Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AN15.20250515
Published: February 18, 2025

Factors Influencing the Delays in Execution and Implementation of Road Infrastructure Projects Supervised by DPWH Isabela 4th District Engineering Office

Jean Kyle L. Tuason
Office of the District Engineer – Procurement Unit
Department of Public Works and Highways, Isabela Fourth District Engineering Office,
Quezon, San Isidro, Isabela, 3310, PHILIPPINES and
Graduate School, Polytechnic University of the Philippines, Manila 1016, Philippines

Joselinda M. Golpeo
Graduate School
Polytechnic University of the Philippines, Manila 1016, Philippines

Abstract

This study examined the variables that contributed to project delays, including endogenous and exogenous factors, specifically the road infrastructure projects supervised by the Department of Public Works and Highways Isabela 4th District Engineering Office. It aimed to provide valuable insights for the creation of mitigation plans intended to reduce delays in road construction projects. The paper utilized a qualitative research methodology, collecting data from project managers, engineers, and inspectors through quantitative questionnaires. It employed rank correlation and severity indexes to analyze the data and identified 46 potential causes of delay for endogenous factors and 7 potential causes of delay for exogenous factors. The top 3 endogenous factors were (1) Insufficient laborers, (2) Shortage of equipment, and (3) Low labor productivity, and the top 2 exogenous factors were (1) Weather conditions and (2) Political Situation. The survey revealed a moderate level of agreement (51.07%) between the implementing office and contractors regarding endogenous factors. There were no correlation (57.14%) amongst the exogenous factors. The recommendations included developing comprehensive plans and schedules for both wet and dry seasons, ensuring adequate personnel, improving equipment management, enhancing worker productivity, conducting thorough surveys, and complying with all legal and regulatory requirements in restricted areas.

Keywords

Exogenous delay factors, endogenous delay factors, severity index, insufficient laborers, road infrastructure projects, DPWH

1. Introduction

By establishing essential transportation links between regions, road construction plays a significant role in the development of road networks in a municipality and a city. The government have increased budget allocations for road infrastructure projects, thus prioritizing the "Build! Build! Build!" program. This initiative was initiated by the previous Duterte administration and is presently being implemented by President Marcos Jr.

One of the six congressional districts of the Philippines is the province of Isabela. The 4th Congressional District of Isabela has representatives in the House of Representatives since 1987. It includes the independent City of Santiago and the municipalities of Cordon, Dinapigue, Jones, and San Agustin. Moreover, the Department of Public Works and Highways Isabela 4th District Engineering Office, which is responsible for road construction and maintenance in the district, oversees the Isabela 6th Congressional District. The Isabela 6th Congressional District, represented in the House of Representatives since 2019, comprises the City of Cauayan and the

municipalities of Echague, San Guillermo, and San Isidro. Thus, the 4th District Engineering Office of DPWH Isabela is responsible for both national and local road construction and maintenance in both districts (Wikipedia 2008)

While the district's projects are closely monitored, unforeseen issues and obstacles will inevitably arise during the implementation process. In certain cases, projects may exceed the contract schedule and encounter delays, thereby leading to adverse consequences for the implementing office, contractors, and end users. Toor & Ogunlana (2008) have emphasized that while certain elements specific to the local industry, socioeconomic background, cultural concerns, and project characteristics are common in developing nations, there are also some common reasons for delays. However, it is imperative to acknowledge that the root cause of the delay problem may not always be directly attributed to either the contractor or the implementing office. Various unforeseen circumstances can arise during the construction process, including adverse weather conditions, modifications to the project scope, delays in procuring materials, and complications in obtaining the required permits and approvals. While numerous studies have investigated delay issues, such as financial constraints and technical incompetence, comparatively less attention has been given to other contributing factors that result in delays in government-funded infrastructure projects, particularly those supervised by the DPWH Isabela 4th District Engineering Office.

This paper aims to assess the factors that lead to delays in the construction of road infrastructure projects overseen by the DPWH Isabela 4th District Engineering Office, from the viewpoint of the implementing office and contractors. The findings of this study will serve as a basis for developing mitigation strategies.

2. Methodology

a) Questionnaire Design

The study used a mixed method of research design. This study utilized a qualitative research methodology to comprehensively comprehend and interpret the level of impact of the factors influencing the delay in the implementation of road infrastructure projects supervised by the DPWH Isabela 4th District Engineering. The quantitative questionnaires were used as data collection tools. These questionnaires have been specifically crafted to collect structured and quantifiable data, such as the severity of the delay factors. Quantitative questionnaires enable the acquisition of numerical data, which can be subjected to statistical analysis to identify patterns and trends. This research aimed to determine the factors that influence how slowly road infrastructure projects under the control of the DPWH Isabela 4th District Engineering Office are implemented.

Final changes were made to the questionnaire to ensure that it successfully captures a wide range of information about the causes of delays in road infrastructure projects. The questionnaire used in this study was based on relevant research completed (Soumphonphakdy et al, 2000; Mahamid, 2012). Consultations were undertaken with highly experienced licensed civil engineers with over a decade of expertise in road infrastructure projects. The customized questionnaire identified 53 probable causes: 46 endogenous factors and 7 exogenous factors, as shown in Table 1. The questionnaire's structure was intended to consist of two primary sections. Part 1 includes the personal information of the respondents, including their roles and other pertinent details. Part 2 covers the respondents' experiences working in the construction industry. The identified causes of road infrastructure project delays are listed below. A question about the severity of each cause's impact on project delay was raised. There were six levels of severity identified: level 0 marked no influence, level 1 low, level 2 low, level 3 moderate, level 4 high, and level 5 extremely high. As part of the data collection process, the researcher reviewed documents. The document examination will reveal important information about the causes of delays.

