The Spirit of Society Journal
International Journal of Society Development and Engagement
LPPM - Universitas Narotama
ISSN : 2594 - 4777 (Online)
2597 - 4742 (Print)
https://jurnal.narotama.ac.id/index.php/scj/index

Analysis of Factors Causing Delays in the Implementation of the 500 L/D Water Treatment Plant Project in Duriangkang, Batam

Denok Suhartini[1], Adi Prawito[1], Koespiadi[1]

[1] Department of Civil Engineering, Narotama University Surabaya, Indonesia
Corresponding author: denokje@gmail.com

Abstract: Batam Development Authority has initiated the construction of a new Water Treatment Plant (WTP) at the Duriangkang Reservoir with a production capacity of 500 liters per second. The project aims to address the increasing demand for clean water driven by rapid population growth, urban expansion, and industrial development. However, the project has experienced implementation delays, prompting the need to identify the main contributing factors, determine the most dominant factor, and propose solutions to mitigate future delays. Using a mixed-methods approach, this study combines qualitative and quantitative analysis through a descriptive–analytical survey method. Data were collected using questionnaires distributed to project stakeholders, including the project owner, supervising consultants, contractors, and relevant government agencies. The findings indicate that financial constraints are the most dominant factor influencing project delays, with a T-Statistic of 3.256 and a P-Value of 0.001. Other important factors include managerial issues, material shortages, and labor availability, while equipment availability is found to have no significant impact. Statistical analysis using SmartPLS 4 confirms the reliability and validity of the constructs, with financial, material, and managerial aspects playing a particularly important role in project implementation. This study provides a theoretical contribution to the body of knowledge on construction project management and offers practical insights for government institutions and stakeholders in mitigating delays in future infrastructure projects.

Keywords: project delays; water treatment plant; construction management; finance; infrastructure development

INTRODUCTION

Construction projects are activities carried out within a limited period of time by utilizing predetermined resources and costs to produce buildings or infrastructure. The implementation of a construction project involves service providers (contractors and consultants) and the project owner, who are bound by a work agreement commonly referred to as a contract. In the construction industry, delays in project implementation are frequently encountered and are often reported as a major source of conflict that affects various stakeholders involved in the project. Such delays generally result in financial losses for both project owners and contractors.

In recent years, many construction projects in Riau Islands Province have experienced significant delays, leading to sanctions against service providers due to negligence. The main factors contributing to these delays include poor project management, inexperienced labor, and insufficient financial capital. According to Triarman, the main causes of delays in structural works of construction projects include incorrect reinforcement specifications, poor material quality, inadequate knowledge of material properties, and technical errors. Similarly, Anna identified ten major factors causing delays in construction projects in Manokwari, including labor shortages, limited material availability, equipment failures, unfavorable site conditions, delays in wage payments, and issues related to project intensity.

Delays remain a critical concern at both the planning and implementation stages of a project. Therefore, further research and analysis are needed to identify the key factors contributing to delays in construction projects. This study focuses on analyzing the factors that cause delays in the construction of the 500 L/s Water Treatment Plant (WTP) in Duriangkang, Batam, Riau Islands Province.

According to Soeharto, a project is a temporary activity carried out within a limited period, utilizing specific resources, and aimed at achieving clearly defined objectives. Project management is the process of planning and organizing the factors that influence project success. The functions of project management follow a logical sequence, indicating that managerial actions are directed toward achieving predetermined objectives. The process begins with setting objectives, followed by planning, organizing, implementation, and control, while utilizing available resources efficiently and effectively. Delays in construction projects refer to extensions of completion time beyond the planned schedule as stated in the contract. For service providers in particular, delays result in time overruns that reduce the expected profit for the contractor handling the project. Consequently, the planned development program fails to achieve its intended targets. Delays may also be caused by environmental factors, unavailability of land at the project site, poor project management, and human resource errors.

The present study is delimited to the 500 L/s Water Treatment Plant (WTP) project located in Duriangkang, Batam City, Riau Islands Province. Within this context, the analysis concentrates on the specific technical and managerial conditions surrounding this single infrastructure project, rather than attempting to generalize across all water treatment facilities in the region. By focusing on one ongoing project with clearly defined design capacity and implementation timeline, the research is able to examine project delays in greater depth and detail, particularly in relation to local institutional, financial, and operational constraints.

