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Cost Analysis Due to the Addition of Working Time on Periodic Road Maintenance Project on Jl. Ir. Soekarno Ruas 3 Blitar City

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Abstract*. Prolonged road damage disrupts community mobility, logistics activities, and reduces road user safety. The road maintenance project on Jl. Ir. Soekarno in Blitar City, which was planned to be completed in 120 days with a budget of Rp1.16 billion, experienced a delay of 8 days due to time management constraints. This study aims to evaluate the use of the Time Cost Trade Off (TCTO) method to accelerate project completion without reducing the quality of work. The TCTO method is used to analyze the relationship between time and cost. This research proposes additional overtime working hours of 2 hours per day with the assumption of resources according to the Cost Budget Plan (RAB). The results show that with this method, the project can be completed in 117 days at a total cost of Rp1,342,177,724. Although it requires additional costs, this acceleration allows the project to be completed faster than the previous condition*

Keywords : *Additional costs, Project delay, Road damage, Road maintenance, Time Cost Trade Off (TCTO)*

1. INTRODUCTION

Roads play an important role in supporting the social, economic, and cultural activities of society. As basic infrastructure, the presence of adequate roads reflects the development level of a region as well as the government’s ability to provide proper public facilities. According to Law No. 38 of 2004 concerning Roads, the sustainable development of road infrastructure is one of the indicators for improving inter-regional connectivity to support national economic growth (Mulyo et al., 2023)(Mulyo et al., 2023) . However, challenges often arise when road management is not carried out optimally, leading to damage that can hinder mobility and logistics activities (Nuryanti & Sari, 2021).

Neglected road damage can result in economic losses, both in terms of travel time and vehicle operational costs (Adhitya Putra et al., 2023). Periodic maintenance is the main step to minimize further damage, although its implementation is often hindered by insufficient budget allocation, improper time management, and weather conditions that slow down productivity (Adhitya Putra et al., 2023). A concrete example is the Periodic Road Maintenance Project on Ir. Soekarno Street, Segment 3, in Blitar City.The project, which was planned to be completed within 120 calendar days with a budget of IDR 1,165,563,000, experienced an eight-day delay,

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requiring the application of the Time Cost Trade Off (TCTO) method to accelerate completion without compromising work quality.

Time and cost are two interconnected aspects in a construction project. Delays in time management not only increase project costs but can also lower the performance of the involved resources (Ervianto, 2004). One way to address this issue is by optimizing the project schedule using the TCTO method, which helps ensure the project is completed on time (Ervianto, 2004). The TCTO method allows adjustments to the project schedule by adding overtime to activities that play a key role in the project's smooth progress. This way, the negative impacts of delays, such as potential fines or financial losses, can be minimized (Dimyati & Nurjaman, 2014).

In road projects, the TCTO method has proven to be a practical solution to overcome time challenges. For instance, research has shown that this method successfully reduced the duration of a high-damage road project without compromising work quality. This is significant because road projects, especially strategic ones like Ir. Soekarno Street, have a wide impact on other sectors, including tourism. This street serves as the main access to the Bung Karno Mausoleum, an important historical tourist destination in Blitar City. Thus, accelerating the completion of the project not only meets local transportation needs but also supports regional economic growth.

The analysis of additional costs due to overtime is an important step in assessing the feasibility of time acceleration in construction and infrastructure development projects, where time is often a crucial factor. Although overtime can increase operational costs, speeding up project completion also offers benefits such as faster revenue, reduced storage costs, and improved client satisfaction (Anggraeni et al., 2017). In the Ir. Soekarno project, this strategy helps decision-makers choose the right acceleration approach by considering overtime costs, impact on work quality, and potential risks. The analysis should also include available resources, such as labor and equipment, to ensure that acceleration does not compromise safety or quality. Through an in-depth overtime cost analysis, project management can plan the budget more accurately and determine whether time acceleration adds value to the overall project. Thus, this analysis becomes an integral part of the project planning and execution process that supports long-term success and the company's reputation in the construction industry.

Construction projects often face obstacles that cause delays, such as bad weather, delayed material procurement, or labor shortages. These obstacles impact the additional costs and time needed to complete the project. By applying the TCTO method, the project can be restructured to speed up completion while still controlling additional costs (Adhitya Putra et al., 2023). For example, in a project in Samarinda City that implemented a similar method, the project completion time was shortened by 12 days, without disregarding cost control (Fazri et al., 2020).