Table 1. List of Possible Delay Causes

Factor	Cause
Endogenous Factors	1. Low project bid price
	2. Construction area restricted
	3. Inconvenient site access
	4. Poor ground conditions
	5. Poor soil quality
	6. Poor terrain conditions
	7. Delayed payment by owner
	8. Delayed decision by owner
	9. Coordination between owner and contractor
	10. Unreasonable project timeframe
	11. Financial issues related to owner

	12. Project delayed by owner
	13. Delayed approval of materials
	14. Not well-defined scope of work
	15. Delayed land expropriation by owner
	16. Change order from owner during construction
	17. Late issue of approval documents by owner
	18. Unclear assignment of responsibility near province boundaries
	19. Difficulties in financing project by contractor
	20. Poor communication between contractor and other parties
	21. Conflict between contractor and other parties
	22. Poor resource management
	23. Necessity to re-do work due to contractor failings
	24. Ineffective planning management by contractor
	25. Insufficiently skilled technical staff
	26. Insufficient equipment and vehicles for the work
	27. Poor quality control
	28. Improper construction method
	29. Contractor cash flow
	30. Consultant too lenient
	31. Poor coordination between the consultant and contractor(s)
	32. Delay in implementing inspection by consultant
	33. Poorly qualified inspector
	34. Insufficient inspectors
	35. Delayed design work
	36. Mistakes in design
	37. Inappropriate design
	38. Low labor productivity
	39. Insufficiently skilled equipment operator
	40. Insufficient laborers
	41. Personal conflict between laborers and management team
	42. Personal conflict among laborers
	43. Lack of equipment efficiency
	44. Shortage of equipment
	45. Changes in material types and specifications during construction
	46. Shortage in materials
Exogenous Factors	47. Political situation
	48. Exchange rate fluctuation under contract
	49. Change in loans policy by bank
	50. Weather conditions
	51. Monopoly market
	52. Oil price increase
	53. Public events

Table 1 divides the causes of the delay into two categories: endogenous variables and exogenous variables (Mahamid 2012).

The study collected data from different groups of respondents, via Google Forms online and survey sheets including DPWH Isabela 4th District Engineering Office 13 project engineers, 22 project inspectors/resident engineers, 4 material engineers, and 10 materials-in-charge of the implementing office and 4 project managers, 2 project engineers, 6 site engineers, and 1 material engineer from the contractors.

b) Data Analysis

i. **Severity Index**. A formula was developed to rank causes of delay based on the severity reported by respondents. (Mahamid, 2017)

$$Severity\ Index\ (\%) = \sum a\ \left(\frac{n}{N}\right) * 100/5$$

Where a is the weight allocated to each response (ranging from 1 for no influence on 5 for extremely high), *n* is the frequency of the responses, and N is the total number of responses.

ii. **Group Severity Index.** A formula for calculating the average severity index of the causes in each group (Mahamid, 2012)

$$Group\ Severity\ Index\ (\%) = \sum_{i=1}^{n} Xi/n$$

Where Xi is the severity index of cause in the group and n is the total number of causes in the group.

As a result, when every participant responded that a certain cause had no influence, that cause was given a severity index of 0, which meant that it had no bearing or was not relevant to project delays and was ranked last. On the other hand, if every respondent indicated that it has a very high influence, the severity index would be 100, indicating that this reason is the most important and most relevant of all. The equation was used to determine each cause's severity index based on the contractor's and the office's joint perspective (Soumphonphakdy et al, 2000; Mahamid 2012)

Table 2. Severity Index and Corresponding Impact Level

Severity index (%)	**Impact level**
0	No influence
1-20	Very low
21-40	Low
41-60	Moderate
61-80	High
81-100	Very high

Table 2 displays the potential ranges for the impact level and severity index (Mahamid , 2013; Mahamid 2012; Soumphonphakdy et al, 2000).

Spearman Rank Correlation. The degree of correlation between the implementing office and contractors in terms of the nature of the delays was investigated, contrasted, and evaluated using Spearman rank correlation. Perfect positive correlation ($r_s = +1$) indicates that the two samples score every object equally, whereas perfect negative correlation ($r_s = -1$) indicates a precise inverse relationship between the ranks of the two samples. It can be stated that values of $r_s < r_o$ indicate no correlation, whereas sample estimates of correlation close to unity in magnitude imply excellent correlation. This process involves applying a two-tailed test with a significance level of 0.05 (95% confidence level) to evaluate the null hypothesis. In the event where $r_s > r_o$ where r_o is the Spearman's rank correlation coefficient critical value, the null hypothesis is rejected (Abolelmagd et al, 2023).

iii. $$r_S = 1 - [6 * \sum d^2/(n^3 - n)$$

Where r_s is the Spearman rank correlation coefficient between two parties, d is the difference in ranks assigned to variables for each reason, and n is the number of pairwise ranks (Abolelmagd et al, 2023)

Table 3. Degree of correlation / agreement

r_s	Strength of correlation/agreement
0.00 to 0.30	Negligible
0.30 to 0.50	Weak
0.50 to 0.70	Moderate
0.70 to 0.90	Strong
0.90 to 1.00	Very Strong

The degree of agreement between two populations according to the correlation coefficient's r_s range value is shown in Table 3 (Abolelmagd et al, 2023).

3. Results and Discussion

a) Ranking of Endogenous Factor-Related Delays

The ranking of 46 delay causes under endogenous factors that affect delays in road construction projects managed by the DPWH Isabela 4th District Engineering Office is connected to the severity index results from the joint perspective of the implementing office and contractors from Table 10 and presented in Table 4, respectively. The labor and equipment issues, management and coordination difficulties, design and technical variables, owner-related issues, and interpersonal elements are the main internal aspects that affect the project and its stakeholders.

The most common delay includes (1) insufficient laborers as the most significant delay factor, highlighting labor shortages as a critical issue, (2) shortage of equipment and (3) low labor productivity are also major contributors, (4) construction area restricted as limited working space hampers progress, and (5) coordination issues where problems in coordination between the owner and contractor are prominent. Mid-ranked causes include (6) insufficient equipment and vehicles for the work, where it emphasizes the importance of adequate resources, (7) unreasonable project timeframes, as overly ambitious timelines lead to delays, (8) site access issues where inconvenient access slows down the work, and (9) delayed decisions by the owner and (10) mistakes in design cause disruptions in the construction flow. Lower mid-ranked causes include (11) shortage in materials and (12) improper construction methods also reflect problems with material availability and construction practices; (13) Insufficiently skilled equipment operators and (14) lack of equipment efficiency need for better-trained operators and efficient machinery; (15) financial issues related to the owner; and (16) ineffective planning management by the contractor gives financial instability and poor planning by the contractor are key challenges. Lower-ranked causes include (17, 18, 25, 26) design and material changes where variations during construction and delays in design work are common issues; (19, 20, 32) physical constraints give poor ground conditions and soil quality impact the project's progress; (21, 35, 40) conflicts where conflicts among contractors, laborers, and management create disruptions; and contractor and (22, 23) owner cash flow issues give financial liquidity and affect timely project completion. The factors with the least impact include (30, 39) poor communication and coordination, which though lower-ranked, still contribute to delays, (31) poor quality control and (32) poor terrain conditions also contribute to slow progress, and (46) low project bid price, which ranked lowest and suggested that underbidding is not a major concern in comparison to other factors.