In terms of research subjects, the investigation is restricted to medium-scale contractors engaged in the WTP project. This limitation is important because medium-scale firms often face different resource, financing, and management challenges compared to large national contractors or small local firms. By narrowing the analysis to this contractor category, the study aims to capture the specific characteristics of delay factors that typically arise in projects handled by medium-scale companies, such as constraints in cash flow, equipment ownership, and experience in managing complex infrastructure works.

Furthermore, the institutional scope of the research includes only the key stakeholders directly involved in the planning and implementation of the 500 L/s WTP in Duriangkang during the 2024 fiscal year. These stakeholders comprise the project owner, supervising consultants, contractors, the Ministry of Public Works and Public Housing (PUPR), and other relevant government agencies. By limiting the population to formally mandated actors within the project governance structure, the study ensures that the data collected—particularly through questionnaires and documentation—reflects official perspectives, responsibilities, and decision-making processes that influence project timelines. This clearly defined scope is expected to enhance the internal validity of the findings while providing practically relevant insights for similar government-funded water infrastructure projects in Indonesia.

METHODS

This study adopts a mixed-methods design, combining quantitative and qualitative approaches within a descriptive–analytical survey framework. The primary emphasis is placed on quantitative analysis, while qualitative insights are used to contextualize and interpret the statistical findings. The mixed-methods approach is considered appropriate because delays in construction projects involve both measurable factors (such as financial performance, material availability, and labor capacity) and contextual conditions (such as managerial practices and institutional arrangements) that cannot be fully captured by numerical data alone. The descriptive–analytical survey method enables the researchers to systematically describe the current conditions of the project and to analyze relationships between the identified factors and the occurrence of delays.

Research Object and Setting

The empirical setting of this research is the 500 L/s Water Treatment Plant (WTP) project located in Duriangkang, Batam City, Riau Islands Province. The project was selected as the research object because it represents a strategic public infrastructure investment intended to meet the growing demand for clean water in an industrial and rapidly urbanizing area. The study covers the implementation period within the 2023–2024 fiscal years, during which critical phases of construction and project management activities took place. Focusing on a single, ongoing WTP project allows for an in-depth investigation of the specific technical, financial, and managerial factors that contribute to schedule delays in a real-world context.

Data Collection Methods

Data collection in this study consists of two main components: a literature study and a field study. The combination of both methods is intended to ensure that the research is grounded in established theoretical frameworks while also reflecting empirical realities.

Literature Study

The literature study was conducted to identify relevant theories, concepts, and previous research findings related to project delay, construction management, and risk factors in infrastructure projects. Academic journals, conference proceedings, textbooks, technical standards, and government regulations were systematically reviewed to construct the conceptual framework and to develop the research hypotheses and indicators. This stage also informed the operationalization of variables such as labor, materials, equipment, finance, and managerial aspects into measurable questionnaire items, thereby enhancing the validity and reliability of the research instrument.

Field Study

The field study was carried out directly on the 500 L/s WTP project in Duriangkang and served as the main source of primary data. It comprised several steps:

a. Questionnaire Preparation

A structured questionnaire was designed to capture respondents' perceptions of the factors that contribute to project delays. The questionnaire consisted of closed-ended items using a Likert-type scale to measure the intensity of agreement with statements related to labor, material supply, equipment, financial management, and managerial practices. The items were derived from the literature review and adjusted to the specific context of water treatment plant construction. A preliminary review and refinement of the questionnaire were conducted to ensure clarity, relevance, and ease of understanding for practitioners.

b. Questionnaire Distribution

The finalized questionnaire was distributed electronically using online communication platforms such as WhatsApp groups and professional networks. The target respondents included project managers, site managers, supervising consultants, team leaders, supervisors, officials from the Ministry of Public Works and Public Housing (PUPR), personnel from BP Batam, and representatives of medium-scale contractors involved in the project. This purposive sampling strategy was adopted to ensure that the data were obtained from individuals who possess direct knowledge and experience of the WTP project's implementation. The use of digital distribution channels increased accessibility and response rates while reducing time and logistical constraints.

c. Data Processing and Analysis

Completed questionnaires were checked for completeness and consistency before being entered into a database for analysis. Data processing began with coding and tabulation of responses, followed by preliminary descriptive statistics to summarize respondent characteristics and general patterns in the data. Subsequent analytical steps included validity and reliability testing of the measurement scales to confirm that the indicators adequately represent the underlying constructs. The overall data processing procedure was designed to produce robust, interpretable results that support evidence-based conclusions and recommendations.

