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# Optimizing Time Calculation with Extended Working Hours in the Periodic Road Maintenance Project on Jl. Ir. Soekarno Ruas 3, Blitar City

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***Abstract**. Road maintenance is a strategic effort to support community mobility and economic development. This study aims to determine the optimal duration and analyze the cost impacts of implementing the Time Cost Trade Off (TCTO) method. The method is applied through critical path analysis and adding overtime hours to reduce the project duration. Data is collected from project documents such as daily reports, S-curves, and cost budget plans, then analyzed using Microsoft Project software. The results show that the project duration can be shortened to 117 days with an additional cost of IDR 176,614,724.00, which is lower than the potential delay penalty of 1% per day. This adjustment leads to a time savings of 8.6% without causing significant changes to the project's organizational structure. The TCTO method proves to be a practical solution for addressing delays while maintaining a balance between time and cost.*

***Keywords** Time Cost Trade Off (TCTO), Road maintenance, Optimal duration, Additional cost, Time saving.*

## 1. INTRODUCTION

Roads play a crucial role in supporting public mobility and the economic development of a region. According to the Indonesian Law Number 38 of 2004, roads are considered strategic infrastructure that supports the nation's development (Law No. 38 of 2004). Well-maintained roads significantly contribute to the smooth operation of public activities, user safety, and connectivity between regions (Minister of Public Works Regulation No. 11 of 2010). Therefore, road maintenance is a priority to ensure optimal infrastructure performance.

In the construction industry, time is one of the main factors determining the success of a project. A project is considered successful if it is completed according to the planned schedule. However, reality often shows that many projects experience delays due to various factors, such as weather, design changes, labor shortages, or other technical constraints (Safrizal et al., 2019).These delays result in additional costs and time, necessitating solutions to address these issues.

The Periodic Road Maintenance Project on Jl. Ir. Soekarno Section 3 in Blitar City is one example of an infrastructure project facing similar challenges. This project was initially planned to be completed within 120 days, with a budget of IDR 1,165,563,000. However, it faced an eight-day delay, requiring acceleration measures to complete the work within the

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target timeframe. One method that can be used to optimize time and costs is the Time Cost Trade Off (TCTO) method, which allows schedule adjustments with minimal additional costs.

The TCTO method is relevant in this case because it offers acceleration solutions, such as adding overtime to critical path tasks. By applying this method, it is expected that the project completion time can be shortened without incurring significant additional costs (Nuryanti & Sari, 2021). This study aims to calculate the optimal time and evaluate the cost impact of adding working hours to this project, providing a reference for optimizing similar projects in the future (Ningrum et al., 2017).

As a key element of infrastructure, roads also play a role in improving accessibility to various public services, including education, healthcare, and the economy. Proper road maintenance not only reduces transportation costs but also improves the overall quality of life for the community (Mulyo et al., 2023). Local governments have the responsibility to ensure the sustainability of this infrastructure to provide maximum benefits to the public.

Field conditions show that infrastructure projects often face a variety of challenges. In addition to weather factors and design changes, delays are often caused by poor coordination among the parties involved in the project (Adhitya Putra et al., 2023). In this context, strategic planning is required to minimize potential obstacles and keep the project on track with the established targets (Safrizal et al., 2019).

The Time Cost Trade Off (TCTO) method has proven to be one of the approaches that can help resolve delays in projects. By identifying the critical path in the project schedule, this method allows for acceleration alternatives while considering both time and cost aspects (Sulistyo & Al Fikri, 2021). This gives project managers the flexibility to choose the best options based on the available situation and resources.

The TCTO method is relevant not only for large-scale projects but also for medium to small-scale infrastructure projects. By conducting a thorough analysis of the project schedule and budget, this method provides a clear picture of how specific changes can affect the final outcome (Muharani et al., 2020). Therefore, it can be a valuable tool in project management (Setiawan & Tamtana, 2020).

In this study, the analysis focuses on acceleration efforts through adding overtime. This approach was selected because it is considered easier to apply than other alternatives, such as increasing the workforce or adding heavy equipment. Additionally, assuming worker productivity remains constant, adding work hours provides a practical solution to delays without requiring significant changes to the project's organizational structure (Fazri et al., 2020).

## 2. LITERATURE REVIEW

### Highway

Highways are an essential part of transportation infrastructure, functioning as connectors between regions to support public mobility and the distribution of goods (Law No. 38 of 2004, Republic of Indonesia). In the context of national development, roads play a crucial role in fostering economic growth, providing access to public services, and enhancing interregional connectivity. Well-maintained highways can reduce travel time and logistics costs, thus supporting the optimization of the national transportation system (M. Nurdin, 2019).