Table 4. Ranking of Endogenous Factor-Related Delays

Causes	Rank
Insufficient laborers	1
Shortage of equipment	2
Low labor productivity	3
Construction area restricted	4
Coordination between owner and contractor	5
Insufficient equipment and vehicles for the work	6
Unreasonable project timeframe	7
Inconvenient site access	8
Delayed decision by owner	9
Mistakes in design	10
Shortage in materials	11
Improper construction method	12
Insufficiently skilled equipment operator	13
Lack of equipment efficiency	14
Financial issues related to owner	15
Ineffective planning management by contractor	16
Changes in material types and specifications during construction	17
Delayed land expropriation by owner	18
Poor ground conditions	19
Poor soil quality	20
Conflict between contractor and other parties	21
Necessity to re-do work due to contractor failings	22
Contractor cash flow	23
Inappropriate design	24
Change order from owner during construction	25
Delayed design work	26
Insufficiently skilled technical staff	27
Project delayed by owner	28
Late issue of approval documents by owner	29
Poor communication between contractor and other parties	30
Poor quality control	31
Poor terrain conditions	32
Not well-defined scope of work	33
Difficulties in financing project by contractor	34
Personal conflict between laborers and management team	35

Delayed approval of materials	36
Poor resource management	37
Delayed payment by owner	38
Poor coordination between the consultant and contractor(s)	39
Personal conflict among laborers	40
Delay in implementing inspection by consultant	41
Consultant too lenient	42
Unclear assignment of responsibility near province boundaries	43
Poorly qualified inspector	44
Insufficient inspectors	45
Low project bid price	46

Table 4 contains the rankings for all 46 causes of project delays in terms of endogenous factors.

b) Ranking of Exogenous Factor-Related Delays

The ranking of seven delay causes under exogenous factors that affect delays in road construction projects managed by the DPWH Isabela 4th District Engineering Office is connected to the severity index results from the joint perspective of the implementing office and contractors from Table 11 and presented in Table 5, respectively. The results are (1) weather conditions being the most significant factor, ranked first, as environmental unpredictability can cause disruptions, which can result in project delays or cancellations, (2) political situation where project schedules may be impacted by political instability or changes that cause uncertainty, alter regulatory frameworks, and cause delays in decision-making processes, (3) monopoly market highlights lack of competition can cause delays and possibly lead to bottlenecks or inefficiencies when one or a small number of firms control the supply of essential resources or services, (4) oil price increase as it can have a direct impact on the cost of operations and logistics, especially for businesses that depend on gasoline, which can lead to delays, (5) exchange rate fluctuation under contract have an impact on the price of imports and exports under current contracts, sometimes causing delays while changes are made, (6) public events such as festivals, strikes, or protests, can disrupt normal operations and logistics, leading to delays, and (7) change in loans policy by bank which could result in funding and execution delays. Examples of these policy changes include adjustments to interest rates or lending requirements.

Table 5. Ranking of Exogenous Factor-Related Delays

Causes	**Rank**
Weather conditions	1
Political situation	2
Monopoly market	3
Oil price increase	4
Exchange rate fluctuation under contract	5
Public events	6
Change in loans policy by bank	7

Table 5 contains the severity rankings and index values for all 7 causes of project delays in terms of exogenous factors.

c) Ranking of Severity of the Endogenous Factor-Related Delays Based on Implementing Office

Table 6. Ranking of Exogenous Factor-Related Delays

Cause	**No Influence (0)**	**Very Low (1)**	**Low (2)**	**Moderate (3)**	**High (4)**	**Very High (5)**	**S.I. %**	**Rank**	**Impact Level**
Insufficient equipment and vehicles for the work	2	3	2	12	14	18	74.12	1	High
Low labor productivity	1	2	4	14	15	15	73.33	2	High
Shortage of equipment	3	1	2	15	16	14	72.16	3	High
Insufficient laborers	2	0	8	14	16	11	69.41	4	High
Improper construction method	3	4	3	11	17	13	69.02	5	High
Ineffective planning management by contractor	0	4	6	17	12	12	68.63	6	High

Mistakes in design	1	5	8	12	8	17	68.24	7	High
Inconvenient site access	1	2	1	26	14	7	67.84	8	High
Coordination between owner and contractor	1	4	3	19	15	9	67.45	9	High
Lack of equipment efficiency	3	1	6	15	17	9	67.06	10	High
Shortage in materials	2	6	3	15	12	13	66.67	11	High
Construction area restricted	1	3	3	25	10	9	66.27	12	High
Inappropriate design	4	4	4	16	7	16	65.88	13	High
Poor quality control	3	5	2	16	15	10	65.49	14	High
Insufficiently skilled technical staff	3	3	5	16	16	8	64.71	15	High
Project delayed by owner	1	4	8	20	9	9	63.14	16	High
Poor communication between contractor and other parties	3	4	6	18	10	10	62.75	17	High
Insufficiently skilled equipment operator	3	3	8	16	12	9	62.75	18	High
Necessity to re-do work due to contractor failings	1	6	7	18	10	9	62.35	19	High
Poor ground conditions	0	1	9	26	13	2	62.35	20	High
Delayed decision by owner	0	4	11	17	13	6	62.35	21	High
Delayed land expropriation by owner	2	3	8	20	11	7	61.96	22	High
Financial issues related to owner	2	5	8	17	9	10	61.96	23	High
Poor soil quality	0	4	9	23	9	6	61.57	24	High
Poor resource management	3	4	6	18	14	6	61.18	25	High
Conflict between contractor and other parties	2	7	6	17	9	10	61.18	26	High
Poor terrain conditions	2	2	8	23	12	4	60.78	27	High
Change order from owner during construction	1	3	11	18	14	4	60.78	28	High
Unreasonable project timeframe	1	5	9	18	12	6	60.78	29	High
Contractor cash flow	3	4	4	24	11	5	60.00	30	High
Changes in material types and specifications during construction	3	5	8	18	8	9	59.61	31	Moderate
Difficulties in financing project by contractor	4	4	9	17	11	6	57.65	32	Moderate
Not well-defined scope of work	5	4	7	16	14	5	57.65	33	Moderate
Delayed design work	3	5	13	10	14	6	57.65	34	Moderate
Late issue of approval documents by owner	2	4	8	25	10	2	56.86	35	Moderate
Poor coordination between the consultant and contractor(s)	5	4	8	19	9	6	56.08	36	Moderate
Delayed approval of materials	4	8	5	20	9	5	54.51	37	Moderate
Delayed payment by owner	4	7	11	13	10	6	54.12	38	Moderate
Personal conflict between laborers and management team	4	8	7	19	10	3	52.55	39	Moderate
Poorly qualified inspector	5	7	8	19	9	3	51.37	40	Moderate
Consultant too lenient	4	6	10	22	7	2	50.98	41	Moderate
Delay in implementing inspection by consultant	6	6	8	21	8	2	49.80	42	Moderate
Unclear assignment of responsibility near province boundaries	4	5	16	18	7	1	48.63	43	Moderate
Insufficient inspectors	6	7	11	16	9	2	48.24	44	Moderate
Personal conflict among laborers	6	10	11	18	4	2	43.92	45	Moderate
Low project bid price	11	12	9	16	0	3	36.47	46	Low