Research Model and Analytical Technique

The research model is constructed based on the existing workflow system and organizational structure applied by the contracting company in managing the WTP project. The model conceptualizes project delay as a dependent latent variable influenced by several independent latent variables, namely labor (TK), materials (MT), equipment (Alat), finance (FIN), and managerial aspects (MAN). Each latent variable is operationalized through a set of observed indicators derived from the literature and adapted to the project context.

To evaluate the relationships within this model, the study employs Structural Equation Modeling (SEM) using the Partial Least Squares (PLS) approach, implemented with SmartPLS 4 software. This technique is selected because it is well suited for complex models with multiple latent variables, relatively small to moderate sample sizes, and non-normal data distributions, which are common in construction management research. The analytical procedure includes assessment of the measurement model (convergent and discriminant validity, reliability) and the structural model (path coefficients, t-statistics, and coefficient of determination). Through this approach, the study is able to quantify the magnitude and significance of the effects of labor, materials, equipment, finance, and managerial factors on project delays, thereby providing a rigorous empirical basis for identifying the most critical sources of delay in the WTP project.

RESULT AND DISCUSSION

Research Results

Indicators and variables contributing to delays in the Water Treatment Plant (WTP) project are presented in Table 1.

Table 1 shows the indicators and variables causing delays in the Water Treatment Plan (WTP) project.

No	Variable	Indicator	Code
1	Labor (TK)	a. Worker knowledge b. Labor availability	TK.1 TK.2
2	Material (MAT)	a. Material delivery b. Material availability	MAT.1 MAT.2
3	Equipment (P)	a. Equipment quality b. Equipment availability	P.1 P.2
4	Finance (FIN)	a. Payments by the owner b. Inflation	FIN.1 FIN.2
5	Managerial (MAN)	a. Errors in work procedures b. Changes in working time by the contractor	MAN.1 MAN.2
6	WTP Delay Factors (FK)	a. Work start delayed by more than 14 days b. Weekly progress deviation minus more than 10%	FK.1 FK.2

After identifying the indicators and variables related to project delays, the next step was to distribute the questionnaires. The questionnaire responses were measured using a Likert scale. According to Anwar, the Likert scale is a method used to measure attitudes based on statements, using the distribution of responses to determine values in the study across five response categories:

1. Strongly Disagree (1): when respondents strongly disagree with the statement.
2. Disagree (2): when respondents disagree with the statement.
3. Neutral (3): when respondents are uncertain.
4. Agree (4): when respondents agree with the statement.
5. Strongly Agree (5): when respondents strongly agree with the statement.

The questionnaire was distributed to 130 respondents consisting of owners, contractors and consultants, as shown in the image below.

Population and Sample/Respondents

Respondent	Position	Number
Owner	PPK	4
	PPTK	1
	Technical Team	9
Contractor	Project Manager	19
	Site Manager	18
	Executive	12
	Quality	8
	Engineering Administration	13
Consultan	Engineer Supervision (SE)	12
	Inspector/Supervisor	10
	Quality Control	11
	Quantity	7
	Engineering Administration	6
Total Number of Respondent = 130 people		

Figure 1. Population and Sample/Respondents

The list of questions and the results of the distributed questionnaires are presented in Table 2.

