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Analysis of Time Acceleration in The Malaka Regent's Office Construction Project Using The Critical Path Method (CPM) and Time-Cost Trade-Off (TCTO)

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Abstract
The construction of the Malaka Regency Regent's Office has encountered significant challenges, including recurring project delays caused by factors such as design changes, unpredictable weather conditions, labor shortages, and insufficient materials or equipment. These issues have resulted in inefficiencies in project scheduling and cost management, highlighting the need for effective project management strategies. This study aims to analyze the project schedule, identify the critical path, and evaluate schedule acceleration alternatives for the Malaka Regent's Office construction project using the Critical Path Method (CPM) and the Time–Cost Trade-Off (TCTO) method. The study applied the Critical Path Method (CPM) and the Time–Cost Trade-Off (TCTO) method to analyze the project schedule, identify critical activities, and evaluate feasible acceleration strategies. The analysis showed that the originally planned project duration of 224 calendar days could be reduced to 196 calendar days using the CPM approach, while the TCTO method further shortened the project duration to 182 calendar days. This acceleration was achieved by minimizing idle time between critical activities, optimizing resource allocation, and implementing time–cost trade-off strategies without compromising the project's quality or scope. The findings demonstrate the effectiveness of CPM and TCTO in optimizing construction schedules and reducing project delays. Furthermore, this study provides a practical framework for improving schedule and cost performance in construction projects, particularly those involving public infrastructure development.

INTRODUCTION

Infrastructure development across Indonesia has continued to expand in line with the government's efforts to promote economic growth and equitable regional development, particularly in newly established administrative regions such as Malaka Regency. However, the increasing number of construction projects has also been accompanied by various implementation challenges, including cost overruns and project delays (Abdelalim et al., 2024; Amini et al., 2023; Gurumayum, 2025; Purushothaman et al., 2024). Construction delays may result from factors such as design changes, unpredictable weather conditions, labor shortages, insufficient material availability, and inadequate equipment (Amoah et al., 2024; Bhattarai, 2023; Duale et al., 2025; Giri, 2023; Latif et al., 2023; Singh et al., 2025). These challenges often lead to inefficiencies in schedule and cost management, highlighting the need for effective project management strategies to ensure that projects are completed on time and within budget.

The construction of the Malaka Regent's Office is one of the region's strategic public infrastructure projects and has experienced significant implementation delays, with project progress falling to approximately half of the planned schedule (Faris et al., 2025; Seran et al., 2022; Seu et al., 2022). Effective project scheduling is essential for defining the relationships among activities, establishing precedence, and estimating realistic activity durations. Inadequate project control can result in schedule delays, increased costs, and reduced project efficiency. Restoring the project to its planned schedule requires acceleration measures, although such measures may incur additional costs. Accordingly, this study applied the Critical Path Method (CPM) and the Time–Cost Trade-Off (TCTO) method to evaluate schedule acceleration alternatives.

The Critical Path Method (CPM) is a project management technique used to identify the longest sequence of interdependent activities that determines the minimum project completion time. Delays affecting activities on the critical path directly extend the overall project duration (Brando et al., 2017; Currie Adde Siregar & Iffiginia, 2019). CPM enables project managers to identify critical activities that require close monitoring and control (Dwiretnani & Kurnia, 2018). In contrast, the Time–Cost Trade-Off (TCTO) method evaluates the balance between project duration and project cost by identifying activities that can be accelerated at the lowest additional cost. This approach is particularly useful when schedule acceleration (crashing) is required while maintaining cost efficiency (Alfianti, 2019; Caprillio Briandhito, 2020). Applying the TCTO method makes it possible to identify the most cost-effective acceleration alternatives while minimizing additional expenditures.

Previous studies have demonstrated that CPM and TCTO are effective tools for optimizing project schedules and costs across a variety of construction projects. Auzan et al. (2024) applied CPM to the Central Laboratory Development Project at Andalas University and successfully optimized the project schedule. Alfianti (2019) optimized both project duration and costs for the Inpatient Building Construction Project at the Wonoayu Community Health Center (Puskesmas) in Sidoarjo using CPM and further evaluated schedule acceleration using the TCTO method for the Class III Inpatient Building and Parking Facility Project at Dr. Moewardi Hospital in Surakarta. Choffaryanto et al. (2024) analyzed schedule optimization in a drainage construction project using CPM, while Caprillio Briandhito (2020) evaluated project time and cost performance using Earned Value Management and TCTO in the Summarecon Bandung Project. Despite these contributions, no previous study has specifically examined the combined application of CPM and TCTO to address delays in the Malaka Regent's

Office construction project, creating a clear research gap in the context of public infrastructure development in the region.