Forty-six causes are identified in this factor. Table 6 contains the severity rankings and index values for all 46 causes of project delays in terms of endogenous factors, as perceived by the implementing office. Twenty-nine have a severity index above 60%, which ranged from 60.78% to 74.12%. Three of them were above 70%, which ranged from 72.13% to 74.12%. These include (1) insufficient equipment and vehicles for the work having the highest index at over 74.12%, (2) low labor productivity with a severity index of 73.33%, and (3) shortage of equipment with a severity index of 72.16%. Sixteen have a severity index ranging from 43.92% to 60.00%. One has a severity index of below 40%. The results show that the implementing office's severity index for delays linked to endogenous factors spans a large range; it ranged from 36.47% to 74.12%, indicating that the influence of each cause on the development of road infrastructure projects ranges from low to high.

d) Ranking of Severity of the Exogenous Factor-Related Delays Based on Implementing Office

Table 7. Ranking of Severity of the Exogenous Factor-Related Delays Based on Implementing Office

Cause	No Influence (0)	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)	S.I. %	Rank	Impact Level
Weather conditions	0	0	2	15	14	20	80.39	1	Very High
Political situation	4	6	3	18	7	13	62.35	2	High
Monopoly market	2	8	6	23	8	4	55.29	3	Moderate
Oil price increase	5	9	11	15	6	5	49.02	4	Moderate
Public events	5	9	9	23	2	3	46.67	5	Moderate
Exchange rate fluctuation under contract	9	6	7	21	5	3	46.27	6	Moderate
Change in loans policy by bank	9	13	8	18	3	0	37.25	7	Low

Seven causes of delay are identified under this factor. Table 7 presents the analysis of the severity of the exogenous factor-related delays based on the implementing office. It shows the results that weather conditions were the most severe, having the highest index at over 80.39%. Political situation ranked second with a 62.35% severity index. Four factors received a severity index ranging from 46.27% to 55.29%. One had a severity index of below 40%. The findings demonstrate that the exogenous factor-related delays' severity index, which is based on implementing offices, spans a large range; it ranges from 37.25% to 80.39%, indicating that each cause has a low to very high influence on how road infrastructure projects are built.

e) Ranking of Severity of the Endogenous Factor-Related Delays Based on Contractors

Table 8. Ranking of Severity of the Endogenous Factor-Related Delays Based on Contractors

Cause	No Influence (0)	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)	S.I. %	Rank	Impact Level
Unreasonable project timeframe	0	0	0	4	4	5	81.54	1	Very High
Insufficient laborers	0	1	0	3	2	7	81.54	2	Very High
Construction area restricted	0	0	1	2	6	4	80.00	3	High
Delayed decision by owner	0	1	0	3	4	5	78.46	4	High
Coordination between owner and contractor	0	1	0	3	4	5	78.46	5	High
Shortage of equipment	1	0	2	1	3	6	75.38	6	High
Inconvenient site access	0	1	2	2	3	5	73.85	7	High
Low labor productivity	0	2	0	4	1	6	73.85	8	High
Insufficiently skilled equipment operator	1	1	1	1	3	6	73.85	9	High
Changes in material types and specifications during construction	0	2	0	3	3	5	73.85	10	High
Financial issues related to owner	0	0	3	3	2	5	73.85	11	High
Mistakes in design	0	2	0	4	2	5	72.31	12	High
Delayed land expropriation by owner	0	1	3	2	2	5	70.77	13	High
Personal conflict between laborers and management team	1	1	1	2	3	5	70.77	14	High
Shortage in materials	1	1	1	1	5	4	70.77	15	High
Late issue of approval documents by owner	0	1	1	5	3	3	69.23	16	High
Contractor cash flow	2	1	0	2	2	6	69.23	17	High
Delayed design work	1	1	1	2	4	4	69.23	18	High
Lack of equipment efficiency	2	1	0	1	4	5	69.23	19	High
Poor ground conditions	0	0	3	5	1	4	69.23	20	High
Poor soil quality	0	0	3	4	3	3	69.23	21	High
Conflict between contractor and other parties	1	1	1	3	2	5	69.23	22	High
Insufficient equipment and vehicles for the work	2	1	1	1	1	7	69.23	23	High
Delayed approval of materials	2	0	1	3	2	5	67.69	24	High
Not well-defined scope of work	2	0	1	2	4	4	67.69	25	High
Necessity to re-do work due to contractor failings	1	1	1	3	3	4	67.69	26	High
Improper construction method	1	2	1	2	1	6	67.69	27	High
Difficulties in financing project by contractor	1	1	1	4	2	4	66.15	28	High
Ineffective planning management by contractor	2	1	1	2	1	6	66.15	29	High

Change order from owner during construction	0	1	2	3	6	1	66.15	30	High
Poor terrain conditions	1	0	2	5	2	3	64.62	31	High
Personal conflict among laborers	2	0	1	4	2	4	64.62	32	High
Project delayed by owner	3	0	1	1	4	4	63.08	33	High
Poor communication between contractor and other parties	1	1	2	2	5	2	63.08	34	High
Inappropriate design	0	3	2	2	2	4	63.08	35	High
Delayed payment by owner	2	0	0	4	6	1	63.08	36	High
Insufficiently skilled technical staff	1	2	1	3	3	3	61.54	37	High
Poor resource management	2	1	1	3	3	3	60.00	38	Moderate
Poor quality control	2	1	1	3	3	3	60.00	39	Moderate
Unclear assignment of responsibility near province boundaries	2	2	1	1	4	3	58.46	40	Moderate
Delay in implementing inspection by consultant	2	1	1	3	4	2	58.46	41	Moderate
Consultant too lenient	1	2	1	4	4	1	56.92	42	Moderate
Poor coordination between the consultant and contractor(s)	2	2	0	2	7	0	55.38	43	Moderate
Poorly qualified inspector	2	2	0	5	3	1	52.31	44	Moderate
Low project bid price	3	1	2	5	0	2	46.15	45	Moderate
Insufficient inspectors	3	2	1	4	2	1	44.62	46	Moderate