Highways are classified based on their function, class, and status. For instance, primary arterial roads are designed to accommodate long-distance travel with high capacity and speed, whereas local roads cater to short-distance transportation (Minister of Public Works Regulation No. 11 of 2010). On the Periodic Maintenance Project for Jl. Ir. Soekarno Section 3 in Blitar City, road improvements aim to maintain functionality, providing the main access route to the historical tourist destination, the Tomb of Bung Karno. This project also supports local economic growth by ensuring road safety and user comfort..

### Projects

Construction projects comprise a series of activities aimed at creating or improving infrastructure using resources such as labor, materials, and heavy equipment. In the context of highways, these projects involve planning, implementation, and control to achieve objectives such as capacity upgrades, rehabilitation, or periodic maintenance. Effective scheduling is a key element of project success, including the identification of critical paths using methods such as the Precedence Diagram Method (PDM) to minimize delays (Ervianto, 2004).

In the Periodic Maintenance Project for Jl. Ir. Soekarno Section 3 in Blitar City, the project was initially planned for completion within 120 working days with a budget of IDR 1,165,563,000. However, due to an eight-day delay, acceleration strategies were required to optimize project completion time (Safrizal et al., 2019). The Time Cost Trade-Off (TCTO) method was applied to determine optimal costs and duration by adding overtime hours on the critical path. Studies show that this method effectively addresses project delays with minimal additional costs (Nuryanti & Sari, 2021).

### Time Cost Trade-Off (TCTO) Analysis

The Time Cost Trade-Off (TCTO) method is an analytical approach used to examine the relationship between time and cost in construction projects. It aims to find the optimal balance between accelerated project completion and additional costs. The core concept of TCTO focuses on activities within the critical path, which is the longest sequence of tasks in a project network diagram determining the total project duration. Acceleration is applied only to activities on the critical path as they directly affect the overall project timeline (Ervianto, 2004).

In implementing the TCTO method, two key durations are considered: Normal Duration (ND) and Crash Duration (CD). Normal Duration represents the project timeline under normal conditions without additional resources or costs, while Crash Duration represents the accelerated timeline achieved by adding resources such as overtime, additional labor, or equipment, resulting in higher costs than under normal conditions (Dimyati & Nurjaman, 2014). The efficiency of acceleration is calculated using the concept of Cost Slope, defined as the ratio between the additional cost and the reduced time for a specific activity. The formula is as follows:

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

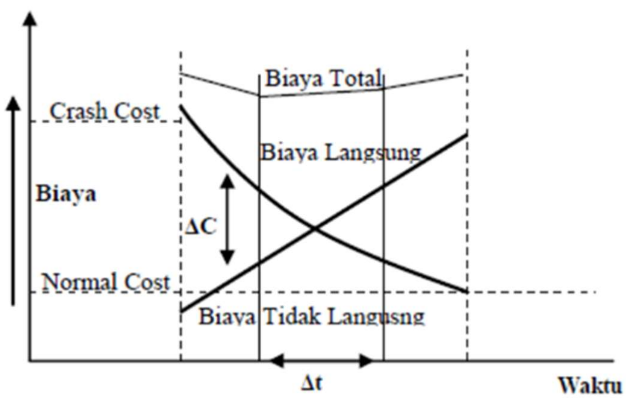


**Fig. 1.** Graph of the relationship between time and direct cost, indirect cost, total cost fund

TCTO analysis is conducted by identifying critical paths, calculating the cost slope of each activity, and accelerating the activity with the lowest cost slope until it reaches the optimal duration or cost. The advantages of this method are time and cost efficiency, as seen in the studies of Salindeho (2022) and Muharani (2020), where project acceleration was successfully carried out with additional controllable costs. By focusing on critical trajectory and cost efficiency, TCTO is an effective solution to overcome delays in construction projects.

**Implementation Through Overtime**

The TCTO method is often applied in delayed projects to expedite completion by adding overtime hours, especially for activities on the critical path with the lowest cost slope. Overtime work is conducted beyond regular working hours, with overtime pay calculated at 1.5 times the normal rate for the first hour and twice the rate for subsequent hours, in accordance with Minister of Manpower Decree No. KEP.102/MEN/VI/2004. However, overtime productivity tends to decline due to worker fatigue and less optimal working conditions during nighttime hours.