Road damage not only causes financial losses but also potentially endangers the safety of road users. Therefore, accelerating the completion of maintenance projects is often a top priority for both the government and contractors. In the case of Ir. Soekarno Street, this acceleration also positively impacts the tourism sector, which is a significant source of regional income.

Careful planning that can adapt to changes is crucial in facing the various challenges that arise in highway development projects, such as traffic disruptions and unpredictable weather conditions. The main objective of this study is to assess the impact of adding working hours on total project costs and to find better ways to accelerate the work process that offers the greatest benefits.

This study is expected to provide direct benefits to construction project management in Indonesia, especially in addressing the frequent delays that occur. By applying the appropriate methods, it is hoped that projects can be completed more optimally. The findings are also expected to serve as a reference for similar projects in the future, helping in more structured project management, reducing potential delays, and offering practical solutions to improve the quality and smooth implementation of projects.

2. LITERATURE REVIEW

2.1 Previous Research

Several previous studies have shown the benefits of applying the Time-Cost Trade-Off (TCTO) method in construction projects, which allows project managers to balance completion time and costs. TCTO is particularly useful for infrastructure projects with tight deadlines. Research by Cindy G. Salindeho (2022) revealed that adding two hours of overtime per day on a road repair project could reduce the completion time by one day. This suggests that investing in overtime can accelerate project completion, reduce the negative impacts of delays, such as traffic disruptions, and help project managers perform cost-benefit analysis more accurately. The study also emphasizes the importance of thorough planning and risk management in applying TCTO. By understanding the relationship between time and cost, project managers can make more strategic decisions, including when and where overtime is needed, as well as the optimal allocation of resources.

Priyo Ponco Prabowo (2023) conducted a study on a housing project with additional overtime hours between two to six hours per day. This research examined the impact of adding working hours on project duration and costs. The findings showed a reduction in project duration by up to four days, meaning the project could be completed ahead of schedule. However, the time reduction was offset by increased costs, including overtime wages and potential additional costs arising from higher work intensity. Prabowo stressed the importance of balancing time efficiency and cost management in project management, ensuring that the results are not only fast but also stay within budget. This research provides insights for developers and project managers in planning and executing housing projects, highlighting the importance of proper human and financial resource management strategies to achieve optimal results.

Research by Nathasia (2022) showed that the application of the TCTO method in construction projects could accelerate project completion by up to 19%, providing a competitive advantage for construction companies. Although time was expedited, the required cost increase was only 1.6% of the total project budget, indicating that the additional cost was relatively small compared to the time benefits. These findings suggest that the TCTO method can result in significant efficiency in construction project management, allowing projects to be completed faster without substantial costs. This is an important consideration for project managers and other stakeholders in planning and executing projects, especially when completion time is critical.

2.2 Roadways

Roads are crucial infrastructure supporting human and vehicle mobility. According to M. Nurdin (2019), roads consist of paths that can be natural or man-made surfaces facilitating travel between locations. Roads play a key role in transportation, supporting the distribution of goods and services, and facilitating social and economic activities. Moreover, roads are designed considering load capacity and the types of vehicles passing, making them the main foundation for regional development.

Road development has a wide impact on regional economic growth. With good access, the mobility of goods and services becomes smoother, supporting business and investment growth. For example, roads connecting rural areas with cities allow farmers to sell their products more easily. Additionally, the existence of roads also facilitates public access to services such as education and healthcare, contributing to the improvement of social and economic welfare. However, it is important to plan road development while considering environmental impacts to avoid issues such as environmental damage and traffic congestion.

2.3 Road Classification Based on Function

Roads are classified into four main categories based on their primary function: arterial, collector, local, and environmental roads. Each type of road has a specific purpose:

Arterial Roads

Arterial roads are major roads designed for long-distance travel at high speeds. These roads connect important areas or activity centers in the transportation system, either at the national or regional level. Arterial roads are divided into two types: primary and secondary arterials. Primary arterials connect major nodes in the transportation system, while secondary arterials connect intercity or smaller areas.