Under this factor, 46 causes were listed. Table 8 exhibits that the top affecting delay causes for the endogenous factor based on contractors were unreasonable project time frames and insufficient laborers, having the highest index at over 81.54%. Thirty-five attained a severity index above 60%, which ranged from 61.54% to 81.54%. Nine of them were above 40%, which ranged from 44.62% to 60.00%. Based on the contractors, there is a broad range in the severity index of the delays caused by endogenous factors which ranged from 44.62% to 81.54%, indicating that every factor has a moderate to very high influence on the development of road infrastructure projects.

f) Ranking of Severity of the Exogenous Factor-Related Delays Based on Contractors

The exogenous factors consist of seven delay causes. Table 9 presents the severity of the exogenous factor-related delays based on contractors. It shows the results that weather conditions were the most severe, having the highest index at over 84.62%. Three had a severity index between 61.54% and 66.15%. Three obtained a severity index ranging from 44.62% to 58.46%. The findings demonstrate that the exogenous factor-related delays' severity index, which is based on the contractors, spans a large range; it ranges from 44.62% to 84.62%, indicating that every factor has a moderate to very high influence on the development of road infrastructure projects.

Table 9. Ranking of Severity of the Exogenous Factor-Related Delays Based on Contractors

Cause	No Influence (0)	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)	S.I. %	Rank	Impact Level
Weather conditions	0	1	0	1	4	7	84.62	1	Very High
Oil price increase	0	1	1	6	3	2	66.15	2	High
Exchange rate fluctuation under contract	1	2	0	3	5	2	63.08	3	High
Monopoly market	0	2	2	5	1	3	61.54	4	High
Political situation	3	0	1	4	1	4	58.46	5	Moderate
Public events	0	3	1	7	1	1	53.85	6	Moderate
Change in loans policy by bank	4	0	0	8	0	1	44.62	7	Moderate

Table 9 contains the severity rankings and index values for all 7 causes of project delays in terms of exogenous factors, as perceived by the contractors.

g) Overall Impact Level of the Endogenous Factor-Related Delays

Table 10 lists the severity index and ranking of all 46 endogenous factor-related delays in road infrastructure projects that were examined from both perspectives. As seen, 37 causes ranging from 61.10% to 75.48% attained a severity index exceeding 60% and 9 ranging in severity from 41.31% to 58.60% received a severity score below 60%. Despite being the most serious issue from both perspectives, insufficient laborers were ranked second among contractors and fourth in the implementing office. With values ranging from 41.31% to 75.48%, the severity index clearly shows a tight range in the results. That is, they have a moderate to high effect on project delays.

Table 10. Overall Impact Level of the Endogenous Factor-Related Delays

Cause	Combined' View			Implementing Offices' View			Contractors View		
	S.I. %	Rank	Impact Level	S.I. %	Rank	Impact Level	S.I. %	Rank	Impact Level
Insufficient laborers	75.48	1	High	69.41	4	High	81.54	2	Very High
Shortage of equipment	73.77	2	High	72.16	3	High	75.38	6	High
Low labor productivity	73.59	3	High	73.33	2	High	73.85	8	High
Construction area restricted	73.14	4	High	66.27	12	High	80	3	High
Coordination between owner and contractor	72.96	5	High	67.45	9	High	78.46	5	High
Insufficient equipment and vehicles for the work	71.67	6	High	74.12	1	High	69.23	23	High
Unreasonable project timeframe	71.16	7	High	60.78	29	High	81.54	1	Very High
Inconvenient site access	70.84	8	High	67.84	8	High	73.85	7	High
Delayed decision by owner	70.41	9	High	62.35	21	High	78.46	4	High
Mistakes in design	70.27	10	High	68.24	7	High	72.31	12	High
Shortage in materials	68.72	11	High	66.67	11	High	70.77	15	High
Improper construction method	68.36	12	High	69.02	5	High	67.69	27	High
Insufficiently skilled equipment operator	68.3	13	High	62.75	18	High	73.85	9	High
Lack of equipment efficiency	68.14	14	High	67.06	10	High	69.23	19	High
Financial issues related to owner	67.9	15	High	61.96	23	High	73.85	11	High
Ineffective planning management by contractor	67.39	16	High	68.63	6	High	66.15	29	High
Changes in material types and specifications during construction	66.73	17	High	59.61	31	Moderate	73.85	10	High
Delayed land expropriation by owner	66.37	18	High	61.96	22	High	70.77	13	High
Poor ground conditions	65.79	19	High	62.35	20	High	69.23	20	High
Poor soil quality	65.4	20	High	61.57	24	High	69.23	21	High
Conflict between contractor and other parties	65.2	21	High	61.18	26	High	69.23	22	High
Necessity to re-do work due to contractor failings	65.02	22	High	62.35	19	High	67.69	26	High
Contractor cash flow	64.62	23	High	60	30	Moderate	69.23	17	High
Inappropriate design	64.48	24	High	65.88	13	High	63.08	35	High
Change order from owner during construction	63.47	25	High	60.78	28	High	66.15	30	High
Delayed design work	63.44	26	High	57.65	34	Moderate	69.23	18	High
Insufficiently skilled technical staff	63.12	27	High	64.71	15	High	61.54	37	High
Project delayed by owner	63.11	28	High	63.14	16	High	63.08	33	High
Late issue of approval documents by owner	63.05	29	High	56.86	35	Moderate	69.23	16	High
Poor communication between contractor and other parties	62.91	30	High	62.75	17	High	63.08	34	High
Poor quality control	62.75	31	High	65.49	14	High	60	39	Moderate
Poor terrain conditions	62.7	32	High	60.78	27	High	64.62	31	High
Not well-defined scope of work	62.67	33	High	57.65	33	Moderate	67.69	25	High
Difficulties in financing project by contractor	61.9	34	High	57.65	32	Moderate	66.15	28	High
Personal conflict between laborers and management team	61.66	35	High	52.55	39	Moderate	70.77	14	High
Delayed approval of materials	61.1	36	High	54.51	37	Moderate	67.69	24	High
Poor resource management	60.59	37	High	61.18	25	High	60	38	Moderate
Delayed payment by owner	58.6	38	Moderate	54.12	38	Moderate	63.08	36	High
Poor coordination between the consultant and contractor(s)	55.73	39	Moderate	56.08	36	Moderate	55.38	43	Moderate
Personal conflict among laborers	54.27	40	Moderate	43.92	45	Moderate	64.62	32	High
Delay in implementing inspection by consultant	54.13	41	Moderate	49.8	42	Moderate	58.46	41	Moderate