This study aims to evaluate the project schedule and cost from project initiation to completion and to analyze schedule acceleration alternatives using the Critical Path Method (CPM) and the Time–Cost Trade-Off (TCTO) method for the Malaka Regent's Office construction project. Because the project experienced substantial delays relative to the original schedule, rescheduling and acceleration strategies became necessary to restore project progress. By identifying the critical path and evaluating time–cost trade-offs, this study seeks to reduce project duration, improve resource utilization, and support more effective project management decisions. The findings are expected to provide a practical framework for project stakeholders to address schedule delays and cost overruns while improving resource efficiency and decision-making in the management of public infrastructure projects, particularly in Malaka Regency and other regions with similar characteristics.

METHOD

This study employed the Critical Path Method (CPM) and the Time–Cost Trade-Off (TCTO) method. CPM was used to identify the critical path and determine the minimum project duration, while the TCTO method was applied to evaluate schedule acceleration alternatives by balancing project duration and additional costs. Microsoft Project was used to identify the critical path and perform the schedule analysis.

RESULTS AND DISCUSSION

Based on the time acceleration calculation required to complete the Malaka Regent Office Construction Project using the Critical Path Method (CPM) and Time Cost Trade Off (TCTO) method, it is:

Recap of Duration Requirements for Each Project

The duration of each task is obtained from the S-curve of the Malaka Regent's Office building construction plan, which includes two types of work groups: the main building structure work and the main building architecture work of the Malaka Regent's Office. The total duration allocation according to the contract is 196 (one hundred ninety-six) calendar days, which the researcher presents in tabular form.

Table 1. Recapitulation of Total Price and Duration for Each Type of Work

WORK IMPLEMENTATION SCHEDULE			
No	**Description**	**Amount (IDR)**	**Durasi (Hari)**
I	**MAIN BUILDING (MALAKA REGENT OFFICE)**		
A	**PREPARATORY WORKS**		
1	General Preparatory Works	Rp 283,833,147.14	7
2	Occupational Health and Safety (OHS) & Construction Safety Organizer Fee	Rp 9,750,000.00	7
3	Work Protection Equipment (APK)	Rp 12,000,000.00	7
4	Personal Protective Equipment (PPE)	Rp 8,285,000.00	7
5	Insurance and Licensing	Rp 7,500,000.00	7
6	Construction Safety Personnel	Rp 106,250,000.00	7
7	Health Facility Equipment	Rp 1,500,000.00	7
8	Required Signage	Rp 7,350,000.00	7
9	Consultation with Related Experts	Rp 1,250,000.00	7
10	Other Risk Control Tools for OHS	Rp 4,850,000.00	7
B	**STRUCTURAL WORKS**		
1	Substructure Works	Rp 8,837,400,838.46	70
2	First Floor Structural Works	Rp 2,078,680,233.14	49
3	Second Floor Structural Works – Elevation +2.65	Rp 137,925,090.23	7
4	Second Floor Structural Works – Elevation +4.20	Rp 3,359,354,405.61	49
5	Third Floor Structural Works – Elevation +8.40	Rp 2,946,776,182.46	49
6	Roof Floor Structural Works – Elevation +12.60	Rp 1,265,962,098.93	14
7	Roof Frame Structural Works	Rp 2,008,508,380.32	21
C	**ARCHITECTURAL WORKS – MAIN BUILDING**		
1	First Floor Architectural Works	Rp 4,608,874,083.12	63
2	Second Floor Architectural Works	Rp 4,230,085,706.10	63
3	Third Floor Architectural Works	Rp 3,197,204,160.69	35
4	Roof Floor & Roof Architectural Works	Rp 315,013,220.93	7
5	Roofing Works	Rp 1,310,547,293.63	14
6	Façade Works	Rp 2,462,304,847.71	21
7	Site Development	Rp 4,734,687,890.58	35
D	**MEP (MECHANICAL, ELECTRICAL & PLUMBING) WORKS**		