Steps in TCTO implementation include identifying the critical path, analyzing normal duration and cost, calculating crash duration and crash cost, and selecting the most efficient acceleration alternative. A study by Cindy G. Salindeho (2022) demonstrated that adding two hours of overtime in a road improvement project resulted in significant time savings with minimal additional costs, proving the method's effectiveness in mitigating project delays.

### Project Scheduling

Project scheduling is a critical component of construction management, designed to determine the sequence of activities and allocate time efficiently. According to Husen (2009), scheduling facilitates the identification of resource needs such as labor, equipment, and materials based on the planned duration. This enables project management to stay on track with time and budget targets.

Commonly used scheduling tools include Gantt Charts and Precedence Diagrams, which help visualize activity relationships. These tools simplify the identification of the critical path, comprising activities with no slack or float time. Delays in these activities directly affect the entire project schedule (Dimyati & Nurjaman, 2014). Careful management of the critical path can thus prevent overall project delays.

## 3. METHODS

### Research Object

The object of this research is the Periodic Road Maintenance Project on Ir. Soekarno Street, Section 3, in Blitar City. The project spans a length of 865.70 meters and serves as a critical component of infrastructure supporting access to tourist and economic areas in Blitar City. The project is managed by the contractor CV. Cakrawangsa Adinata, with a total budget of IDR 1,165,563,000.

### Research Location and Duration

The research is conducted in Blitar City, specifically on Ir. Soekarno Street, Section 3, which serves as a main route to Bung Karno's Tomb. The study takes place over six months, from data collection to analysis and report preparation, running from January to June 2025.

### Data Collection

The data collection process in this research includes several key steps to ensure data completeness and validity, such as: project schedule/s-curve, daily reports, contract documents, and budget plan (rab)

**Data Processing**

The Time-Cost Trade-Off (TCTO) analysis involves several steps, including:

1. Identifying and breaking down structural tasks into smaller sub-tasks, referred to as the Work Breakdown Structure (WBS).
2. Analyzing the volume of each task divided into smaller sub-tasks.
3. Calculating the normal duration and cost for each task in the project.
4. Creating a schedule using software tools like Microsoft Project with normal durations to determine the project's critical path.
5. Identifying acceleration alternatives by increasing work hours.
6. Calculating the normal cost for each activity.
7. Determining the acceleration cost for each activity.
8. Calculating the cost slope for each activity.
9. Shortening activity durations by prioritizing critical tasks with the lowest cost slopes.

## 4. RESULTS AND DISCUSSION

***Crash Duration***

a. Porous Material Work for Water Trap Filter Grill / 40 x 60 cm / Painting.

Volume : 27.00

Normal Duration : 23 days

Normal Working Hours: 7 hours

- Daily productivity:

$$\frac{\text{Volume}}{\text{Normal Duration}} = \frac{27.00\text{ m}^3}{23\text{ hari}} = 1.174\text{ m}^3\text{/ day}$$

- Hourly productivity:

$$\frac{\textit{Daily productivity}}{\textit{Working Hours Per Day}} = \frac{1.174}{7\textit{ hours}} = 0.17\text{ m}^3\text{/ days/hours}$$

- Productivity after the crash:

Normal working hours : 7 hours

Overtime work hours : 2 hours

Overtime performance coefficient 80% : 0,2

Then:

(Working Hours per day x Productivity per hour + (a x b x Productivity per hour)

= (7 x 0.17) + (2 x 0,2 x 0.17)

= 1.26

- Crash Duration:

$$\frac{\text{Volume}}{\text{Productivity after the crash}} = \frac{27.00}{1.26} = 21 \text{ days}$$

The following are the results of the crash duration calculation as shown in table 1 below:

**Table 1.**
Results of crash duration calculation

| Work Type | Volume ($m^3$) | Normal Duration (Days) | Normal Work Hours (Hours) | Daily Productivity ($m^3$/day) | Hourly Productivity ($m^3$/hour) | Post-Crash Productivity ($m^3$/day) | Crash Duration (Days) |
|---|---|---|---|---|---|---|---|
| Porous Material Work | 27.00 | 23 | 7 | 1.174 | 0.17 | 1.26 | 21 |
| Asphalt Pavement Excavation (Cold Milling Machine) | 5.98 | 2 | 7 | 2.99 | 0.42 | 3.11 | 1 |
| Liquid Asphalt Primer/Emulsion | 4,393.19 | 4 | 7 | 1,098 | 157 | 1,161 | 4 |
| Laston Wearing Layer (AC-WC) | 811.38 | 4 | 7 | 202.845 | 28.9 | 213.86 | 4 |

From the above calculations, acceleration can be carried out on the work of Making Porous Material for Water Catchment Filter Grill and Excavation of Paved Pavement with Cold Milling Machine. Meanwhile, the work of Liquid Asphalt/Emulsion Adhesive Layer and Wear Layer Laston (AC-WC) cannot be accelerated because the duration is already optimum.