Consultant too lenient	53.95	42	Moderate	50.98	41	Moderate	56.92	42	Moderate
Unclear assignment of responsibility near province boundaries	53.54	43	Moderate	48.63	43	Moderate	58.46	40	Moderate
Poorly qualified inspector	51.84	44	Moderate	51.37	40	Moderate	52.31	44	Moderate
Insufficient inspectors	46.43	45	Moderate	48.24	44	Moderate	44.62	46	Moderate
Low project bid price	41.31	46	Moderate	36.47	46	Low	46.15	45	Moderate

Table 10 contains the severity rankings and index values for all 46 causes of project delays in terms of endogenous factors, as perceived by both contractors and implementing offices, as well as their combined perspective.

h) Overall Impact Level of the Exogenous Factor-Related Delays

Table 11 lists the severity index and ranking of all seven exogenous factors associated with delays in road infrastructure projects that were examined from both perspectives. With a severity score of 82.50%, weather conditions ranked highest in both the implementing office and contractors, while political situations ranked second with a severity index of 60.41%. The severity index of five more reasons, ranging from 40.94% to 58.42%, was higher than 40%. The severity index data, which varied from 40.94% to 82.50%, clearly demonstrate a large range. That is, they have a moderate to high impact on project delays.

Table 11. Overall Impact Level of the Exogenous Factor-Related Delays

Cause	Combined' View			Implementing Offices' View			Contractors View		
	S.I. %	Rank	Impact Level	S.I. %	Rank	Impact Level	S.I. %	Rank	Impact Level
Weather conditions	82.5	1	Very High	80.39	1	High	84.62	1	Very High
Political situation	60.41	2	High	62.35	2	High	58.46	5	Moderate
Monopoly market	58.42	3	Moderate	55.29	3	Moderate	61.54	4	High
Oil price increase	57.59	4	Moderate	49.02	4	Moderate	66.15	2	High
Exchange rate fluctuation under contract	54.68	5	Moderate	46.27	6	Moderate	63.08	3	High
Public events	50.26	6	Moderate	46.67	5	Moderate	53.85	6	Moderate
Change in loans policy by bank	40.94	7	Moderate	37.25	7	Low	44.62	7	Moderate

Table 11 contains the severity rankings and index values for all 7 causes of project delays in terms of exogenous factors, as perceived by both contractors and implementing offices, as well as their combined perspective.

i) Rank Correlation

The relationship between the implementing office and contractors as the two parties involved in the ranking of the overall importance index was investigated using Spearman's rank correlation coefficient. The DPWH Isabela 4th District Engineering Office had overseen road construction projects, and this statistical measure was used to evaluate the degree of agreement between the implementing office and contractors regarding the causes of delays in such projects.

Equation (3) was used for this purpose, with n representing the number of delay causes (n = 46 in terms of endogenous factors and n = 7 in terms of exogenous factors). The value r_s was employed as a statistical test to determine whether there is a relationship or agreement between results from different populations.

If $r_s > r_o$, the null hypothesis is rejected in a two-tailed test with a significance threshold of 0.05 (95% confidence level). In this case, r_o stands for the essential Spearman's Rank Correlation Coefficient values for n = 46 endogenous components (0.246) and n = 7 external factors (0.714) (Rohatgi et al. 2000). The correlation coefficient r_s indicates that there is a degree of correlation between the implementing office and contractors, and this can be investigated using the range of values shown in Table 3. The test results of both viewpoints indicated that there is a moderate correlation between their point of view in terms of the endogenous factors' correlation coefficient value $r_s = 0.5107$ being higher than average. On the other hand, the test results show that the correlation coefficient value $r_s = 0.5714$ in terms of exogenous factors is less than r_o, which indicates negligible correlation (no correlation) between their points of view (Abolelmagd et al, 2023). Based on these results, the study findings can be deemed reliable.

j) Mitigation Action for Endogenous Factor-Related Delays

A strategic plan for mitigating delays in road construction based on the overall ranking of the severity of the delay causes in terms of endogenous factors was developed and included various strategies to ensure timely completion.

Cause of delay	Research Findings (S.I. %)	Strategies	KPIs	Time Frame	Responsible	Expected Outcome
Insufficient laborers	75.48	Labor Force Assessment • Conduct an assessment to determine the required number of laborers and their skill levels. Recruitment and Retention Recruit laborers with relevant experience and skills • Provide competitive wages and benefits to retain skilled laborers. Maximize Equipment Use • Increase reliance on equipment to compensate for potential labor shortages	Labor Utilization Rate Labor Cost Variance Workforce Availability Task Completion Rate	Notice of Award (NOA) to Notice-to-Proceed (NTP).	Contractors	Sufficient and skilled labor force was maintained throughout the project.
Shortage of equipment	73.77	Equipment Inventory and Procurement • Perform an initial inventory of required equipment. • Procure or lease equipment that meets project specifications. Maintenance and Reliability • Implement a preventive maintenance schedule for all equipment. • Invest in reliable, modern equipment to minimize downtime. Coordination with Suppliers • Establish strong relationships with equipment suppliers for timely delivery and support.	Equipment Utilization Rate Equipment Downtime Equipment Availability Rate Equipment Turnaround Time	Notice of Award (NOA) to Notice-to-Proceed (NTP).	Contractors	Continuous availability of well-maintained equipment throughout the project.
Low labor productivity	73.59	Worker Selection and Training • Establish a rigorous selection process to hire skilled workers. • Develop and implement training programs focusing on productivity and safety. Incentive Programs • Design incentive programs to reward high productivity and adherence to safety standards. Ongoing Evaluation • Regularly evaluate labor productivity and adjust training and incentives as necessary.	Labor Efficiency Ratio Skill Utilization Rate Idle Time Labor Productivity Rate	All year round.	Implementing Office and Contractors	Increased labor productivity and project efficiency.
Construction area restricted	73.14	Pre-Project Survey • Conduct detailed surveys to understand the extent of space restrictions. Optimized Planning • Develop a detailed construction plan that maximizes the use of available space. • Coordinate with local authorities to minimize restrictions where possible. Logistics Management • Implement logistics strategies to efficiently manage the movement of materials and equipment within restricted areas.	Space Utilization Efficiency Project Schedule Variance Rework Rate Due to Area Restrictions Permit and Compliance Adherence	Pre-Procurement Conference to Pre-Bid Conference.	Implementing Office	Efficient use of restricted areas and minimal delays due to space constraints.
Coordination between owner and contractor	72.96	Establish Clear Communication Channels • Establish both official and informal channels of contact between the contractor and owner to guarantee prompt information exchange and transparency. Regular Progress Meetings • Arrange regular progress meetings to go over the project's status, talk about obstacles, and make plans for future tasks. Clear Contractual Agreements • Create a comprehensive contract that outlines all duties, responsibilities, the extent of the task, and performance standards, and get agreement on it.	Communication Efficiency Change Order Response Time Adherence to Scheduled Coordination Meetings Timely Decision-Making	Notice-to-Proceed (NTP) to Project Acceptance.	Implementing Office and Contractors	Reduced misunderstandings and provides a strong foundation for coordination and accountability.