Collector Roads

Collector roads serve as links between regional or local activity centers. These roads cater to travel over medium distances and speeds compared to arterial roads. Like arterial roads, collector roads are also divided into two types: primary and secondary collectors. Primary collectors connect activity centers at the district or regional level, while secondary collectors are used for distributing traffic within cities, helping mobility in urban areas.

Local Roads

Local roads are designed for short-distance travel at lower speeds. These roads typically connect residential areas or neighborhoods to main roads, such as collector roads. The primary function of local roads is to facilitate small-scale mobility in both urban and rural areas. Their presence is vital to support daily transportation needs within residential areas.

Environmental Roads

Environmental roads serve more limited functions, catering to traffic within specific areas, such as housing or rural areas. These roads are generally used for low-speed travel and are not suitable for heavy vehicles. Environmental roads connect residential units or plots in the area, ensuring smooth access at the local level.

In addition to functional classification, roads are also differentiated by their capacity and the load they can carry. This classification is divided into three classes:

- Class I Roads: Designed for vehicles with a maximum axle load of up to 10 tons, such as large transport vehicles.

- Class II Roads: Designed for vehicles with axle loads up to 8 tons.
- Class III Roads: Serve light vehicles with a capacity of less than 8 tons. This classification ensures that roads can withstand the load of passing vehicles in accordance with their design capacity.

2.4 Project

A project is a series of activities designed to achieve specific results within predetermined time and budget constraints. In the context of construction projects, meticulous planning is necessary to avoid resource wastage and ensure that the project is completed on time, within budget, and with the required quality. Soeharto (1997) states that good planning is critical for the success of a construction project, as improper planning can hinder the achievement of project objectives. Thus, every aspect of the project must be carefully considered to minimize risks during the construction process.

A Bill of Quantities (BoQ) is an essential component of project planning. The BoQ outlines the cost requirements, including labor, materials, and equipment to be used. Detailed planning simplifies project management and helps identify potential issues that may arise. According to Mariani (2019), with careful planning, project management becomes easier, reducing obstacles and promoting smoother processes. Moreover, the success of the project is influenced by the balance between cost, time, and quality. These three elements are interconnected, and proper management ensures that the project meets expectations. In practice, good coordination among team members is necessary to ensure that all activities proceed according to the established plan, including resource allocation and regular progress monitoring (Santosa, 2009).

2.5 Time and Cost Trade-off Analysis (TCTO)

Time-Cost Trade-Off (TCTO) analysis is an approach used to optimize the completion time of a construction project by adding specific costs. Its primary goal is to accelerate the project duration by adding resources or changing work methods for activities on the critical path, the sequence of activities that determines the overall project duration. TCTO allows projects to be completed faster without compromising work quality, but with higher costs. This process involves a thorough analysis of each activity in the project to identify which ones can be expedited with the least additional cost (Ervianto, 2004).

This method involves two key elements: Normal Duration and Crash Duration. Normal Duration is the standard time required to complete an activity, while Crash Duration is the minimum time after acceleration. The cost required to complete an activity in normal time is called Normal Cost, while Crash Cost is the higher cost needed to finish the activity faster. One crucial calculation in TCTO is the Cost Slope, which helps determine which activities can be expedited at the lowest additional cost. The Cost Slope is calculated by comparing the additional cost with the time saved (Nurjaman, 2014).

The TCTO analysis steps start with identifying the critical path using a network diagram method, then analyzing which activities can be expedited with low additional costs. After acceleration, the impact on the project duration is evaluated to ensure the critical path remains valid. The optimal combination of time and cost is then determined. This method is highly beneficial for projects with tight deadlines, as it allows for acceleration without wasteful spending and helps project managers plan acceleration steps more systematically (Ervianto, 2004; Soeharto, 1997).