Table 2. List of questions and results of the distributed questionnaire

No	Survey Questions	Likert Scale				
		STS (1)	TS (2)	N (3)	S (4)	SS (5)
Labor						
1	Worker knowledge influences project implementation delays	8	1	8	56	53
2	Labor availability influences project implementation delays	8	1	5	35	78
Material						
1	Material delivery influences project implementation delays	9	1	11	44	62
2	Material availability influences project implementation delays	9	0	6	37	73
Equipment						
1	Equipment quality influences project implementation delays	7	7	20	55	38
2	Equipment availability influences project implementation delays	8	2	15	47	54
Financial						
1	Payments by the owner influence project implementation delays	5	7	22	31	62
2	Inflation influences project implementation delays	3	18	45	35	26

Managerial						
1	Errors in procedures influence project implementation delays	7	7	6	36	71
2	Changes in working time by contractor during implementation influence project implementation delays	7	10	17	57	36
WTP Project Delays						
1	Work start delayed by more than 14 working days	2	4	24	11	11
2	Weekly progress deviation minus more than 10 percent	8	14	43	41	21

Legend:
STS = Strongly Disagree (Sangat Tidak Setuju)
TS = Disagree (Tidak Setuju)
N = Neutral
S = Agree (Setuju)
SS = Strongly Agree (Sangat Setuju)

After collecting the responses from 130 respondents, the next step was to analyze the data using SmartPLS 4.

Data Analysis Process:

1. **Input data**

   Input data and create constructs in the Smart PLS v.4.09 program, as shown in the figures below:

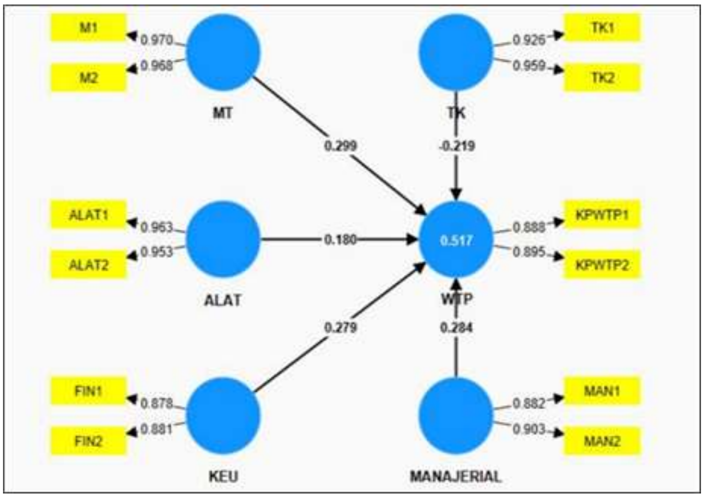

Figure 2: Results of the PLS-Sem Algorithm

2. **Validity Test**

The validity test assesses the extent to which a measurement instrument can accurately and validly measure a construct. An indicator is considered valid if its loading value exceeds 0.70. According to Dimas, the criteria for validity are as follows:

1. If the calculated r ≥ table r, the variable is declared valid.

2. If the calculated r ≤ table r, the variable is declared invalid.

The convergent validity test process can be seen in Figure 3.

(a) (b)

Figure 3. The convergent validity test process

The results of the convergent validity test and discriminant validity (cross-loading) confirm that all constructs meet the required criteria, indicating that each variable is interrelated in influencing project delays. The most dominant factor contributing to project delays is the financial aspect, with a T-Statistic of 3.256 and a P-Value of 0.001. Other important factors include managerial aspects (MAN), material availability (MT), and labor (TK), while equipment (Alat) does not show a significant effect on project delays.

3. Path Coefficients

The path coefficient results (as shown in Figure 4) highlight the relationships between latent variables and their impact on project delays. Finance (FIN) has a significant effect on project delays, with a coefficient of 0.279 (p = 0.001), making it the most critical factor. Material (MT) follows with a coefficient of 0.299 (p = 0.017), indicating a substantial impact. Managerial aspects (MAN) also play an important role, with a coefficient of 0.284 (p = 0.024). Labor (TK) shows a significant negative effect on delays, with a coefficient of -0.219 (p = 0.044). However, equipment (Alat) is not a significant factor, with a coefficient of 0.180 (p = 0.109). Thus, finance is the most influential factor, followed by material, managerial aspects, and labor.

Figure 4. Relationship between Variables

4. Reliability Test

The reliability test measures the reliability of the questionnaire, namely the consistency of the results when used repeatedly. According to Mayggie (2011), the purpose of the reliability test is to assess the dependability (reliability) of the questionnaire instrument. The results of the reliability test can be seen in Figure 5 .