Figure 1. Strategic Plan for Endogenous Factor-Related Delays

A few measures are included in the strategy plan to guarantee the timely completion of road construction projects to mitigate delays caused by endogenous variables, as shown in Figure 1. An important component is a skilled labor force, with an emphasis on hiring, retention, and equipment utilization. Procurement, maintenance, and supplier management are all crucial aspects of equipment management. Low labor productivity can be addressed using incentive programs in addition to stringent hiring and training practices. Project efficiency and worker productivity can be increased by regular assessment and modification of incentives and training. The pre-project survey, personnel selection and training, equipment inventory and procurement, labor force assessment, and the establishment of clear communication channels are a few of these. Optimized planning, logistics management, and pre-project surveys are also crucial to reducing delays brought on by space limitations. Laying a solid foundation for cooperation and accountability also requires holding frequent progress meetings to discuss challenges, evaluate the state of the project, and plan the next actions.

k) Mitigation Action for Exogenous Factor-Related Delays

A strategic plan was also prepared to mitigate road construction delays, considering exogenous factors and the overall rating of the severity of the delay reasons. The plan contains several methods to ensure timely completion.

Cause of delay	Research Findings (S.I. %)	Strategies	KPIs	Time Frame	Responsible	Expected Outcome
Weather conditions	82.50	Pre-Construction Planning • Utilize advanced weather forecasting tools to predict potential weather impacts. • Prioritize weather-sensitive activities during favorable seasons. Real-Time Monitoring • Implement a weather monitoring system to adjust work schedules as needed. • Develop contingency plans for unexpected weather events. Training • Train staff on best practices for working in various weather conditions.	Seasonal Weather Impact Analysis Weather-Related Delay Days Productivity Impact Response Time to Weather Changes	Pre-construction Meeting to Notice-to-Proceed (NTP).	Implementing Office and Contractors	Optimized schedules that mitigate the impact of weather on construction timelines.
Political Situation	60.41	Stakeholder Engagement and Relationship Management • Create a plan for engaging stakeholders that considers political players at all tiers (local, regional, national). • Assign a specific team or political liaison to oversee interactions and correspondence with political stakeholders. Flexibility in Project Planning • Divide the project into phases so that it can be adjusted in reaction to political developments without having to come to a complete stop. Risk Assessment and Contingency Planning • To determine probable political scenarios that could have an impact on the project, do a political risk assessment.	Government Contractor Relationship Stability Government Stakeholder Engagement Public Sentiment and Support Legislative Changes Affecting Project Scope	Pre-Procurement Conference to Project Acceptance.	Implementing Office and Contractors	Greater political support for the project and reduced potential delays caused by political issues.
Monopoly Market	58.42	Diversify Services and Specializations • Concentrate on specialized services that may not be the monopoly's primary focus, such as environmentally friendly road building, cutting-edge materials, or cutting-edge technologies. Form Strategic Partnerships • Form cooperative partnerships with businesses that can provide resources or supplementary talents. Enhance Cost Efficiency • Utilize data analytics to maximize the utilization of personnel, equipment, and supplies, making sure that each resource is utilized efficiently.	Price Variance Supply Chain Risk Supplier Dependence Ratio Availability of Alternatives	Pre-Procurement Conference to Project Completion.	Implementing Office and Contractors	Improved profitability and competitive pricing, even when competing with a monopoly that controls market prices.
Oil Price Increase	57.59	Budget Reassessment and Adjustment • Re-evaluate the project's budget to consider rising oil prices. Cost Control and Efficiency Measures • Put cost-cutting strategies in place to lessen the effects of rising oil prices. Long-Term Contracts with Suppliers • Establish long-term agreements with suppliers to fix prices and maintain expenses.	Fuel Cost Impact Equipment Operating Cost Increase Project Budget Overrun Due to Oil Prices Cost per Kilometer of Road Constructed	All year round.	Implementing Office and Contractors	Stabilize material costs, avoid sudden price shocks due to fluctuations in oil prices, and minimize fuel consumption.
Exchange rate fluctuation under contract	54.68	Contractual Provisions • Add provisions allowing for pricing adjustments in response to changes in exchange rates. This facilitates the parties' sharing of the risk. Cost Contingency Reserves • A contingency budget should be set up expressly to deal with fluctuations in exchange rates. This guarantees the ability to pay unforeseen expenses brought on by currency fluctuations. Insurance and Guarantees • To guard against unfavorable currency fluctuations, buy currency insurance. • Guarantees backed by the government may occasionally be available to guard against currency risk.	Cost Variance Due to Exchange Rate Fluctuations Contract Adjustments Due to Exchange Rate Fluctuations Profit Margin Impact Due to Exchange Rate Changes Time Lag Impact Due to Exchange Rate Fluctuations	All year round.	Implementing Office and Contractors	Ensured that financial risks were minimized, and contracts were optimized to handle currency volatility.

Figure 2. Strategic Plan for Exogenous Factor-Related Delays

Figure 2 illustrates several of the strategies employed in the strategic plan to ensure that road construction projects are completed on schedule and to reduce delays brought on by exogenous factors. Several strategies include pre-construction planning, contract clauses, diversifying services and specializations, budget reevaluation and adjustment, and stakeholder involvement and relationship management, are a few of these. A detailed building schedule that accounts for seasonal weather variations can help to minimize delays. One strategy to boost political support for the project and reduce the likelihood of political delays is to establish stability in the relationship

between the government and contractors. To reduce monopolistic markets, concentrate on specialized services that might not be the monopoly's focus, such as creating environmentally friendly roads, using cutting-edge materials, or utilizing cutting-edge technologies. Limiting fuel consumption, stabilizing material costs, and averting unanticipated price shocks from fluctuations in oil prices can all be achieved by reevaluating the project's budget, devising cost-cutting strategies, and establishing long-term contracts with suppliers to set pricing and keep costs steady. Including provisions that allow pricing adjustments in response to exchange rate variations can also help reduce financial risks.