2.6 Implementation with Additional Working Hours

The implementation of construction projects often requires additional working hours to meet tight deadlines. One solution used is overtime, which becomes necessary when the project is delayed or needs to be expedited. According to the Minister of Manpower Decree No. KEP.102/MEN/VI/2004, the normal working hours in Indonesia are 8 hours per day, with the possibility of adding overtime hours calculated at overtime rates. However, the longer the overtime duration, the more worker productivity decreases due to physical fatigue and adverse environmental conditions, such as lower temperatures or limited lighting (Soeharto, 1997). Productivity during overtime can be calculated using the formula:

$$Daily\ Productivity\ = \frac{Volume}{Planned\ Duration}$$

$$Hourly\ Productivity\ = \frac{Daily\ Productivity}{Working\ Hours\ in\ Hours}$$

Productivity = (8 hours x hourly productivity) + (a x b x hourly productivity)

Where:

- a = number of overtime hours
- b = overtime productivity reduction coefficient

Then the Crash Duration can be obtained as:

$$Crash\ duration\ = \frac{\text{Volume}}{\text{Post} - \text{crash Daily Productivity}}$$

In addition, overtime costs are an important factor that needs to be calculated in project planning. Overtime costs are determined by multiplying the overtime wage rate by the number of overtime hours worked. The first overtime rate is 1.5 times the normal hourly wage, while subsequent overtime hours are paid at twice the normal hourly wage. The total overtime cost is calculated using the following formula:

$$Crash\ Cost\ = (Normal\ Worker\ Cost\ per\ Day) + (Overtime\ Worker\ Cost)$$

Lastly, adding work hours can also affect the project duration, known as "Crash Duration." Crash Duration refers to the time required to complete a project with additional overtime hours. This duration is shorter than the normal time but incurs higher costs. The formula to calculate Crash Duration is as follows:

$$Crash\ Duration\ = Normal\ Time\ - Time\ Reduction\ Due\ to\ Overtime$$

3. METHODS

This research employs the primary method of Time Cost Trade-Off (TCTO) analysis, aiming to evaluate the impact of schedule adjustments on project duration and costs. In this method, activities on the critical path are analyzed to determine normal and accelerated durations while considering the additional costs incurred due to these changes.

3.1 Research Object

The research object is the Periodic Road Maintenance Project on Jl. Ir. Soekarno Section 3 in Blitar City, with a length of 865.70 meters and a cost of IDR 1,165,563,000.00. The project was undertaken by CV. Cakrawangsa Adinata, starting on June 18, 2021, and finishing on October 15, 2021, with a calendar duration of 120 days. The maintenance period lasted for 365 days, from September 29, 2021, to September 28, 2022. Funded by the Special Allocation Fund (DAK), the project included drainage, earthworks, asphalt, and structural works. During its execution, the project experienced an 8-day delay, which is the focus of this research to analyze the time-cost impact using the Time Cost Trade-Off (TCTO) method.

3.2 Research Location and Timeline

The research location is Jl. Ir. Soekarno Section 3 in Blitar City, a primary route to the historical tourist destination of Bung Karno's Mausoleum. This location was chosen due to its strategic role as a main connector for local transportation and tourism, making its repair a top priority for the local government. The research was conducted over six months, covering all project phases, from initial data collection, such as project document analysis and work schedule review, to field observations for directly monitoring work progress.

3.3 Data Analysis Techniques

The Time Cost Trade-Off (TCTO) analysis process comprises several steps, as follows:

- Identifying and breaking down each structural task into smaller sub-tasks, known as the work breakdown structure (WBS).
- Analyzing the volume of each task divided into smaller sub-tasks.
- Calculating the project's normal duration and costs for each task.
- Creating a schedule using Microsoft Project software with normal durations to identify the critical path.
- Determining acceleration alternatives by planning to add working hours.
- Determining the normal cost of each activity.
- Determining the accelerated cost of each activity.
- Calculating the cost slope of each activity.
- Shortening the activity duration, starting with critical activities that have the lowest cost slope.
- Restructuring the work network.
- Creating a graph showing the relationship between cost and time.
- Drawing conclusions.

4. RESULTS AND DISCUSSION

4.1 Project Data

The project used as a case study in this research is the Periodic Road Maintenance Project on Jl. Ir. Soekarno, Section 3, Blitar City, planned to be completed within 120 days, starting from June 1 to November 29, 2021, with a budget of Rp. 1,165,563,000.00, including VAT. Below are the general details of the project:

Contractor	: CV. Cakrawangsa Adinata
Planning Consultant	: CV. Terate Manunggal
Supervisory Consultant	: CV. EK Consultant
Contract Value	: Rp. 1,165,563,000.00