***Crash Cost***

a. Porous material work for filter material of water catchment grill / pair / 40 x 60 cm / painting.

- Daily Normal Wages

Workers : Rp. 80,188

Masons : Rp. 82,188

Supervisor : Rp. 89,188

- Number of Workers

Workers : 6 people

Masons : 3 people

Supervisor : 1 person

- Normal Working Hours = 7 hours

Normal Hourly Wage $= \frac{(Daily\ Normal\ Wage)}{(Normal\ Working\ Hours)}$

Workers $= \frac{(Rp.80{,}188)}{7} = Rp.\ 11{,}455.00$

Masons $= \frac{(Rp.82{,}188)}{7} = Rp.\ 11{,}741.00$

Supervisor $= \frac{(Rp.89{,}188)}{7} = Rp.\ 12{,}741.00$

- Overtime Wages for the First Hour = 1.5 × Normal Hourly Wage

Workers : 1.5 × Rp. 11,455.00 = Rp. 17,182.00

Masons : 1.5 × Rp. 11,741.00 = Rp. 17,611.00

Supervisor : 1.5 × Rp. 12,741.00 = Rp. 19,111.00

- Overtime Wages for the Next Two Hours = 2 × Normal Hourly Wage

Workers : 2 × Rp. 11,455.00 = Rp. 22,910.00

Masons : 2 × Rp. 11,741.00 = Rp. 23,482.00

Supervisor : 2 × Rp. 12,741.00 = Rp. 25,482.00

- Total Overtime Costs:

Daily Normal Wage + First Hour Overtime Wage + Two Hours Overtime Wage

Workers : Rp. 120,280.00

Masons : Rp. 123,281.00

Supervisor : Rp. 133,781.00

- Overtime Wage per Day:

Number of Workers × Total Overtime Costs

Workers = 6 × Rp. 120,280.00 = Rp. 721,680.00

Masons = 3 × Rp. 123,281.00 = Rp. 369,843.00

Supervisor = 1 × Rp. 133,781.00 = Rp. 133,781.00

Total = Rp. 1,225,304.00

- Crash Cost:

Total Overtime Wage per Day × Acceleration Duration

= Rp. 1,225,304.00 × 21 days

= Rp. 25,731,384.00

b. Asphalt Pavement Excavation with Cold Milling Machine

- Daily Normal Wages

Workers: Rp. 80,188

Supervisor: Rp. 89,188

- Number of Workers

Workers : 6 people

Supervisor : 1 person

- Normal Working Hours = 7 hours

Normal Hourly Wage = (Daily Normal Wage) / (Normal Working Hours)

Workers = (Rp. 80,188) / 7 = Rp. 11,455.00

Supervisor = (Rp. 89,188) / 7 = Rp. 12,741.00

- Overtime Wages for the First Hour = 1.5 × Normal Hourly Wage

Workers : 1.5 × Rp. 11,455.00 = Rp. 17,182.00

Supervisor : 1.5 × Rp. 12,741.00 = Rp. 19,111.00

- Overtime Wages for the Next Two Hours = 2 × Normal Hourly Wage

Workers : 2 × Rp. 11,455.00 = Rp. 22,910.00

Supervisor : 2 × Rp. 12,741.00 = Rp. 25,482.00

- Total Overtime Costs:

Daily Normal Wage + First Hour Overtime Wage + Two Hours Overtime Wage

Workers : Rp. 120,280.00

Supervisor : Rp. 133,781.00

- Overtime Wage per Day:

Number of Workers × Total Overtime Costs

Workers = 6 × Rp. 120,280.00 = Rp. 721,680.00

Supervisor = 1 × Rp. 133,781.00 = Rp. 133,781.00

Total = Rp. 855,461.00

- Crash Cost:

Total Overtime Wage per Day × Acceleration Duration

= Rp. 855,461.00 × 1 day

= Rp. 855,461.00

***Cost Slope***

$$\text{Cost Slope} = \frac{\text{Normal cost} - \text{Crash cost}}{\text{Normal duration} - \text{Cr} \quad \text{duration}}$$

The results of the cost slope calculation for each activity can be seen in Table 2 below.