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ALAT	0.912	0.921	0.957	0.918
KEU	0.708	0.708	0.872	0.774
MANAJERIAL	0.745	0.749	0.887	0.797
MT	0.935	0.936	0.968	0.939
TK	0.877	0.929	0.941	0.888
WTP	0.743	0.743	0.886	0.795

Figure 5. Reliability test results

Reliability and validity analysis of the constructs using Cronbach's Alpha (≥ 0.7), Composite Reliability (≥ 0.7), and Average Variance Extracted (AVE ≥ 0.5) confirms that all constructs are valid and reliable. This indicates that the indicators effectively represent their respective variables. Among the constructs, Material (MT) shows the highest reliability and validity, with a Composite Reliability of 0.968 and an AVE of 0.939, making it the most significant variable in the research model.

5. Structural Equation Modeling (SEM) Analysis with SmartPLS 4

The Structural Equation Modeling (SEM) developed using SmartPLS 4 illustrates the relationships between latent variables with an R-Square (R^2) value. The results of Structural Equation modeling (SEM) analysis with Smart PLS 4 can be seen in Figure 6

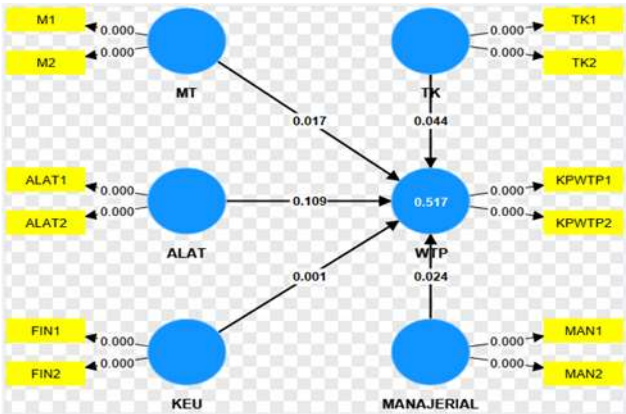

Figure 6. 5.Structural Equation Modeling (SEM)

The R^2 value of 0.517 indicates that the variables Finance (FIN), Managerial (MAN), Material (MT), Labor (TK), and Equipment (Alat) collectively explain 51.7% of the variation in WTP project delays, while the remaining 48.3% is influenced by other factors outside the model. Although equipment has a relatively large effect on project delays, it is not statistically significant. Relationships with P-values less than 0.05 are considered significant in the model. The results show that Finance (FIN) is the most dominant factor contributing to project delays, while Material (MT), Managerial (MAN), and Labor (TK) also have significant impacts. Equipment, however, does not show a significant effect in this model despite its relatively large influence.

CONCLUSION

The findings of this study indicate that delays in the Water Treatment Plant (WTP) project are primarily driven by four key factors: labor, materials, finance, and managerial aspects, all of which exert a statistically significant influence, whereas equipment does not show a significant effect on schedule performance. This is supported by the statistical results, which show that equipment has no significant impact on project delay ($t = 1.604 < 1.96$), while finance ($t = 3.256 > 1.96$), managerial aspects ($t = 2.258 > 1.96$), materials ($t = 2.380 > 1.96$), and labor ($t = 2.011 > 1.96$) each exhibit significant relationships with delay outcomes.

Among these, the financial factor emerges as the most dominant determinant of project delays, with a T-Statistic of 3.256 and a P-Value of 0.001, highlighting the critical role of payment flows and funding reliability in sustaining construction progress. Delays in payments from project owners to contractors, suppliers, and other stakeholders have the potential to disrupt cash flow, slow down procurement and site activities, and eventually prolong the overall project duration in both public and private sector projects. Consequently, effective financial management and the assurance of timely disbursement of funds are essential prerequisites for maintaining smooth and continuous project implementation.

