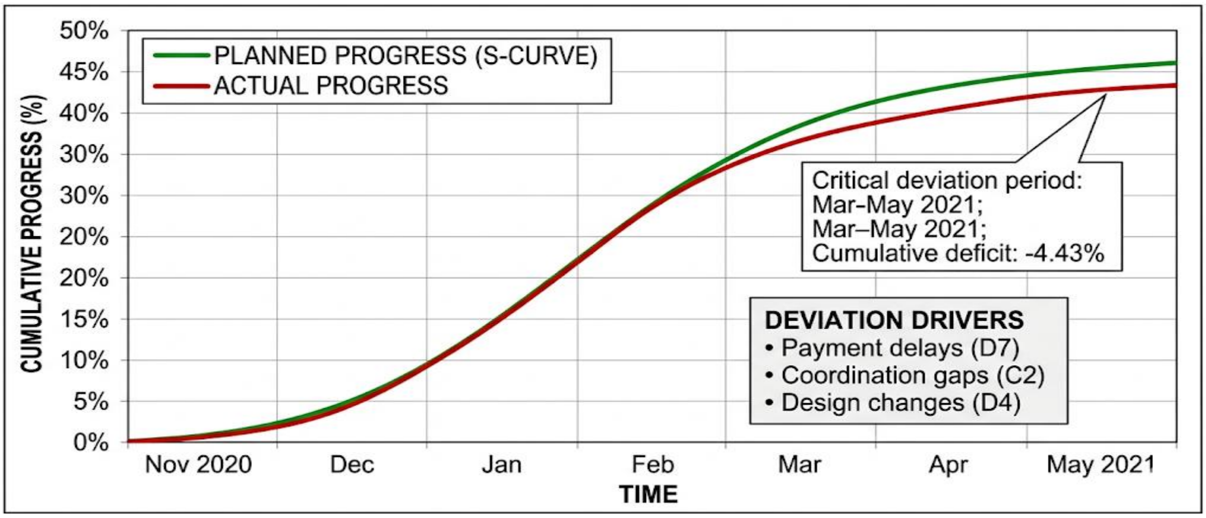

FIGURE 2 **S-Curve Analysis: Planned vs. Actual Progress (Nov 2020–May 2021)**
(Source: Project documentation; Authors' analysis, 2025)

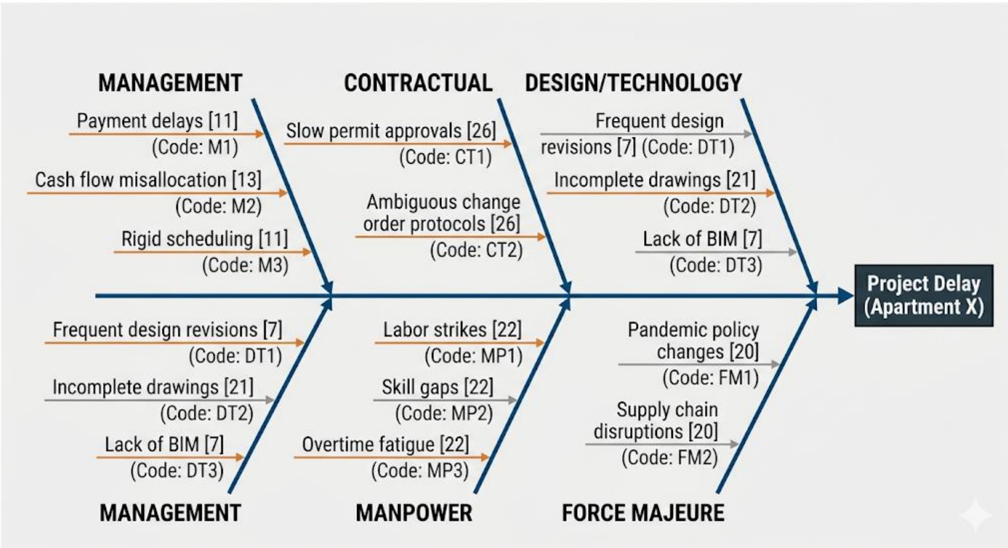

FIGURE 3 **Fishbone (Cause-Effect) Diagram: Root Causes of Project Delays**
(Source: Authors' analysis, 2025)

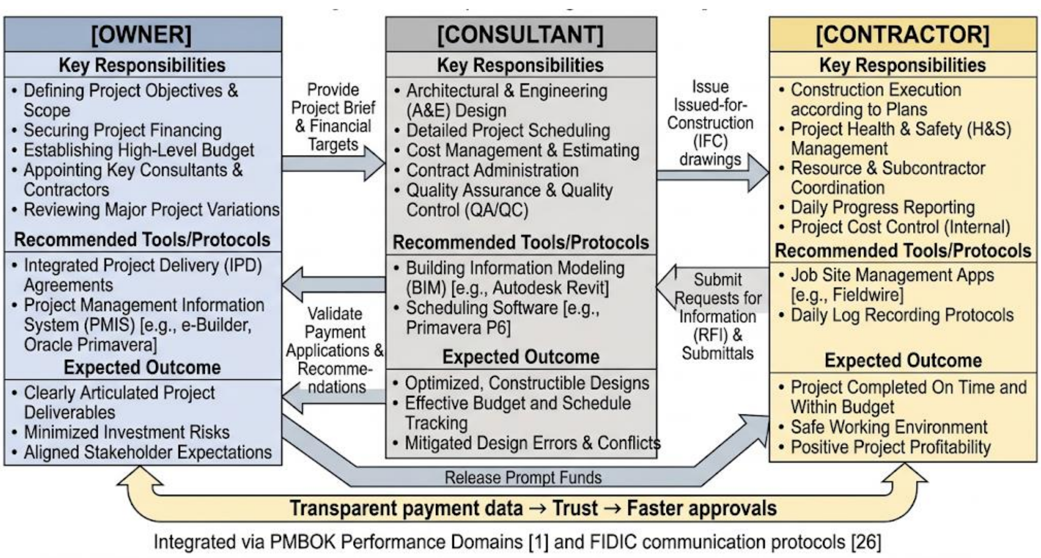

FIGURE 4 **Role-Based Mitigation Framework for Delay Prevention**
(Source: Authors' synthesis, 2025)

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