**Table 2.**
Results of cost slope calculation

| Activities | Normal Cost (Rp) | Crash Cost (Rp) | Normal Duration (hari) | Crash Duration (hari) | Cost Slope (Rp) |
|---|---|---|---|---|---|
| a. Manufacture of porous materials | 26.784.000 | 25.731.384 | 23 | 21 | 350.872 |
| b. Excavation with Cold Milling Machine | 2.266.594,07 | 855.461 | 2 | 1 | 5.411.088 |

## 5. CONCLUSION

The Time Cost Trade Off (TCTO) method was used to calculate the optimum time for the Road Periodic Maintenance project on Jl. Ir. Soekarno Ruas 3 Blitar City. By adding 2 hours of overtime per day, the project duration can be shortened from 128 days to 117 days, resulting in 8.6% time savings. The total project cost after acceleration is Rp. 1,342,177,724, which includes an additional cost of Rp. 176,614,724. This additional cost is lower than the potential delay penalty of 1% per day. Cost slope shows that the cost of acceleration is still within reasonable limits, supporting the completion of the project on time.

## 6. REFERENCES

Adhitya Putra, D., Lhara Sari, O., & Situmorang, R. (2023). Analisis Faktor Keterlambatan Proyek Konstruksi Di Kota Balikpapan. *Jurnal Teknik Sipil : Rancang Bangun*, *9*(1), 017–024. https://doi.org/10.33506/rb.v9i1.2044

Dimyati, H., & Nurjaman, K. (2014). *Manajemen Proyek*. PUSTAKA SETIA.

Ervianto, W. I. (2004). *Teori – Aplikasi Manajemen Proyek Konstruksi*. Yogyakarta: Andi.

Fazri, M., Widiastuti, M., & Jamal, M. (2020). Analisis Percepatan Waktu Dengan Menggunakan Metode Time Cost Trade Off Pada Proyek Pembangunan Rusun 1 Kota Samarinda Kalimantan Timur. *Teknologi Sipil*, *3*(2), 1–14.

Muharani, A., Mulyatno, I. P., & Jokosisworo, S. (2020). Optimasi Percepatan Proyek Pembangunan Kapal Kelas I Kenavigasian dengan Metode Pendekatan Analisa Time Cost Trade Off. *Jurnal Teknik Perkapalan*, *8*(3), 330–338. https://ejournal3.undip.ac.id/index.php/naval/article/view/27228

Mulyo, S. A., Said, L. B., & H, S. M. (2023). Analisis Pemeliharaan Jalan Nasional dengan Metode Bina Marga dan PCI Pada Ruas Jalan Slamet Riyadi Kota Samarinda. *Jurnal Flyover*, *3*(1), 51–59. https://doi.org/10.52103/jfo.v3i1.1508

Ningrum, F. G. A., Hartono, W., & Sugiyarto. (2017). Pengertian Metode Crashing Dalam Percepatan Durasi Proyek. *e-Jurnal MATRIKS TEKNIK SIPIL*, 583–591.

Nuryanti, P., & Sari, N. (2021). *( Kumai Seberang Kabupaten Kotawaringin Barat Provinsi Kalimantan Tengah ) MAINTENANCE OF ROADS AND SUPPLEMENTARY ROADS IN THE TRANSMIGRATION AREA*. *12*(1), 56–67.

Safrizal, M. D., Rauzana, A., & Muttaqin. (2019). Analisis Faktor Keterlambatan Proyek Konstruksi Paling Dominan Di Kabupaten Aceh Utara. *Teras Jurnal*, *9*(2), 145. https://doi.org/10.29103/tj.v9i2.210

Setiawan, L., & Tamtana, J. S. (2020). Analisis Percepatan Durasi Pekerjaan Basement Semi Top Down Dengan Metode Time Cost Trade Off. *JMTS: Jurnal Mitra Teknik Sipil*, *3*(1), 143. https://doi.org/10.24912/jmts.v3i1.6974

Sulistyo, A. B., & Al Fikri, M. (2021). Analisis Optimalisasi Waktu Dan Biaya Proyek Konstruksi Menggunakan Metode Time Cost Trade Off (Studi Kasus: Proyek Pembangunan Jalan Gorda-Bandung). *Jurnal InTent*, *4*(1), 25–40.