1	Main Building Electrical Distribution Panel	Rp 1,053,036,602.74	7
2	Cable Ladder, Tray, and Grounding Installation	Rp 225,269,318.64	7
3	Armature, Cable, Lightning Protection	Rp 1,576,367,396.56	14
4	Fire Alarm System	Rp 349,112,917.15	7
5	CCTV System	Rp 239,064,274.87	7
6	Clean Water Installation	Rp 324,433,852.58	7
7	Wastewater and Bio Filter Installation	Rp 373,733,701.05	7
8	Rainwater Drainage System	Rp 226,247,261.08	7
9	Fire Extinguishing System	Rp 38,175,473.18	7
10	Air Conditioning and Fan	Rp 3,207,017,106.70	21
E	**AUDIO VISUAL SYSTEM FOR THE REGENT'S OFFICE MAIN HALL**		
1	Audio Visual System Installation	Rp 378,462,500.00	7
	TOTAL COST	**Rp 49,926,812,983.60**	

Source: Secondary Data, 2025

Creating Network Planning Based on the S-Curve of the CPM Method Plan

The S-curve plan from secondary data is not yet in the form of Network Planning, so it cannot provide information on the dependencies between tasks, and the Critical Path is not yet known. Using Microsoft Project software, scheduling is carried out in the form of Network Planning with the following stipulations:

a. Scheduling using reference: Project Star Date
b. Duration of work hours per day for the project: 8 hours
c. Number of days per week: 7 days
d. Duration of hours per week: 56 hours
e. Number of days per month: 30 days (calendar days)
f. Determining predecessors

Table 2. Detailed Table of Predecessors by Type of Work

Task Name	Duration	Start	Finish	Predecessors
General Preparatory Works	7d	03/04/2024 08:00	03/12/2024 05:00	
Occupational Health and Safety (OHS) & Construction Safety Organizer Fee	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Work Protection Equipment (APK)	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Personal Protective Equipment (PPE)	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Insurance and Licensing	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Construction Safety Personnel	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Health Facility Equipment	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Required Signage	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Consultation with Related Experts	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
Other Risk Control Tools for OHS	7d	03/04/2024 08:00	03/12/2024 05:00	2SS
STRUCTURAL WORKS	**168d**	**03/11/2024 08:00**	**10/30/24 5:00**	
First Floor Architectural Works	49d	03/11/2024 08:00	5/16/24 5:00	11SS
First Floor Structural Works	35d	4/29/24 8:00	6/14/24 5:00	13SS+35d
Second Floor Structural Works – Elevation +2.65	7d	06/06/2024 08:00	6/14/24 5:00	14SS+28d
Second Floor Structural Works – Elevation +4.20	42d	06/06/2024 08:00	08/02/2024 05:00	14SS+28d
Third Floor Structural Works – Elevation +8.40	49d	7/16/24 8:00	9/20/24 5:00	16SS+28d
Roof Floor Structural Works – Elevation +12.60	14d	9/23/24 8:00	10/10/2024 05:00	17
Roof Frame Structural Works	21d	10/02/2024 08:00	10/30/24 5:00	18SS+7d
ARCHITECTURAL WORKS – MAIN BUILDING	**126d**	**06/06/2024 08:00**	**11/28/24 5:00**	
First Floor Architectural Works	56d	06/06/2024 08:00	8/22/24 5:00	14SS+28d
Second Floor Architectural Works	63d	7/25/24 8:00	10/21/24 5:00	21SS+35d
Third Floor Architectural Works	35d	09/12/2024 08:00	10/30/24 5:00	22SS+35d
Roof Floor & Roof Architectural Works	7d	10/02/2024 08:00	10/10/2024 05:00	23SS+14d
Roofing Works	14d	10/11/2024 08:00	10/30/24 5:00	24