4. Conclusion

a) Ranking of Endogenous Factor-Related Delays

The ranking of endogenous factors associated with construction delays indicates that the availability of resources, including staff and equipment, effective management and coordination, and timely decision-making by the owner are the most critical areas to address to mitigate delays. The key priorities should be making sure there are enough resources, enhancing the planning and coordination procedures, and preserving excellent communication amongst all stakeholders, as technical and design challenges are also significant. By addressing these main criteria, construction projects may be completed more quickly and with more success.

b) Ranking of Exogenous Factor-Related Delays

External factors highlight a variety of reasons for delays, the most notable of which are weather and political circumstances. Knowing these rankings aids in the prioritization of risk management techniques, with an emphasis on minimizing delays by mitigating the risks that are listed highest.

c) Ranking of Severity of the Endogenous Factor-Related Delays Based on Implementing Office

The most crucial delays were determined to be those caused by endogenous factors, which included insufficient equipment and vehicles for the work, low labor productivity, and a shortage of equipment. The impact level of these delays was considerable. The DPWH Isabela 4th District Engineering Office is responsible for managing and supervising several road development projects. Contractors frequently operate on several projects at once, so they might allocate equipment and cars to the most important one. In addition, most construction workers are from rural areas, such as hills and sitios. These individuals relocate to the city in search of employment, frequently taking on roles that are beneath their skill level. On occasion, road development projects in remote locations require construction companies to hire local laborers as temporary workers; many of these workers lack formal training or construction work experience. Moreover, most contracting businesses in the DPWH Isabela 4th District Engineering Office are tiny and fall between the Small A and Medium A license categories. Because of this, many of these businesses must rent construction equipment when needed because they lack the necessary equipment. There is a high demand for the equipment during periods of building, which leads to a shortage and inadequate upkeep. The project is delayed because of the equipment failure brought about by this shortage of equipment. Although these issues are mostly under control, they serve as reminders of how important it is to manage equipment, train staff, and allocate resources sensibly.

d) Ranking of Severity of the Exogenous Factor-Related Delays Based on Implementing Office

Under exogenous factors, weather conditions proved to be the primary source of delay. These may put workers' safety in jeopardy and force a halt to construction operations. For instance, prolonged, intense rains can result in damage as well as other issues like equipment failure, road closures, and structural collapses. These are not under the implementing office's control, but they have a major effect on project durations.

e) Ranking of Severity of the Endogenous Factor-Related Delays Based on Contractors

Endogenous factors showed that, according to contractors, the two main reasons for delays are unreasonable project timelines and insufficient laborers. The DPWH Isabela 4th District Engineering Office's planning engineers scheduled and determined the project's duration based on the project's scope of work and their estimated hourly output in accordance with the DPWH Standards and Specifications; some of these may be too short and could be the cause of an unrealistic work program issue. In addition, skilled labor is currently in short supply in the construction industry. Despite the rising demand for their services, several firms are experiencing a labor shortage, and some contractors are not recruiting enough people.

f) Ranking of Severity of the Exogenous Factor-Related Delays Based on Contractors

Weather conditions were determined to be the most serious cause of exogenous factor-related delays based on contractors. While this isn't always the case, contractors' subpar project management practices usually contribute to these delays. Contractors need to prioritize and expedite their work because Isabela Province may have unexpected weather for a lengthy period. All year long, there is a considerable amount of rainfall in the eastern

and coastal regions. However, weather is a known concern in building projects, especially those involving roads and highways that are vulnerable to outside influences.

g) Overall Impact Level of the Endogenous Factor-Related Delays

Based on the examination of 46 endogenous factors, it can be concluded that resource constraints, poor project management, and logistical difficulties are the main reasons behind building project delays. By addressing those crucial areas, building project delays can be minimized and project outcomes can be greatly improved.

h) Overall Impact Level of the Exogenous Factor-Related Delays

Rapidly expanding districts, such as the Isabela Fourth and Isabela Sixth Districts of Isabela, must find a balance between the construction of road infrastructure and responding to weather-related emergencies. Ignoring these worries is not a feasible option. However, neither endogenous nor external elements should be able to impede the growth of road infrastructure projects. Instead, it should promote greater flexibility.

i) Rank Correlation

According to the study's findings, implementing offices and contractors have a moderate understanding of how to rank endogenous factors-related delay causes in road infrastructure projects. A Spearman's rank correlation coefficient of 0.5107, which is higher than the crucial value, suggests this. However, because it is below the crucial value, the correlation coefficient of 0.5714 for exogenous factors-related delay causes indicates that there is a negligible agreement or correlation between the two groups. The study's findings lend credibility to the conclusions, which point to differences in viewpoints regarding exogenous factors yet a reasonable consensus regarding endogenous factors-related delay causes.

j) Mitigation Action for Endogenous and Exogenous Factor-Related Delays

To effectively mitigate delays in road construction projects, a mitigation plan was made in terms of endogenous factors and exogenous factors. It is expected that all parties involved take responsibility for the implementation of these strategies and consistently monitor the project using defined Key Performance Indicators (KPIs) to ensure timely completion and cost control.

References

Abolelmagd, Y. M., Mobarak, W. F. M., & Eskander, R. F. A. Evaluating Delay Causes for Constructing Road Projects in Saudi Arabia. Information Sciences Letters, 12(9), 2211–2224, 2023. https://doi.org/10.18576/isl/120926

Mahamid, I. , Common risks affecting time overrun in road construction projects in Palestine: Contractors' perspective. Construction Economics and Building, 13(2), 45–53, 2013. https://doi.org/10.5130/ajceb.v13i2.3194

Mahamid, I, Schedule delay in Saudi Arabia road construction projects: Size, estimate, determinants and effects. International Journal of Architecture, Engineering, and Construction, 6(3), 2017. https://doi.org/10.7492/ijaec.2017.017

Mahamid, I., Bruland, A., & Dmaidi, N. (2012). Causes of delay in road construction projects. Journal of Management in Engineering, 28(3), 300–310. https://doi.org/10.1061/(asce)me.1943-5479.0000096

Rohatgi, V. K. & Saleh, A. K. M. E. , An introduction to probability and statistics. In Wiley series in probability and statistics. 2000. https://doi.org/10.1002/9781118165676

Soumphonphakdy, B., Nakamura, S., Okumatsu, T., & Nishikawa, T. , Causes of delays in road construction projects in Laos. Global Journal of Researches in Engineering, 19–32, 2020. https://doi.org/10.34257/gjreevol20is3pg19

Toor, S.-U.-R. & Ogunlana, S., Problems causing delays in major construction projects in Thailand. Construction Management and Economics, 26(4), 395–408, 2008. https://doi.org/10.1080/01446190801905406

Wikipedia Contributors. , Isabela's 4th congressional district. 2024, July 16, Wikipedia. https://en.wikipedia.org/wiki/Isabela%27s_4th_congressional_district#:~:text=The%20district%20consists%20of%20the,Federal%20ng%20Pilipinas%20(PFP).