In practical terms, the results suggest that efforts to reduce delays in similar infrastructure projects should prioritize targeted interventions in labor, material management, managerial capacity, and financial governance. Recommended measures include recruiting competent and adequately trained workers, coupled with incentive schemes to enhance productivity; ensuring timely procurement and quality control of materials to minimize rework and waiting time; and strengthening leadership, communication, and planning and decision-making skills within project management teams. From a financial perspective, careful cash-flow planning and alignment of budget allocations with project schedules are necessary to prevent funding bottlenecks. Although equipment was not found to be a statistically significant factor in this case, maintaining appropriate and well-functioning machinery remains important to avoid potential operational disturbances that could exacerbate existing delays. Together, these strategies provide a practical framework for stakeholders seeking to mitigate schedule overruns in future water infrastructure developments.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Narotama University Surabaya, the Batam Development Authority (BP Batam), and all project stakeholders, including the Ministry of Public Works and Public Housing (PUPR), for their support and contributions to this research.

REFERENCES

Anwar, S., Tistogondo, J. & Wulandari, D.A.R. 2023, 'Analisis pengendalian waktu pekerjaan proyek dengan menggunakan metode fast-track', Ge-STRAM J. Perenc. dan Rekayasa Sipil, vol. 6, September, pp. 100–105, viewed 19 February 2026, https://doi.org/10.25139/jprs.v6i2.6247.

Bedje, M.R., Kantor, S., Unsrat, P., Sompie, B.F. & Tarore, H. 2012, 'Analisis pengaruh pengendalian kualitas pelaksanaan proyek dermaga milik pemerintah di Sulawesi Utara', J. Ilm. MEDIA Eng., vol. 2, no. 4, pp. 238–246.

Dimas Adhitya Putra, Oryza Lhara Sari & Raftonado Situmorang 2023, 'Analisis faktor keterlambatan proyek konstruksi di Kota Balikpapan', J. Tek. Sipil Ranc. Bangun, vol. 9, no. 1, pp. 17–24, doi: 10.33506/rb.v9i1.2044.

Langlang, H., Putra, B. & Simanjuntak, M.R.A. 2021, 'Kajian faktor-faktor pengendalian waktu pada bangunan gedung bertingkat di proyek kampus Universitas Islam Internasional Indonesia', Pros. CEEDRiMS 2021 Inov. Teknol. dan Mater. Terbarukan Menuju Infrastruktur yang Aman Terhadap Bencana dan Ramah Lingkung, no. 978-602-361-385-4, pp. 255–261.

Malir, A.M.A., Sudarwadi, D. & Saptomo, Y.H. 2019, 'Faktor-faktor penyebab keterlambatan pelaksanaan pekerjaan proyek konstruksi di Kabupaten Manokwari (Studi kasus: PT. Jabez Perkasa)', Cakrawala Manag. Bus. J., vol. 1, no. 1, p. 152, doi: 10.30862/cm-bj.v1i1.10.

Massie, M., Manoppo, F.J. & Dundu, A.K.T. 2022, 'Studi penerapan pengendalian waktu, biaya, dan mutu pelaksanaan proyek Boulevard Pantai Amurang Kabupaten Minahasa Selatan', J. Ilm. Media Eng., vol. 12, no. 1, pp. 2087–9334.

Nabut, Y.V. et al. n.d., 'Analisa faktor-faktor yang paling dominan penyebab keterlambatan proyek', pp. 1–9.

Soeharto 2013, 'Pengendalian waktu dan biaya pekerjaan konstruksi sebagai dampak dari perubahan desain (Studi kasus Embung Irigasi Oenaem, Kecamatan Biboki Selatan, Kabupaten)', J. Tek. Sipil, Univ. Nusa Cendana Kupang, vol. II, no. 2, pp. 121–132, viewed 19 February 2026, http://jurnalmanajemen.petra.ac.id/index.php/jurnal-teknik-sipil/article/view/18950.

Triarman, C. & Sekarsari, J. 2018, 'Analisis faktor penyebab keterlambatan waktu pada pekerjaan struktur atas proyek konstruksi', J. Penelit. Dan Karya Ilm. Lemb. Penelit. Univ. Trisakti, vol. 3, no. 2, pp. 1–9, doi: 10.25105/pdk.v3i2.2980.

Wirabakti, D.M., Abdullah, R. & Maddeppungeng, A. 2014, 'Studi faktor-faktor penyebab keterlambatan proyek konstruksi bangunan gedung', J. Konstr., vol. 6, no. 1, pp. 15–29.