Façade Works	21d	10/22/24 8:00	11/19/24 5:00	25SS+7d
Site Development	35d	10/11/2024 08:00	11/28/24 5:00	24SS+7d
MEP (MECHANICAL, ELECTRICAL & PLUMBING) WORKS	**28d**	**10/22/24 8:00**	**11/28/24 5:00**	
Main Building Electrical Distribution Panel	7d	10/22/24 8:00	10/30/24 5:00	27SS+7d
Cable Ladder, Tray, and Grounding Installation	7d	10/31/24 8:00	11/08/2024 05:00	29
Armature, Cable, Lightning Protection	14d	11/11/2024 08:00	11/28/24 5:00	30
Fire Alarm System	7d	11/11/2024 08:00	11/19/24 5:00	30SS+7d
CCTV System	7d	11/20/24 8:00	11/28/24 5:00	32
Clean Water Installation	7d	10/31/24 8:00	11/08/2024 05:00	29SS+7d
Wastewater and Bio Filter Installation	7d	10/31/24 8:00	11/08/2024 05:00	29SS+7d
Rainwater Drainage System	7d	11/20/24 8:00	11/28/24 5:00	35FS+7d
Fire Extinguishing System	7d	11/20/24 8:00	11/28/24 5:00	36SS
Other Risk Control Tools for OHS	21d	10/31/24 8:00	11/28/24 5:00	29SS+7d
AUDIO VISUAL SYSTEM FOR THE REGENT'S OFFICE MAIN HALL	**7d**	**11/20/24 8:00**	**11/28/24 5:00**	**38SS+14d**
Audio Visual System Installation	7d	11/20/24 8:00	11/28/24 5:00	38SS+14d

Source: Secondary Data, 2025

Accelerating 224 Calendar Days to 196 Calendar Days

After identifying the tasks on the Critical Path, the work schedule was accelerated from 224 calendar days (8 months) to 196 calendar days (7 months). The steps taken are

1. Reschedule by eliminating break times between work activities and overtime hours (especially for tasks on the critical path).
2. Rescheduling to shorten the duration of activities (especially for tasks on the critical path)

By using Microsoft Project software, the acceleration of work can be carried out as follows

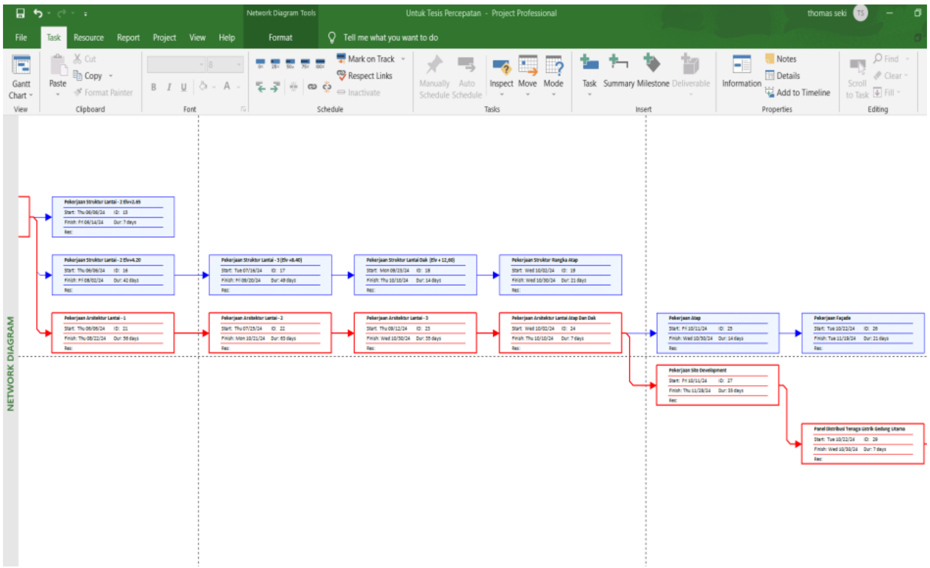

Figure 1. Network Planning Acceleration Diagram
Source: Analysis Results, 2025

Activities conducted an acceleration analysis using the TCTO Method

The steps to determine the activities that will be accelerated using the Time Cost Trade Off method are as follows:

Analyze Network Planning with Microsoft Project

In this study, network planning was developed based on the analysis results using Microsoft Project software, referring to the S-Curve of the implementation plan for the construction of the regent's office building in Malaka Regency. Through this network planning, several critical activities that play an important role in the time compression analysis process (crashing) using the TCTO method can be identified. The S-Curve produced from the project provides information on the sequence of activity execution and the overall project duration. To determine the list of critical activities in the implementation of this project, please refer to the following table:

Table 3. List of Critical Activities

No.	Activity Description	Activity Code	Predecessor Activity	Duration	Critical Activity
A	**PREPARATORY WORKS**				
1	General Preparatory Works	1	2SS	7d	
2	Occupational Health and Safety (OHS) & Construction Safety Organizer Fee	2	2SS	7d	
3	Work Protection Equipment (APK)	3	2SS	7d	
4	Personal Protective Equipment (PPE)	4	2SS	7d	
5	Insurance and Licensing	5	2SS	7d	
6	Construction Safety Personnel	6	2SS	7d	
7	Health Facility Equipment	7	2SS	7d	
8	Required Signage	8	2SS	7d	
9	Consultation with Related Experts	9	2SS	7d	

10	Other Risk Control Tools for OHS	10	2SS	7d	
B	**STRUCTURAL WORKS**				
1	Substructure Works	11	11SS	49d	**Critical**
2	First Floor Structural Works	12	13SS+35d	35d	**Critical**
3	Second Floor Structural Works – Elevation +2.65	13	14SS+28d	7d	
4	Second Floor Structural Works – Elevation +4.20	14	14SS+28d	42d	**Critical**
5	Third Floor Structural Works – Elevation +8.40	15	16SS+28d	49d	
6	Roof Floor Structural Works – Elevation +12.60	16	17	14d	
7	Roof Frame Structural Works	17	18SS+7d	21d	
C	**ARCHITECTURAL WORKS – MAIN BUILDING**				
1	First Floor Architectural Works	18	14SS+28d	56d	**Critical**
2	Second Floor Architectural Works	19	21SS+35d	63d	
3	Third Floor Architectural Works	20	22SS+35d	35d	
4	Roof Floor & Roof Architectural Works	21	23SS+14d	7d	
5	Roofing Works	22	24	14d	
6	Façade Works	23	25SS+7d	21d	
7	Site Development	24	24SS+7d	35d	
D	**MEP (MECHANICAL, ELECTRICAL & PLUMBING) WORKS**			**28d**	
1	Main Building Electrical Distribution Panel	25	27SS+7d	7d	
2	Cable Ladder, Tray, and Grounding Installation	26	29	7d	
3	Armature, Cable, Lightning Protection	27	30	14d	
4	Fire Alarm System	28	30SS+7d	7d	
5	CCTV System	29	32	7d	
6	Clean Water Installation	30	29SS+7d	7d	
7	Wastewater and Bio Filter Installation	31	29SS+7d	7d	
8	Rainwater Drainage System	32	35FS+7d	7d	
9	Fire Extinguishing System	33	36SS	7d	
10	Air Conditioning and Fan	34	29SS+7d	21d	
E	**AUDIO VISUAL SYSTEM FOR THE REGENT'S OFFICE MAIN HALL**				
1	Audio Visual System Installation	35	38SS+14d	7d	

Source: Analysis Results, 2025

Based on the data in table 3 of the critical activity list for the construction of the Malaka Regency Bupati office building, there are several activities on the critical path. The critical activities that will be expedited using the TCTO method include:

1. Substructure Work
2. Structural Work Floor-2 Elv +2.65
3. Structural Work Floor-2 Elv +4.20

Architectural Work Floor-1

Analysis of Time Cost Trde Off Planning

In this analysis, time compression (crashing) will be carried out through two alternatives, namely the implementation of a shift work system and the addition of the number of workers and overtime. In accordance with the research objectives, this analysis aims to obtain an optimal combination of time and cost in an effort to shorten the project execution duration. Next, the results of each alternative will be compared with the normal conditions before the acceleration is implemented. The crashing process will be applied to the critical path.

a. Calculating Crashing with Additional Labor and Overtime

In this alternative, a system of Adding Workforce and Overtime is applied, and a two-shift work system is implemented, with the first shift running from 08:00 to 17:00, and the second shift running from 17:00 to 22:00. The crashing process is carried out repeatedly until the critical path reaches a saturation condition. Therefore, in this alternative, the network planning document processed using Microsoft Project and the crashing process are presented in the appendix. It should be noted that the workforce assigned to the morning and night shifts are different groups, where the productivity of the night shift workforce is assumed to be 85% of the productivity of the morning shift. Additionally, the cost slope calculation for this alternative differs from the previous alternative. Here is an example of activity calculations for the shift work system alternative in the Construction of the Malaka Regent's Office Building project.