Implementation Date : June 18, 2024

Duration : 120 days

Project Location : Jl. Ir. Soekarno, Section 3, Blitar City

Project Owner : Department of Public Works and Spatial Planning, Blitar Regency

Address : Jl. A. Yani No. 20, Sananwetan, Blitar City

4.2 Direct Costs

Direct costs are expenses directly associated with the execution of construction work on-site, including labor wages, material procurement, and equipment usage for the project. In this research, direct costs are calculated based on the Unit Price Analysis (AHSP) and Budget Plan (RAB) for the Periodic Road Maintenance Project on Jl. Ir. Soekarno, Section 3, Blitar City, using wage and material costs from the initial project planning RAB. Equipment costs are excluded from the direct costs due to the absence of specific data on equipment usage during implementation. Thus, the direct costs calculated based on available project data amount to Rp. 1,165,563,000.00, covering labor wages and materials directly supporting the project's progress.

4.3 Indirect Costs

Indirect costs are expenses not directly tied to construction work but support project continuity. These include administrative project costs (e.g., documentation and permits), supervision costs (including supervisory salaries), and overhead costs for the contractor's head office. Assuming indirect costs are 8% of the total normal costs, the calculated indirect costs are:

Total Indirect Costs = 8% x Total Normal Costs

= 8% x Rp 1.165.563.000.00

= Rp. 93.245.040

4.4 Crash Duration

Crash duration calculations involve accelerating certain tasks by shortening the project's completion time. Some tasks have already reached optimal duration and cannot be further shortened. Below are the crash duration calculations for each task:

Table 1. Crash Duration Calculation

Task	Volume (m^3)	Normal Duration (days)	Normal Productivity (m^3/day)	Crash Productivity (m^3/day)	Crash Duration (days)
Porous Material for Filter	27.00	23	1.174	1.26	21
Asphalt Pavement Excavation (Cold Milling)	5.98	2	2.99	3.11	1
Asphalt Emulsion Adhesive Layer	4,393.19	4	1,098	1,161	4
Laston Surface Layer (AC-WC)	811.38	4	202.845	213.86	4

Based on the calculations above, tasks that can be accelerated include Porous Material for Filter and Asphalt Pavement Excavation with Cold Milling. The Asphalt Emulsion Adhesive Layer and Laston Surface Layer (AC-WC) tasks cannot be further accelerated due to reaching optimal duration.

4.5 Crash Cost

Crash costs are calculated based on overtime costs incurred due to project duration acceleration. The crash cost breakdown for accelerated tasks is as follows:

Table 2. Crash Cost Calculation

Task	Overtime Wage Per Day (Rp)	Crash Duration (days)	Crash Cost (Rp)
Porous Material for Filter	1,225,304	21	25,731,384
Asphalt Pavement Excavation (Cold Milling)	855,461	1	855,461

4.6 Cost Slope

The cost slope calculates the difference between normal and crash costs and the difference between normal and crash durations. The cost slope for each task is as follows:

Table 3. Cost Slope Calculation

Task	Normal Cost (Rp)	Crash Cost (Rp)	Normal Duration (days)	Crash Duration (days)	Cost Slope (Rp)
Porous Material for Filter	26,784,000	25,731,384	23	21	350,872
Asphalt Pavement Excavation (Cold Milling)	6,266,549	855,461	2	1	5,411,088

After processing data and accelerating tasks through overtime, the results can be summarized as follows:

Table 4. Processing Results

No	Direct Cost	Indirect Cost	Total Cost	Duration	Remarks
1	Rp. 1,165,563,000	Rp. 93,245,040	Rp. 1,258,808,040	120 days	Normal
2	Rp. 1,166,418,461	Rp. 93,313,476	Rp. 1,259,731,937	119 days	Asphalt Pavement Excavation with Cold Milling
3	Rp. 1,242,757,152	Rp. 99,420,572	Rp. 1,342,177,724	117 days	Calculation for Porous Material for Filter

5. CONCLUSION

Based on the results of the analysis, the calculation of costs due to additional working time in the Road Periodic Maintenance project on Jl. Ir. Soekarno Ruas 3 Blitar City shows that the Time Cost Trade Off (TCTO) method is effectively used to calculate additional costs and optimize project duration. The addition of working time in the form of overtime for 2 hours per day reduced the project duration from 120 days to 117 days with the total cost increasing from Rp. 1,165,563,000 to Rp. 1,342,177,724.

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