1) Main Structural Work

Known:

Volume: 126.809 m^3

Duration : 70 days

Shift: 1

Normal Direct Cost: Rp 962.460.082

a) Calculation of normal productivity

Productivity = Volume/ Duration

= 126,809 m3 / 70 days

= 2,587.93 m3/day

b) Calculation of crash duration

Durasi Crash = Volume / (Morning Shift Production)

= 126.809 m^3 / 2,587.93 m^3/day

= 49 days

c) Calculation of crash cost

The first step in determining the crash cost is to determine the normal wage cost spent over 1 day, where the calculation is explained in the table below:

Table 4. Calculation of Morning Shift Wage Costs

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	25	11428.57	8	Rp 80,000	Rp 2,000,000
Foreman	1	24285.71	8	Rp 170,000	Rp 170,000
Total					**Rp 2,170,000**

Source: Analysis Results, 2025

Table 5. Overtime Cost Calculation

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	25	22857.14	5	114285,71	Rp 2.857,143
Foreman	1	4857.43	5	242857,14	Rp 242.857
Total					**Rp 3,100,000**

Source: Analysis Results, 2025

From the table above, it is known that the normal cost spent in one day to carry out that work item is Rp 2,170,000.
Cost (Wage) = Worker Wage Per Day x Normal Duration
= Rp2,170,000.00 × 49
= Rp106,330,000.00
Cost (Material) = Direct Cost – Labor Cost
= Rp 962,460,082.43 – Rp 106,330,000.00
= Rp 856,130,082.43
Crash Cost = Cost (Material) + (Labor Cost x Number of Shifts x Crash Duration)
= Rp 856.130.082,43 + (Rp2.170.000 × 1 × 49)
= Rp853,960,082.43

$$\text{Cost Slope} = \frac{Crash\ Cost - Normal\ Direct\ Cost}{Normal\ Duration - Crash\ Duration}$$

$$= \frac{Rp853.960.082,34 \quad - \quad Rp962.460.082}{70\ day \ - \ 49\ day}$$

= Rp4.020.645,00 /day

2) Ground Floor Structural Work
Given:
Volume: 61,887 m3
Duration : 49 days
Number of Shifts: 1
Normal Direct Cost: Rp. 97,031,602.21
Calculation of normal productivity
Productivity = Volume/ Duration
= 61,887 m3 / 49 days
= 1,768.19 m3/day

Calculation of crash duration
Durasi Crash = Volume / (Morning Shift Production)
= 61,887 m3 / 1,768.19 m3/day
= 35 days
Calculation of crash cost
The first step in determining the crash cost is to determine the normal wage cost spent over 1 day, where the calculation is explained in the table below:

Table 6. Calculation of Morning Shift Wage Costs

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	20	11428.57	8	Rp 80,000	Rp 1,600,000
Foreman	1	24285.71	8	Rp 170,000	Rp 170,000
Total					**Rp 1,770,000**

Source: Analysis Results, 2025

Table 7. Overtime Cost Calculation

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	20	22857.14	5	114285,71	Rp 2.285,714
Foreman	1	4857.43	5	242857,14	Rp 242.857
Total					**Rp 2,528,571**

Source: Analysis Results, 2025

From the table above, it is known that the normal cost spent in one day to carry out that work item is Rp 1,170,000.
Cost (Wage) = Worker Wage Per Day x Normal Duration
= Rp2,170,000.00 × 49
= Rp86,730,000.00
Cost (Material) = Direct Cost – Labor Cost
= Rp 97.031.602,21 – Rp 86.730,000.00
= Rp 10.301.602,21
Crash Cost = Cost (Material) + (Labor Cost x Number of Shifts x Crash Duration)
= Rp 10.301.602,21+ (Rp1.770.000 × 1 × 35)
= RP 72.251.602,21

$$\text{Cost Slope} = \frac{Crash\ Cost - Normal\ Direct\ Cost}{Normal\ Duration - Crash\ Duration}$$

$$= \frac{Rp97.031.602{,}21 \quad - \quad Rp72.251.602{,}21}{49\ day\ -\ 35\ day}$$

= Rp177.000.000,00 /day

3) Floor Structure Work - 2 Elv+4.20
Given:
Volume: 4,115 m3

Duration : 49 days
Number of Shifts: 1
Normal Direct Cost: Rp. 224.319.026,28
Calculation of normal productivity
Productivity = Volume/ Duration
= 4,115 m3 / 49 days
= 83,97 m3/day
Calculation of crash duration
Durasi Crash = Volume / (Morning Shift Production)
= 4.115 m3/ 83,97 m3/day
= 42 days
Calculation of crash cost
The first step in determining the crash cost is to determine the normal wage cost spent over 1 day, where the calculation is explained in the table below:

Table 8. Calculation of Morning Shift Wage Costs

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	20	11428.57	8	Rp 80,000	Rp 1,600,000
Foreman	1	24285.71	8	Rp 170,000	Rp 170,000
Total					**Rp 1,770,000**

Source: Analysis Results, 2025

Table 9. Overtime Cost Calculation

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	20	22857.14	5	114285,71	Rp 2.285,714
Foreman	1	4857.43	5	242857,14	Rp 242.857
Total					**Rp 2,528,571**

Source: Analysis Results, 2025

From the table above, it is known that the normal cost spent in one day to carry out that work item is Rp 1,170,000.

Cost (Wage) = Worker Wage Per Day x Normal Duration
= Rp2,170,000.00 × 49
= Rp86,730,000.00
Cost (Material) = Direct Cost – Labor Cost
= Rp 224.319.026,28 – Rp 86.730,000.00
= Rp 137.589.026,28
Crash Cost = Cost (Material) + (Labor Cost x Number of Shifts x Crash Duration)
= Rp 137.589.026,28+ (Rp1.770.000 × 1 × 42)
= RP 211.929.026

$$\text{Cost Slope} = \frac{Crash\ Cost - Normal\ Direct\ Cost}{Normal\ Duration - Crash\ Duration}$$

$$= \frac{Rp224.319.026{,}28 \quad - \quad Rp211.929.026}{49\ day \ - \ 42\ day}$$

= Rp177.000.000,00 /day

4) Floor Architect Work - 1
Given:
Volume: 16.574,19 m3
Duration : 63 days
Number of Shifts: 1
Normal Direct Cost: Rp. 82.433.720,26
Calculation of normal productivity
Productivity = Volume/ Duration
= 16.574,19 m3 / 63 days
= 263,08 m3/day
Calculation of crash duration
Durasi Crash = Volume / (Morning Shift Production)
= 16.574,19 m3/ 263,08 m3/day
= 56 days
Calculation of crash cost
The first step in determining the crash cost is to determine the normal wage cost spent over 1 day, where the calculation is explained in the table below:

Table 10. Calculation of Morning Shift Wage Costs

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	20	11428.57	8	Rp 80,000	Rp 1,600,000
Foreman	1	24285.71	8	Rp 170,000	Rp 170,000
Total					**Rp 1,770,000**

Source: Analysis Results, 2025

Table 11. Overtime Cost Calculation

Labor Type	Normal (people)	Working Hours	Working Hours	Daily Wage (IDR)	Total Wage (IDR)
Worker	20	22857.14	5	114285,71	Rp 2.285,714
Foreman	1	4857.43	5	242857,14	Rp 242.857
Total					**Rp 2,528,571**

Source: Analysis Results, 2025

From the table above, it is known that the normal cost spent in one day to carry out that work item is Rp 1,170,000.

Cost (Wage) = Worker Wage Per Day x Normal Duration
= Rp2,170,000.00 ×63
= Rp11.510.000,00
Cost (Material) = Direct Cost – Labor Cost
= Rp 82.433.720,26 – Rp 11.510,000.00
= Rp 70.923.720,26
Crash Cost = Cost (Material) + (Labor Cost x Number of Shifts x Crash Duration)
= Rp 70.923.720,26+ (Rp1.770.000 × 1 × 56)
= RP 170.043.720,26

$$\text{Cost Slope} = \frac{Crash\ Cost - Normal\ Direct\ Cost}{Normal\ Duration - Crash\ Duration}$$

$$= \frac{Rp170.043.720{,}26 \quad - \quad Rp82.433.720{,}26}{63\ day\ -\ 56\ day}$$

= Rp12.515.714,29/day

CONCLUSION

Based on the analysis, the construction project for the Malaka Regent's Office could be completed in 196 calendar days using the Critical Path Method (CPM) and in 182 calendar days using the Time–Cost Trade-Off (TCTO) method. These findings indicate that the TCTO method provided greater schedule acceleration than CPM while supporting effective project planning. For future research, additional project acceleration techniques should be evaluated and compared with CPM and TCTO to identify the most effective approaches for optimizing construction project schedules and costs.

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